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

(71) Applicant: **Universal Display Corporation**, Ewing, NJ (US)

(72) Inventors: **Morgan C. MACINNIS**, Yardley, PA (US); **Tyler FLEETHAM**, Yardley, PA (US); **Jerald FELDMAN**, Cherry Hill, NJ (US); **Ivan MILAS**, Summit, NJ (US); **Wei-Chun SHIH**, Warrington, PA (US); **Pierre-Luc T. BOUDREAULT**, Pennington, NJ (US)

(73) Assignee: **Universal Display Corporation**, Ewing, NJ (US)

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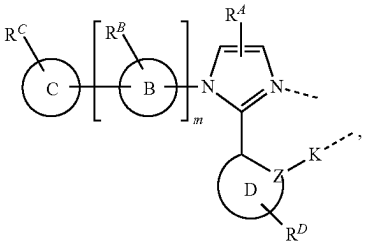
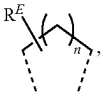
(57) **ABSTRACT**

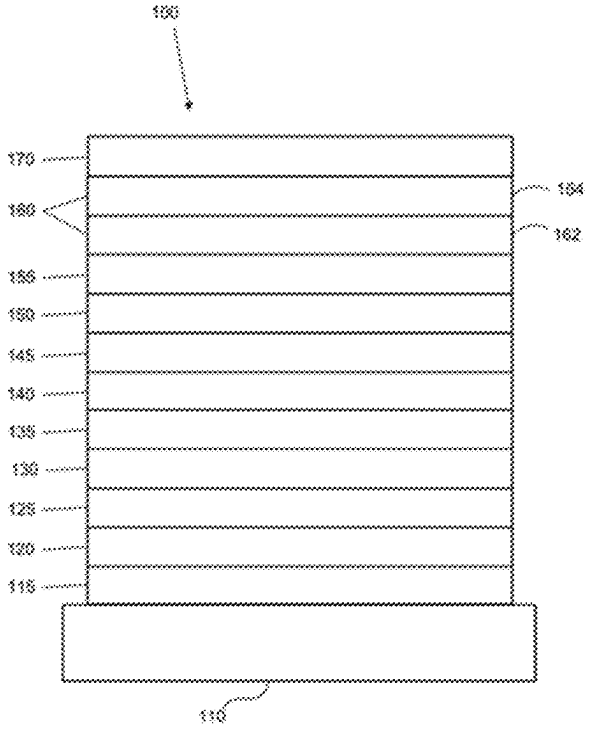
A compound is provided that has a first ligand L_A comprising a structure of Formula I,



where at least one of a moiety B or moiety C has a structure of Formula II,



fused thereto. In Formulas I and II, each of moiety B to moiety D is a monocyclic ring or a polycyclic fused ring system; m is 0, 1, 2, or 3; Z is C or N; K is a direct bond or a linking group; n is 1, 2, or 3; each of R^{α}, R^{β}, R^{A}, R^{B}, R^{C}, R^{D}, and R^{E} is hydrogen or a General Substituent defined herein; and L_A is coordinated to a metal M by the dashed lines in Formula I. Formulations, OLEDs, and consumer products containing the compound are also provided.



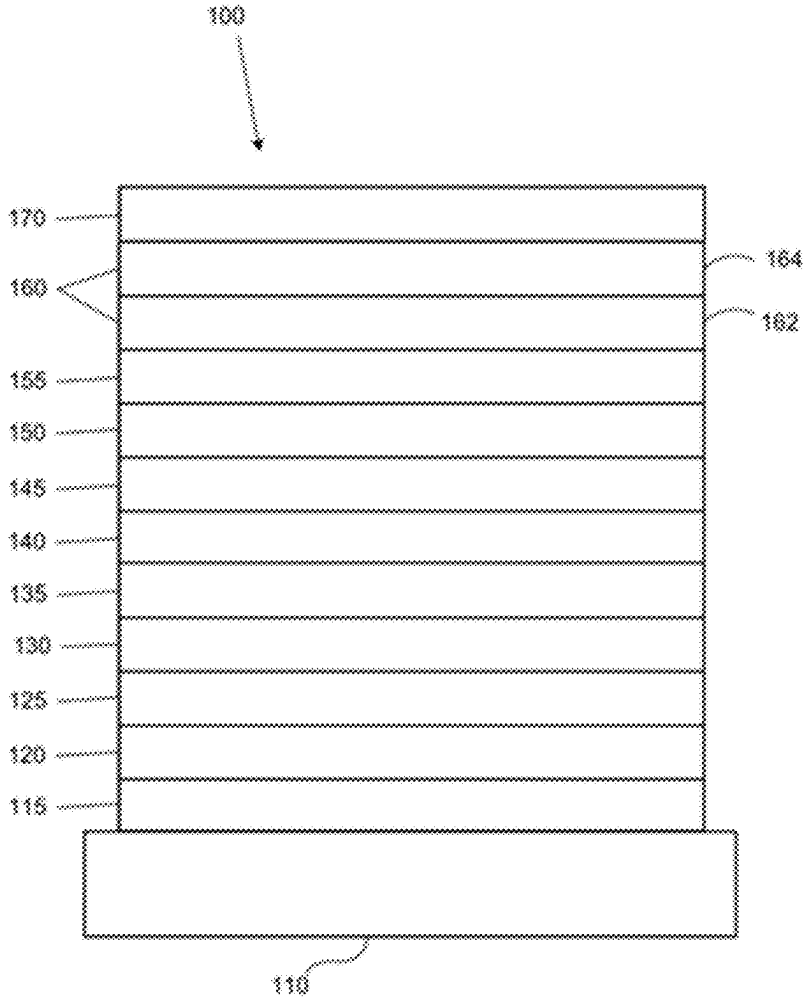

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Fig. 1

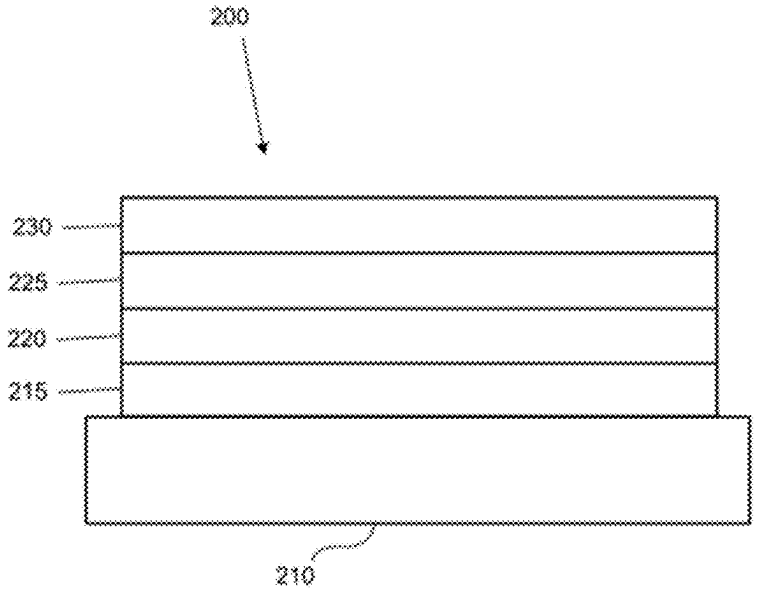
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Fig. 2

ORGANIC ELECTROLUMINESCENT MATERIALS AND DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application No. 63/612,767, filed on Dec. 20, 2023, the entire contents of which are incorporated herein by reference.

FIELD

[0002] The present disclosure generally relates to organic or metal coordination compounds and formulations and their various uses including as emitters, sensitizers, charge transporters, or exciton transporters in devices such as organic light emitting diodes and related electronic devices and consumer products.

BACKGROUND

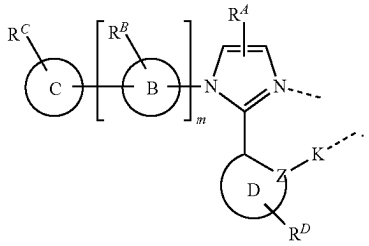
[0003] Opto-electronic devices that make use of organic materials are becoming increasingly desirable for various reasons. Many of the materials used to make such devices are relatively inexpensive, so organic opto-electronic devices have the potential for cost advantages over inorganic devices. In addition, the inherent properties of organic materials, such as their flexibility, may make them well suited for particular applications such as fabrication on a flexible substrate. Examples of organic opto-electronic devices include organic light emitting diodes/devices (OLEDs), organic phototransistors, organic photovoltaic cells, organic scintillators, and organic photodetectors. For OLEDs, the organic materials may have performance advantages over conventional materials.

[0004] OLEDs make use of thin organic films that emit light when voltage is applied across the device. OLEDs are becoming an increasingly interesting technology for use in applications such as flat panel displays, illumination, and backlighting.

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

SUMMARY

[0006] In one aspect, the present disclosure provides a compound having a first ligand L_A comprising a structure of Formula I,



In Formula I:

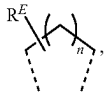
[0007] each of moiety B, moiety C, and moiety D is independently a monocyclic ring or a polycyclic fused ring system, wherein the monocyclic ring or each ring of the polycyclic fused ring system is independently a 5-membered to 10-membered carbocyclic or heterocyclic ring;

[0008] m is 0, 1, 2, or 3;

[0009] Z is C or N;

[0010] K is selected from the group consisting of a direct bond, O, S, $N(R^{\alpha})$, $P(R^{\alpha})$, $B(R^{\alpha})$, $C(R^{\alpha})(R^{\beta})$, and $Si(R^{\alpha})(R^{\beta})$;

[0011] at least one of a moiety B or moiety C has a structure of Formula II,



fused thereto;

[0012] where n is 1, 2, or 3;

[0013] the dashed lines in Formula II indicate a direct bond to two adjacent carbon atoms;

[0014] each of R^A, R^B, R^C, R^D, and R^E independently represents mono to the maximum allowable substitutions, or no substitutions;

[0015] each R^{α}, R^{β}, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, selenyl, and combinations thereof;

[0016] L_A is coordinated to a metal M by the dashed lines in Formula I;

[0017] metal M has an atomic mass of at least 40 and may be coordinated to other ligands;

[0018] L_A may join with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and

[0019] any two substituents may be joined or fused to form a ring.

[0020] In another aspect, the present disclosure provides a formulation comprising a compound having a first ligand L_A as described herein.

[0021] In yet another aspect, the present disclosure provides an OLED having an organic layer comprising a compound having a first ligand L_A as described herein.

[0022] In yet another aspect, the present disclosure provides a consumer product comprising an OLED with an organic layer comprising a compound having a first ligand L_A as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** shows an organic light emitting device.

[0024] FIG. **2** shows an inverted organic light emitting device that does not have a separate electron transport layer.

DETAILED DESCRIPTION

A. Terminology

[0025] Unless otherwise specified, the below terms used herein are defined as follows:

[0026] 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.

[0027] As used herein, "solution processable" means capable of being dissolved, dispersed, or transported in and/or deposited from a liquid medium, either in solution or suspension form.

[0028] 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.

[0029] As used herein, and as would be generally understood by one skilled in the art, a first work function is "greater than" or "higher than" a second work function if the first work function has a higher absolute value. Because work functions are generally measured as negative numbers relative to vacuum level, this means that a "higher" work function is more negative. On a conventional energy level diagram, with the vacuum level at the top, a "higher" work function is illustrated as further away from the vacuum level in the downward direction. Thus, the definitions of HOMO and LUMO energy levels follow a different convention than work functions.

[0030] Layers, materials, regions, and devices may be described herein in reference to the color of light they emit. In general, as used herein, an emissive region that is described as producing a specific color of light may include one or more emissive layers disposed over each other in a stack.

[0031] As used herein, a "NIR", "red", "green", "blue", "yellow" layer, material, region, or device refers to a layer, a material, a region, or a device that emits light in the wavelength range of about 700-1500 nm, 580-700 nm, 500-600 nm, 400-500 nm, 540-600 nm, respectively, or a layer, a material, a region, or a device that has a highest peak in its emission spectrum in the respective wavelength region. In some arrangements, separate regions, layers, materials, or devices may provide separate "deep blue" and "light blue" emissions. As used herein, the "deep blue" emission component refers to an emission having a peak emission wavelength that is at least about 4 nm less than the peak emission wavelength of the "light blue" emission component. Typically, a "light blue" emission component has a peak emission wavelength in the range of about 465-500 nm, and a "deep blue" emission component has a peak emission wavelength in the range of about 400-470 nm, though these ranges may vary for some configurations.

[0032] In some arrangements, a color altering layer that converts, modifies, or shifts the color of the light emitted by another layer to an emission having a different wavelength is provided. Such a color altering layer can be formulated to shift wavelength of the light emitted by the other layer by a defined amount, as measured by the difference in the wavelength of the emitted light and the wavelength of the resulting light. In general, there are two classes of color altering layers: color filters that modify a spectrum by removing light of unwanted wavelengths, and color changing layers that convert photons of higher energy to lower energy. For example, a "red" color filter can be present in order to filter an input light to remove light having a wavelength outside the range of about 580-700 nm. A component "of a color" refers to a component that, when activated or used, produces or otherwise emits light having a particular color as previously described. For example, a "first emissive region of a first color" and a "second emissive region of a second color different than the first color" describes two emissive regions that, when activated within a device, emit two different colors as previously described.

[0033] As used herein, emissive materials, layers, and regions may be distinguished from one another and from other structures based upon light initially generated by the material, layer or region, as opposed to light eventually emitted by the same or a different structure. The initial light generation typically is the result of an energy level change resulting in emission of a photon. For example, an organic emissive material may initially generate blue light, which may be converted by a color filter, quantum dot or other structure to red or green light, such that a complete emissive stack or sub-pixel emits the red or green light. In this case the initial emissive material, region, or layer may be referred to as a "blue" component, even though the sub-pixel is a "red" or "green" component.

[0034] In some cases, it may be preferable to describe the color of a component such as an emissive region, sub-pixel, color altering layer, or the like, in terms of 1931 CIE coordinates. For example, a yellow emissive material may have multiple peak emission wavelengths, one in or near an edge of the "green" region, and one within or near an edge of the "red" region as previously described. Accordingly, as

used herein, each color term also corresponds to a shape in the 1931 CIE coordinate color space. The shape in 1931 CIE color space is constructed by following the locus between two color points and any additional interior points. For example, interior shape parameters for red, green, blue, and yellow may be defined as shown below:

Color	CIE Shape Parameters
Central Red	Locus: [0.6270, 0.3725]; [0.7347, 0.2653]; Interior: [0.5086, 0.2657]
Central Green	Locus: [0.0326, 0.3530]; [0.3731, 0.6245]; Interior: [0.2268, 0.3321
Central Blue	Locus: [0.1746, 0.0052]; [0.0326, 0.3530]; Interior: [0.2268, 0.3321]
Central Yellow	Locus: [0.3731, 0.6245]; [0.6270, 0.3725]; Interior: [0.3700, 0.4087]; [0.2886, 0.4572]

[0035] The terms "halo," "halogen," and "halide" are used interchangeably and refer to fluorine, chlorine, bromine, and iodine.

[0036] The term "acyl" refers to a substituted carbonyl group (—C(O)—R_s).

[0037] The term "ester" refers to a substituted oxycarbonyl (—O—C(O)—R_s or —C(O)—O—R_s) group.

[0038] The term "ether" refers to an —OR, group.

[0039] The terms "sulfanyl" or "thio-ether" are used interchangeably and refer to a —SR, group.

[0040] The term "selenyl" refers to a —SeR_s group.

[0041] The term "sulfinyl" refers to a —S(O)—R_s group.

[0042] The term "sulfonyl" refers to a —SO_2—R_s group.

[0043] The term "phosphino" refers to a group containing at least one phosphorus atom bonded to the relevant structure. Common examples of phosphino groups include, but are not limited to, groups such as a —$P(R_s)_2$ group or a —$PO(R_s)_2$ group, wherein each R_s can be same or different.

[0044] The term "silyl" refers to a group containing at least one silicon atom bonded to the relevant structure. Common examples of silyl groups include, but are not limited to, groups such as a —$Si(R_s)_3$ group, wherein each R_s can be same or different.

[0045] The term "germyl" refers to a group containing at least one germanium atom bonded to the relevant structure. Common examples of germyl groups include, but are not limited to, groups such as a —$Ge(R_s)_3$ group, wherein each R_s can be same or different.

[0046] The term "boryl" refers to a group containing at least one boron atom bonded to the relevant structure. Common examples of boryl groups include, but are not limited to, groups such as a —$B(R_s)_2$ group or its Lewis adduct —$B(R_s)_3$ group, wherein R_s can be same or different.

[0047] In each of the above, R_s can be hydrogen or a substituent selected from the group consisting of the General Substituents as defined in this application. Preferred R_s is selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, and combination thereof. More preferably R_s is selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combination thereof.

[0048] The term "alkyl" refers to and includes both straight and branched chain alkyl groups having an alkyl carbon atom bonded to the relevant structure. Preferred alkyl groups are those containing from one to fifteen carbon atoms, preferably one to nine carbon atoms, and includes methyl, ethyl, propyl, 1-methylethyl, butyl, 1-methylpropyl, 2-methylpropyl, pentyl, 1-methylbutyl, 2-methylbutyl, 3-methylbutyl, 1,1-dimethylpropyl, 1,2-dimethylpropyl, 2,2-dimethylpropyl, and the like. Additionally, the alkyl group can be further substituted.

[0049] The term "cycloalkyl" refers to and includes monocyclic, polycyclic, and spiro alkyl groups having a ring alkyl carbon atom bonded to the relevant structure. Preferred cycloalkyl groups are those containing 3 to 12 ring carbon atoms and includes cyclopropyl, cyclopentyl, cyclohexyl, bicyclo[3.1.1]heptyl, spiro[4.5]decyl, spiro[5.5]undecyl, adamantyl, and the like. Additionally, the cycloalkyl group can be further substituted.

[0050] The terms "heteroalkyl" or "heterocycloalkyl" refer to an alkyl or a cycloalkyl group, respectively, having at least one carbon atom replaced by a heteroatom. Optionally the at least one heteroatom is selected from O, S, N, P, B, Si, Ge and Se, preferably, O, S or N. Additionally, the heteroalkyl or heterocycloalkyl group can be further substituted.

[0051] The term "alkenyl" refers to and includes both straight and branched chain alkene groups. Alkenyl groups are essentially alkyl groups that include at least one carbon-carbon double bond in the alkyl chain with one carbon atom from the carbon-carbon double bond that is bonded to the relevant structure. Cycloalkenyl groups are essentially cycloalkyl groups that include at least one carbon-carbon double bond in the cycloalkyl ring. The term "heteroalkenyl" as used herein refers to an alkenyl group having at least one carbon atom replaced by a heteroatom. Optionally the at least one heteroatom is selected from O, S, N, P, B, Si, Ge, and Se, preferably, O, S, or N. Preferred alkenyl, cycloalkenyl, or heteroalkenyl groups are those containing two to fifteen carbon atoms. Additionally, the alkenyl, cycloalkenyl, or heteroalkenyl group can be further substituted.

[0052] The term "alkynyl" refers to and includes both straight and branched chain alkyne groups. Alkynyl groups are essentially alkyl groups that include at least one carbon-carbon triple bond in the alkyl chain with one carbon atom from the carbon-carbon triple bond that is bonded to the relevant structure. Preferred alkynyl groups are those containing two to fifteen carbon atoms. Additionally, the alkynyl group can be further substituted.

[0053] The terms "aralkyl" or "arylalkyl" are used interchangeably and refer to an aryl-substituted alkyl group having an alkyl carbon atom bonded to the relevant structure. Additionally, the aralkyl group can be further substituted.

[0054] The term "heterocyclic group" refers to and includes aromatic and non-aromatic cyclic groups containing at least one heteroatom. Optionally the at least one heteroatom is selected from O, S, Se, N, P, B, Si, Ge, and Se, preferably, O, S, N, or B. Hetero-aromatic cyclic groups may be used interchangeably with heteroaryl. Preferred hetero-non-aromatic cyclic groups are those containing 3 to 10 ring atoms, preferably those containing 3 to 7 ring atoms, which includes at least one hetero atom, and includes cyclic amines such as morpholino, piperidino, pyrrolidino, and the like, and cyclic ethers/thio-ethers, such as tetrahydrofuran, tetrahydropyran, tetrahydrothiophene, and the like. Additionally, the heterocyclic group can be further substituted or fused.

[0055] The term "aryl" refers to and includes both single-ring and polycyclic aromatic hydrocarbyl groups. The polycyclic rings may have two or more rings in which two carbons are common to two adjoining rings (the rings are "fused"). Preferred aryl groups are those containing six to thirty carbon atoms, preferably six to twenty-four carbon atoms, six to eighteen carbon atoms, and more preferably six to twelve carbon atoms. Especially preferred is an aryl group having six carbons, ten carbons, twelve carbons, fourteen carbons, or eighteen carbons. Suitable aryl groups include phenyl, biphenyl, triphenyl, triphenylene, tetraphenylene, naphthalene, anthracene, phenalene, phenanthrene, pyrene, chrysene, perylene, and azulene, preferably phenyl, biphenyl, triphenyl, triphenylene, and naphthalene. Additionally, the aryl group can be further substituted or fused, such as, without limitation, fluorene.

[0056] The term "heteroaryl" refers to and includes both single-ring aromatic groups and polycyclic aromatic ring systems that include at least one heteroatom. The heteroatoms include, but are not limited to O, S, Se, N, P, B, Si, Ge, and Se. In many instances, O, S, N, or B are the preferred heteroatoms. Hetero-single ring aromatic systems are preferably single rings with 5 or 6 ring atoms, and the ring can have from one to six heteroatoms. The hetero-polycyclic ring systems can have two or more aromatic 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. The hetero-polycyclic aromatic ring systems can have from one to six heteroatoms per ring of the polycyclic aromatic ring system. Preferred heteroaryl groups are those containing three to thirty carbon atoms, preferably three to twenty-four carbon atoms, three to eighteen carbon atoms, and more preferably three to twelve carbon atoms. Suitable heteroaryl groups include 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, benzofuropyridine, furodipyridine, benzothienopyridine, thienodipyridine, benzoselenophenopyridine, selenophenodipyridine, azaborine, borazine, $5\lambda^2,9\lambda^2$-diaza-13b-boranaphtho[2,3,4-de]anthracene, $5\lambda^2$-benzo[d]benzo[4,5]imidazo[3,2-a]imidazole, and 5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene; preferably dibenzothiophene, dibenzofuran, dibenzoselenophene, carbazole, indolocarbazole, imidazole, pyridine, triazine, benzimidazole, $5\lambda^2,9\lambda^2$-diaza-13b-boranaphtho[2,3,4-de]anthracene, $5\lambda^2$-benzo[d]benzo[4,5]imidazo[3,2-a]imidazole, and 5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene. Additionally, the heteroaryl group can be further substituted or fused.

[0057] Of the aryl and heteroaryl groups listed above, the groups of triphenylene, naphthalene, anthracene, dibenzothiophene, dibenzofuran, dibenzoselenophene, carbazole, indolocarbazole, imidazole, pyridine, pyrazine, pyrimidine, triazine, benzimidazole, $5\lambda^1,9\lambda^2$-diaza-13b-boranaphtho[2,3,4-de]anthracene, $5\lambda^2$-benzo[d]benzo[4,5]imidazo[3,2-a]imidazole, 5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene, and the respective aza-analogs of each thereof are of particular interest.

[0058] In many instances, the General Substituents are selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, selenyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

[0059] In some instances, the Preferred General Substituents are selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, heteroalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, aryl, heteroaryl, nitrile, isonitrile, sulfanyl, and combinations thereof.

[0060] In some instances, the More Preferred General Substituents are selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, aryl, heteroaryl, nitrile, sulfanyl, and combinations thereof.

[0061] In some instances, the Even More Preferred General Substituents are selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, silyl, aryl, heteroaryl, nitrile, and combinations thereof.

[0062] In yet other instances, the Most Preferred General Substituents are selected from the group consisting of deuterium, alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0063] The terms "substituted" and "substitution" refer to a substituent other than H that is bonded to the relevant position, e.g., a carbon or nitrogen. For example, when R^1 represents mono-substitution, then one R^1 must be other than H (i.e., a substitution). Similarly, when R^1 represents di-substitution, then two of R^1 must be other than H. Similarly, when R^1 represents zero or no substitution, R^1, for example, can be a hydrogen for all available valencies of ring atoms, as in carbon atoms for benzene and the nitrogen atom in pyrrole, or simply represents nothing for ring atoms with fully filled valencies, e.g., the nitrogen atom in pyridine. The maximum number of substitutions possible in a ring structure will depend on the total number of available valencies in the ring atoms.

[0064] As used herein, "combinations thereof" indicates that one or more members of the applicable list are combined to form a known or chemically stable arrangement that one of ordinary skill in the art can envision from the applicable list. For example, an alkyl and deuterium can be combined to form a partial or fully deuterated alkyl group; a halogen and alkyl can be combined to form a halogenated alkyl substituent; and a halogen, alkyl, and aryl can be combined to form a halogenated arylalkyl. In one instance, the term substitution includes a combination of two to four of the listed groups. In another instance, the term substitution includes a combination of two to three groups. In yet another instance, the term substitution includes a combination of two groups. Preferred combinations of substituent groups are those that contain up to fifty atoms that are not hydrogen or deuterium, or those which include up to forty atoms that are not hydrogen or deuterium, or those that include up to thirty atoms that are not hydrogen or deuterium. In many instances, a preferred combination of substituent groups will include up to twenty atoms that are not hydrogen or deuterium.

[0065] The "aza" designation in the fragments described herein, i.e. aza-dibenzofuran, aza-dibenzothiophene, etc. means that one or more of the C—H groups in the respective aromatic ring 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.

[0066] As used herein, "deuterium" refers to an isotope of hydrogen. Deuterated compounds can be readily prepared using methods known in the art. For example, U.S. Pat. No. 8,557,400, Patent Pub. No. WO 2006/095951, and U.S. Pat. Application Pub. No. US 2011/0037057, which are hereby incorporated by reference in their entireties, describe the making of deuterium-substituted organometallic complexes. Further reference is made to Ming Yan, et al., *Tetrahedron* 2015, 71, 1425-30 and Atzrodt et al., *Angew. Chem. Int. Ed.* (*Reviews*) 2007, 46, 7744-65, which are incorporated by reference in their entireties, describe the deuteration of the methylene hydrogens in benzyl amines and efficient pathways to replace aromatic ring hydrogens with deuterium, respectively.

[0067] As used herein, any specifically listed substituent, such as, without limitation, methyl, phenyl, pyridyl, etc. includes undeuterated, partially deuterated, and fully deuterated versions thereof. Similarly, classes of substituents such as, without limitation, alkyl, aryl, cycloalkyl, heteroaryl, etc. also include undeuterated, partially deuterated, and fully deuterated versions thereof. Unless otherwise specified, atoms in chemical structures without valences fully filled by H or D should be considered to include undeuterated, partially deuterated, and fully deuterated versions thereof. For example, the chemical structure of

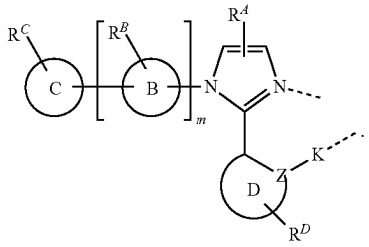
implies to include C_6H_6, C_6D_6, CH_3D_3, and any other partially deuterated variants thereof. Some common basic partially or fully deuterated groups include, without limitation, CD_3, $CD_2C(CH_3)_3$, $C(CD_3)_3$, and C_6D_5.

[0068] It is to be understood that when a molecular fragment is described as being a substituent or otherwise attached to another moiety, its name may be written as if it were a fragment (e.g. phenyl, phenylene, naphthyl, dibenzofuryl) or as if it were the whole molecule (e.g. benzene, naphthalene, dibenzofuran). As used herein, these different ways of designating a substituent or attached fragment are considered to be equivalent.

[0069] In some instances, a pair of substituents in the molecule can be joined or fused into a ring. The preferred ring is a five to nine-membered carbocyclic or heterocyclic ring, includes both instances where the portion of the ring formed by the pair of substituents is saturated and where the portion of the ring formed by the pair of substituents is unsaturated. In yet other instances, a pair of adjacent substituents can be joined or fused into a ring. As used herein, "adjacent" means that the two substituents involved can be on the same ring next to each other, or on two neighboring rings having the two closest available substitutable positions, such as 2,2' positions in a biphenyl, or 1, 8 position in a naphthalene.

B. The Compounds of the Present Disclosure

[0070] In one aspect, the present disclosure provides a compound having a first ligand L_A comprising a structure of Formula I,



In Formula I:

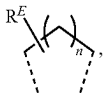
[0071] each of moiety B, moiety C, and moiety D is independently a monocyclic ring or a polycyclic fused ring system, wherein the monocyclic ring or each ring of the polycyclic fused ring system is independently a 5-membered to 10-membered carbocyclic or heterocyclic ring;

[0072] m is 0, 1, 2, or 3;

[0073] Z is C or N;

[0074] K is selected from the group consisting of a direct bond, O, S, $N(R^{\alpha})$, $P(R^{\alpha})$, $B(R^{\alpha})$, $C(R^{\alpha})(R^{\beta})$, and $Si(R^{\alpha})(R^{\beta})$;

[0075] at least one of a moiety B or moiety C has a structure of Formula II,



fused thereto;

[0076] where n is 1, 2, or 3;

[0077] the dashed lines in Formula II indicate a direct bond to two adjacent carbon atoms; each of R^A, R^B, R^C, R^D, and R^E independently represents mono to the maximum allowable substitutions, or no substitutions;

[0078] each R^{α}, R^{β}, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of the General Substituents defined herein;

[0079] L_A is coordinated to a metal M by the dashed lines in Formula I; metal M has an atomic mass of at least 40 and may be coordinated to other ligands;

[0080] L_A can join with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and any two substituents can be joined or fused to form a ring.

[0081] In some embodiments, the first ligand L_A has a structure of Formula I. In some embodiments, the first ligand L_A consists essentially of Formula I.

[0082] In some embodiments, at least one R^A, R^B, R^C, R^D, or R^E is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^A is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^B is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^C is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^D is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^E is a substituent selected from the group consisting of the General Substituents defined herein.

[0083] In some embodiments of Formula I, at least one R^A, R^B, R^C, or R^D is partially or fully deuterated. In some embodiments, at least one R^A is partially or fully deuterated. In some embodiments, at least one R^B is partially or fully deuterated. In some embodiments, at least one R^C is partially or fully deuterated. In some embodiments, at least one R^D is partially or fully deuterated. In some embodiments, at least one R^E is partially or fully deuterated.

[0084] In some embodiments, each of moiety B, moiety C, and moiety D is independently a monocyclic ring or a polycyclic fused ring system, wherein the monocyclic ring or each ring of the polycyclic fused ring system is independently a 5-membered or 6-membered carbocyclic or heterocyclic ring.

[0085] In some embodiments, each of moiety B, moiety C, and moiety D is independently a monocyclic ring or a polycyclic fused ring system, wherein the monocyclic ring or each ring of the polycyclic fused ring system is independently a 5-membered or 6-membered aryl or heteroaryl ring.

[0086] In some embodiments, each R^α, R^β, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of the Preferred General Substituents. In some embodiments, each R^α, R^β, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of the More Preferred General Substituents. In some embodiments, each R^α, R^β, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of the Most Preferred General Substituents.

[0087] In some embodiments, metal M is selected from the group consisting of Ir, Rh, Re, Ru, Os, Pt, Pd, Ag, Au, and Cu. In some embodiments, metal M is Ir. In some embodiments, metal M is Pt or Pd. In some embodiments, metal M is Pt. In some embodiments, metal M is Pd.

[0088] In some embodiments, each of moiety B and moiety C is independently selected from the group consisting of benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, triazole, naphthalene, quinoline, isoquinoline, quinazoline, benzofuran, aza-benzofuran, benzoxazole, aza-benzoxazole, benzothiophene, aza-benzothiophene, benzothiazole, aza-benzothiazole, benzoselenophene, aza-benzoselenophene, indene, aza-indene, indole, aza-indole, benzimidazole, aza-benzimidazole, carbazole, aza-carbazole, dibenzofuran, aza-dibenzofuran, dibenzothiophene, aza-dibenzothiophene, quinoxaline, phthalazine, phenanthrene, aza-phenanathrene, anthracene, aza-anthracene, phenanthridine, fluorene, and aza-fluorene.

[0089] In some embodiments, moiety B is a monocyclic ring. In some embodiments, moiety B is benzene.

[0090] In some embodiments, moiety B is a polycyclic fused ring system. In some embodiments, moiety B is naphthalene. In some embodiments, moiety B comprises at least one 5-membered ring.

[0091] In some embodiments, moiety C is a monocyclic ring. In some embodiments, moiety C is benzene.

[0092] In some embodiments, moiety D is a polycyclic fused ring system. In some embodiments, moiety D is naphthalene. In some embodiments, moiety D comprises at least one 5-membered ring.

[0093] In some embodiments, moiety D is selected from the group consisting of benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, imidazole derived carbene, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, triazole, naphthalene, quinoline, isoquinoline, quinazoline, benzofuran, aza-benzofuran, phenanthro[3,2-b]benzofuran, benzoxazole, aza-benzoxazole, benzothiophene, aza-benzothiophene, benzothiazole, aza-benzothiazole, benzoselenophene, aza-benzoselenophene, indene, aza-indene, indole, aza-indole, benzimidazole, benzimidazole derived carbene, aza-benzimidazole, aza-benzimidazole derived carbene, benzobenzimidazole, aza-benzobenzimidazole, carbazole, aza-carbazole, dibenzofuran, aza-dibenzofuran, dibenzothiophene, aza-dibenzothiophene, quinoxaline, phthalazine, phenanthrene, aza-phenanathrene, anthracene, aza-anthracene, phenanthridine, fluorene, and aza-fluorene. In some embodiments, the aza variant includes one N on a benzo ring. In some embodiments, the aza variant includes one N on a benzo ring and the N is bonded to the metal M.

[0094] In some embodiments, moiety D is a monocyclic ring. In some embodiments, moiety D is selected from the group consisting of benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, imidazole derived carbene, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, and triazole. In some embodiments, moiety D is benzene.

[0095] In some embodiments, moiety D is a polycyclic fused ring system. In some embodiments, moiety D is selected from the group consisting of naphthalene, quinoline, isoquinoline, quinazoline, benzofuran, aza-benzofuran, phenanthro[3,2-b]benzofuran, benzoxazole, aza-benzoxazole, benzothiophene, aza-benzothiophene, benzothiazole, aza-benzothiazole, benzoselenophene, aza-benzoselenophene, indene, aza-indene, indole, aza-indole, benzimidazole, aza-benzimidazole, benzimidazole derived carbene, aza-benzimidazole derived carbene, benzobenzimidazole, aza-benzobenzimidazole, carbazole, aza-carbazole, dibenzofuran, aza-dibenzofuran, dibenzothiophene, aza-dibenzothiophene, quinoxaline, phthalazine, phenanthrene, aza-phenanathrene, anthracene, aza-anthracene, phenanthridine, fluorene, and aza-fluorene. In some embodiments, moiety D is naphthalene or dibenzofuran.

[0096] In some embodiments, moiety D can be a polycyclic fused ring structure. In some embodiments, moiety D can be a polycyclic fused ring structure comprising at least three fused rings. In some embodiments, the polycyclic fused ring structure has two 6-membered rings and one 5-membered ring. In some such embodiments, the 5-membered ring is fused to the ring coordinated to metal M and the second 6-membered ring is fused to the 5-membered ring. In some embodiments, moiety D can be selected from the

group consisting of dibenzofuran, dibenzothiophene, dibenzoselenophene, and aza-variants thereof. In some such embodiments, moiety D can be further substituted at the ortho- or meta-position of the O, S, or Se atom by a substituent selected from the group consisting of deuterium, fluorine, nitrile, alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof. In some such embodiments, the aza-variants contain exactly one N atom at the 6-position (ortho to the O, S, or Se) with a substituent at the 7-position (meta to the O, S, or Se).

[0097] In some embodiments, moiety D can be a polycyclic fused ring structure comprising at least four fused rings. In some embodiments, the polycyclic fused ring structure comprises three 6-membered rings and one 5-membered ring. In some such embodiments, the 5-membered ring is fused to the ring coordinated to metal M, the second 6-membered ring is fused to the 5-membered ring, and the third 6-membered ring is fused to the second 6-membered ring. In some such embodiments, the third 6-membered ring is further substituted by a substituent selected from the group consisting of deuterium, fluorine, nitrile, alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0098] In some embodiments, moiety D can be a polycyclic fused ring structure comprising at least five fused rings. In some embodiments, the polycyclic fused ring structure comprises four 6-membered rings and one 5-membered ring or three 6-membered rings and two 5-membered rings. In some embodiments comprising two 5-membered rings, the 5-membered rings are fused together. In some embodiments comprising two 5-membered rings, the 5-membered rings are separated by at least one 6-membered ring. In some embodiments with one 5-membered ring, the 5-membered ring is fused to the ring coordinated to metal M, the second 6-membered ring is fused to the 5-membered ring, the third 6-membered ring is fused to the second 6-membered ring, and the fourth 6-membered ring is fused to the third-6-membered ring.

[0099] In some embodiments, moiety D can be an aza version of the polycyclic fused rings described above. In some such embodiments, moiety D can contain exactly one aza N atom. In some such embodiments, moiety D can contain exactly two aza N atoms, which can be in one ring, or in two different rings. In some such embodiments, the ring having aza N atom is separated by at least two other rings from the metal M atom. In some such embodiments, the ring having aza N atom is separated by at least three other rings from the metal M atom. In some such embodiments, each of the ortho positions of the aza N atom is substituted.

[0100] In some embodiments, moiety D is fused with a structure of Formula II.

[0101] In some embodiments, m is 0. In some embodiments, m is 1. In some embodiments, m is 2. In some embodiments, m is 3.

[0102] In some embodiments, K is a direct bond.

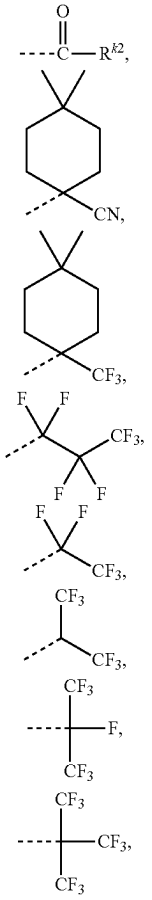
[0103] In some embodiments, K is O or S. In some embodiments, K is 0. In some embodiments, K is S. In some embodiments, K is $N(R^{\alpha})$, $P(R^{\alpha})$, or $B(R^{\alpha})$. In some embodiments, K is $C(R^{\alpha})(R^{\beta})$ or $Si(R^{\alpha})(R^{\beta})$.

[0104] In some embodiments, Z is C. In some embodiments, Z is N.

[0105] In some embodiments, n is 1. In some embodiments, n is 2. In some embodiments, n is 3.

[0106] In some embodiments, the compound comprises an electron-withdrawing group. In some embodiments, the electron-withdrawing group has a Hammett constant larger than 0. In some embodiments, the electron-withdrawing group has a Hammett constant equal or larger than 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, or 1.1.

[0107] In some embodiments, Formula I comprises an electron-withdrawing group selected from the group consisting of the following EWG1 LIST: F, CF_3, CN, $COCH_3$, CHO, $COCF_3$, COOMe, $COOCF_3$, NO_2, SF_3, SiF_3, PF_4, SF_5, OCF_3, SCF_3, $SeCF_3$, $SOCF_3$, $SeOCF_3$, SO_2F, SO_2CF_3, SeO_2CF_3, $OSeO_2CF_3$, OCN, SCN, SeCN, NC, $^{+}N(R^{k2})_3$, $(R^{k2})_2CCN$, $(R^{k2})_2CCF_3$, $CNC(CF_3)_2$, $BR^{k3}R^{k2}$, substituted or unsubstituted dibenzoborole, 1-substituted carbazole, 1,9-substituted carbazole, substituted or unsubstituted carbazole, substituted or unsubstituted pyridine, substituted or unsubstituted pyrimidine, substituted or unsubstituted pyrazine, substituted or unsubstituted pyridoxine, substituted or unsubstituted triazine, substituted or unsubstituted oxazole, substituted or unsubstituted benzoxazole, substituted or unsubstituted thiazole, substituted or unsubstituted benzothiazole, substituted or unsubstituted imidazole, substituted or unsubstituted benzimidazole, ketone, carboxylic acid, ester, nitrile, isonitrile, sulfinyl, sulfonyl, partially and fully fluorinated alkyl, partially and fully fluorinated aryl, partially and fully fluorinated heteroaryl, cyano-containing alkyl, cyano-containing aryl, cyano-containing heteroaryl, isocyanate,



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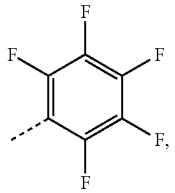

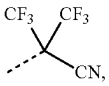

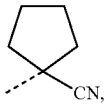

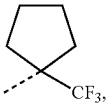

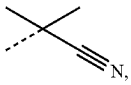

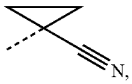

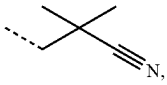

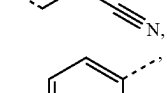

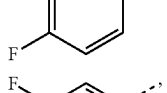

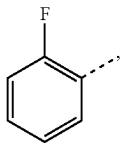

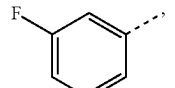

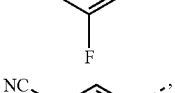

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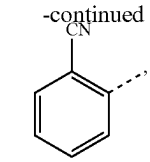

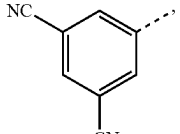

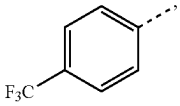

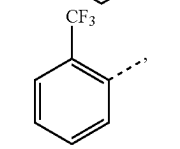

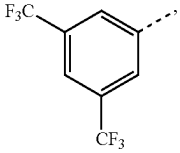

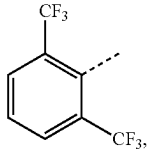

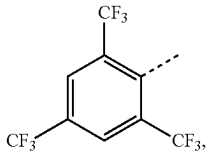

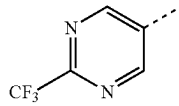

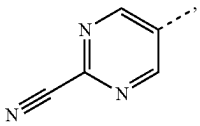

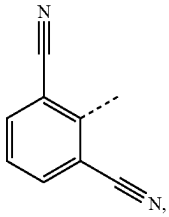

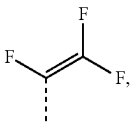

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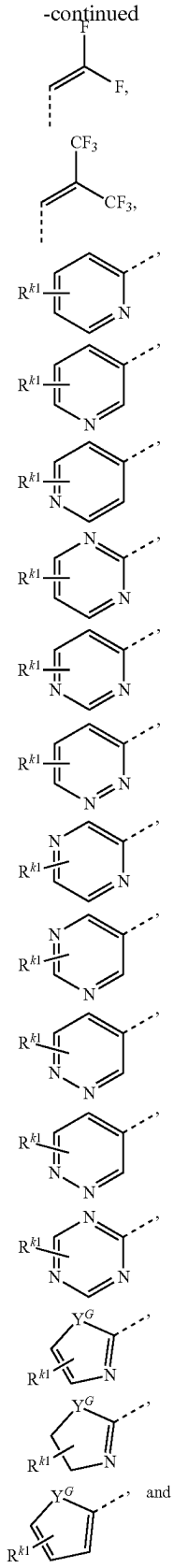

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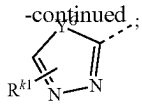


[0108] wherein each R^{k1} represents mono to the maximum allowable substitution, or no substitutions;

[0109] wherein Y^G is selected from the group consisting of BR_e, NR_e, PR_e, O, S, Se, C═O, S═O, SO_2, CR_eR_f, SiR_eR_f, and GeR_eR_f; and

[0110] wherein each of R^{k1}, R^{k2}, R^{k3}, R_e, and R_f is independently a hydrogen or a substituent selected from the group consisting of the General Substituents defined herein.

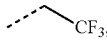
[0111] In some embodiments, Formula I comprises an electron-withdrawing group selected from the group consisting of the structures of the following EWG2 List:

E1

E2

E3

E4



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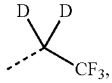

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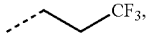

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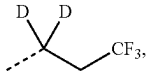

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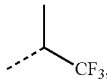

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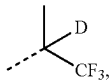

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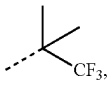

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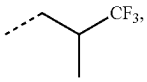

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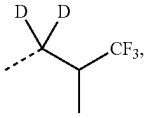

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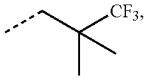

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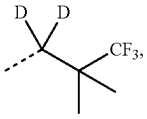

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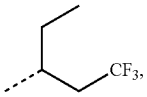

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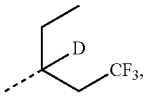

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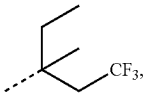

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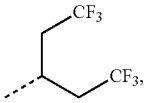

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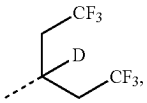

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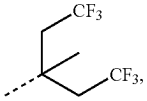

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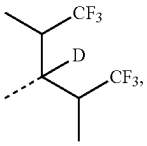

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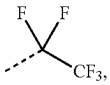

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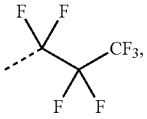

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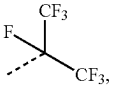

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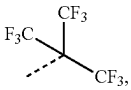

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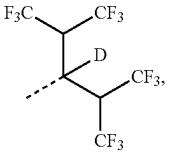

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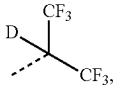

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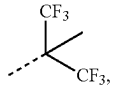

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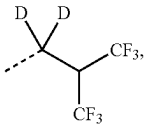

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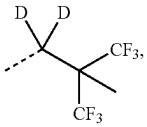

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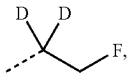

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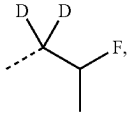

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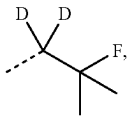

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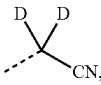

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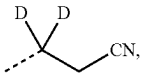

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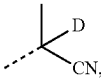

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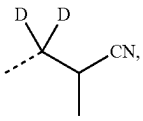

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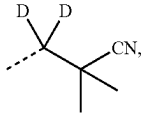

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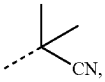

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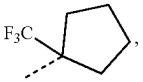

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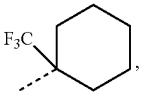

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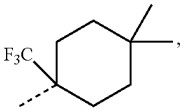

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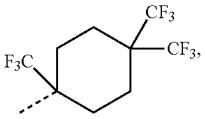

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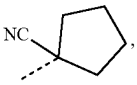

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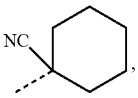

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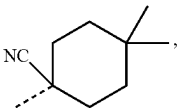

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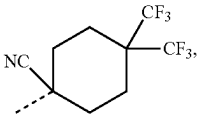

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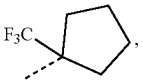

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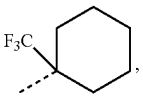

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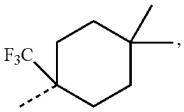

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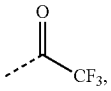

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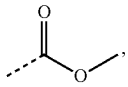

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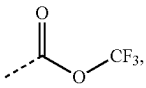

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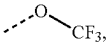

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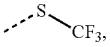

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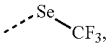

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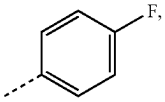

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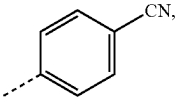

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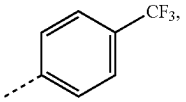

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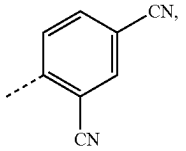

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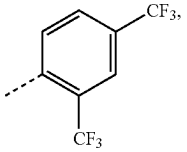

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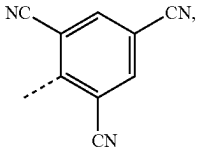

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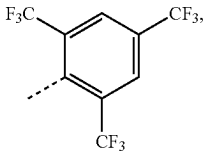

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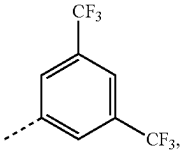

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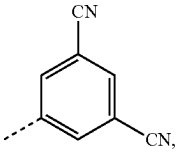

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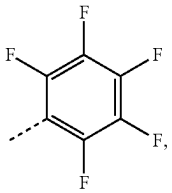

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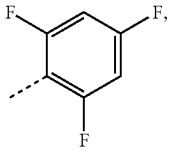

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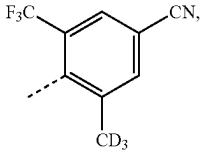

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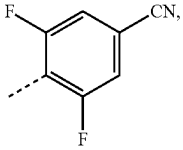

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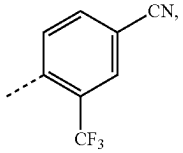

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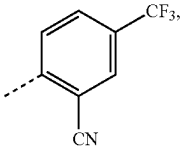

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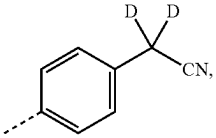

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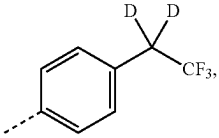

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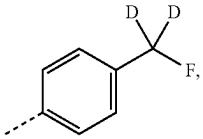

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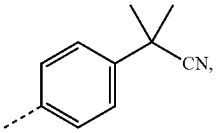

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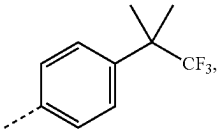

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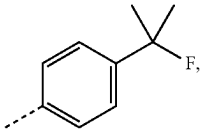

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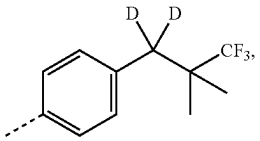

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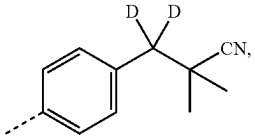

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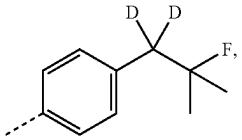

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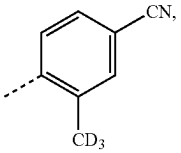

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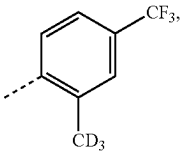

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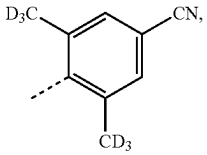

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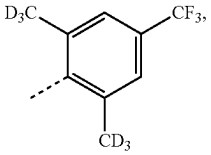

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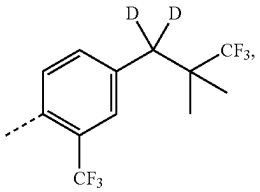

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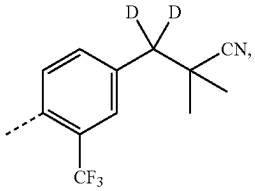

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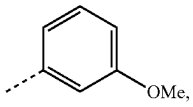

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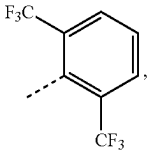

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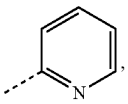

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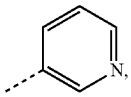

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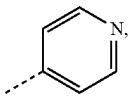

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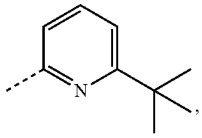

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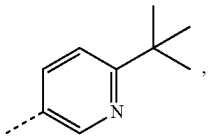

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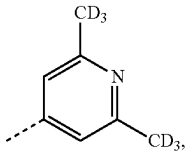

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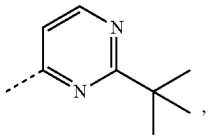

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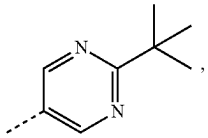

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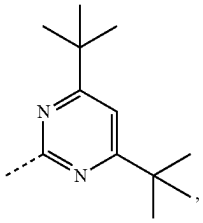

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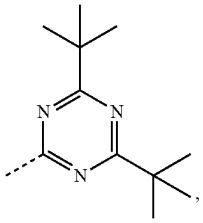

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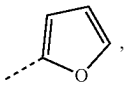

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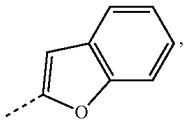

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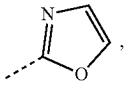

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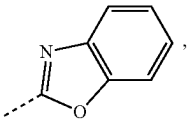

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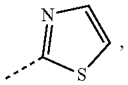

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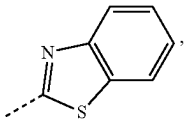

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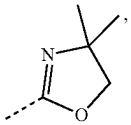

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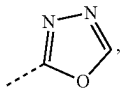

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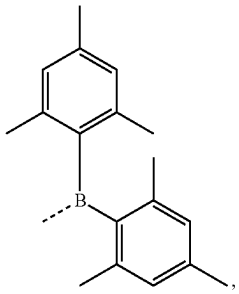

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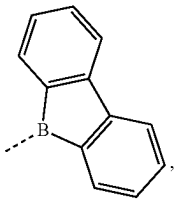

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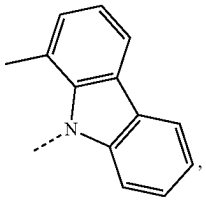

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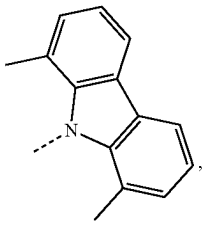

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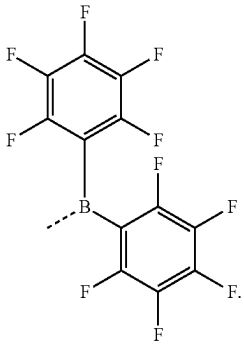

[0112] In some embodiments, Formula I comprises an electron-withdrawing group selected from the group consisting of the structures of the following EWG3 LIST:

E1

E2

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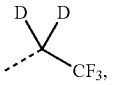
E3

E5



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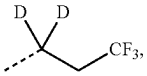

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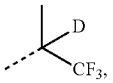

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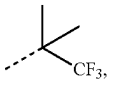

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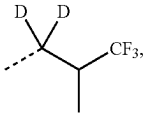

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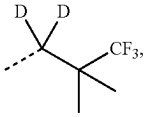

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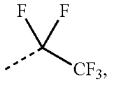

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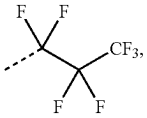

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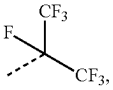

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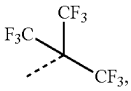

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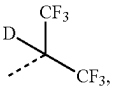

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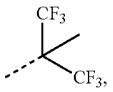

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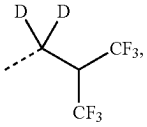

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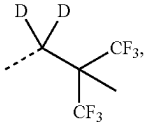

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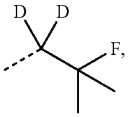

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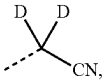

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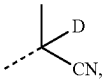

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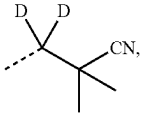

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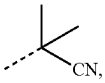

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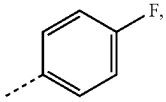

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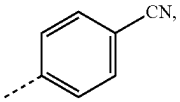

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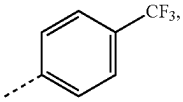

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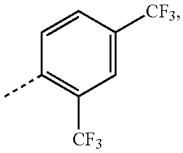

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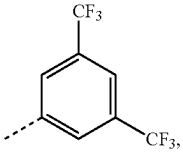

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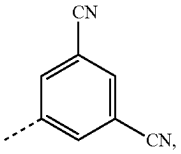

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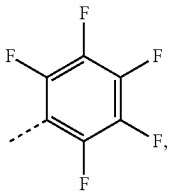

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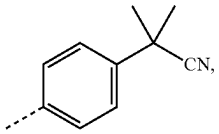

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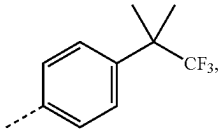

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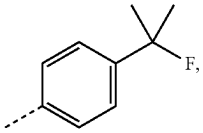

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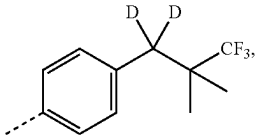

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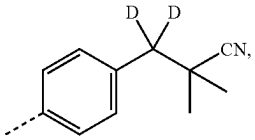

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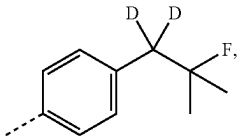

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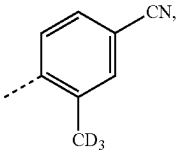

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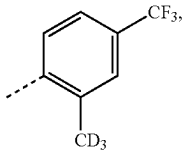

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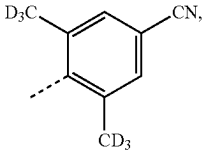

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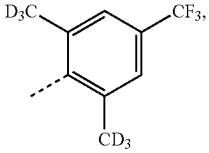

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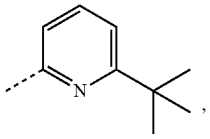

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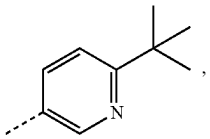

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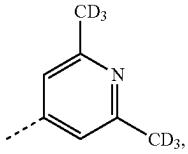

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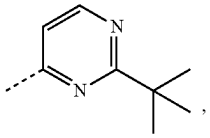

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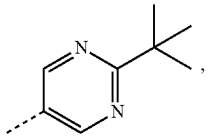

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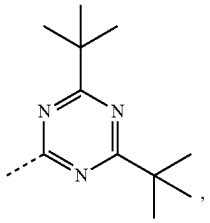

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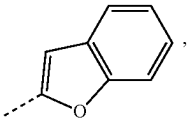

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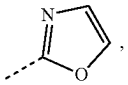

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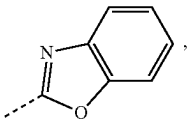

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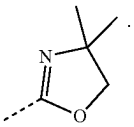
E119



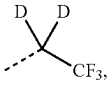
[0113] In some embodiments, Formula I comprises an electron-withdrawing group selected from the group consisting of the structures of the following EWG4 LIST:

E1

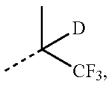
E2

E3

E5



E9



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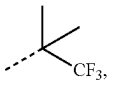

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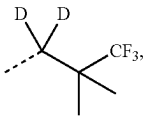

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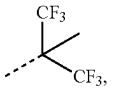

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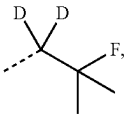

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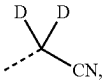

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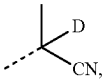

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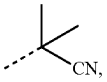

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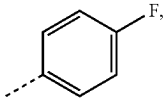

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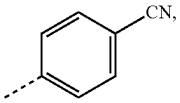

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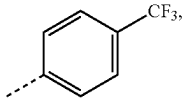

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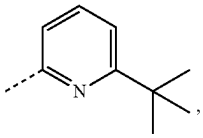

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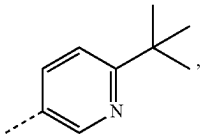

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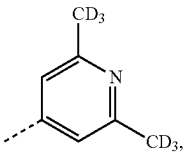

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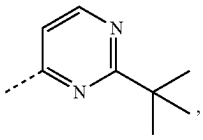

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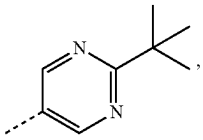

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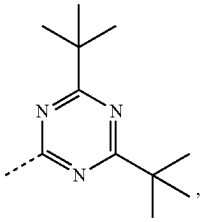

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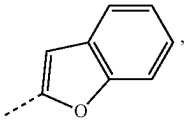

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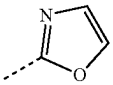

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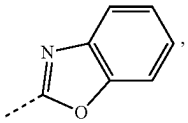

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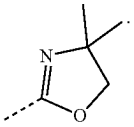
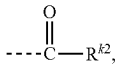
E119



[0114] In some embodiments, Formula I comprises an electron-withdrawing group that is a π-electron deficient electron-withdrawing group. In some embodiments, the π-electron deficient electron-withdrawing group is selected from the group consisting of the structures of the following Pi-EWG LIST: CN, $COCH_3$, CHO, $COCF_3$, COOMe, $COOCF_3$, NO_2, SF_3, SiF_3, PF_4, SF_5, OCF_3, SCF_3, $SeCF_3$, $SOCF_3$, $SeOCF_3$, SO_2F, SO_2CF_3, SeO_2CF_3, $OSeO_2CF_3$, OCN, SCN, SeCN, NC, $^+N(R^{k2})_3$, $BR^{k2}R^{k3}$, substituted or unsubstituted dibenzoborole, 1-substituted carbazole, 1,9-substituted carbazole, substituted or unsubstituted carbazole, substituted or unsubstituted pyridine, substituted or unsubstituted pyrimidine, substituted or unsubstituted pyrazine, substituted or unsubstituted pyridazine, substituted or unsubstituted triazine, substituted or unsubstituted oxazole, substituted or unsubstituted benzoxazole, substituted or unsubstituted thiazole, substituted or unsubstituted benzothiazole, substituted or unsubstituted imidazole, substituted or unsubstituted benzimidazole, ketone, carboxylic acid, ester, nitrile, isonitrile, sulfinyl, sulfonyl, partially and fully fluorinated aryl, partially and fully fluorinated heteroaryl, cyano-containing aryl, cyano-containing heteroaryl, isocyanate,



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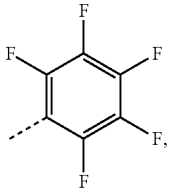

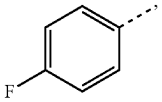

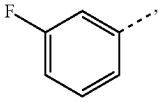

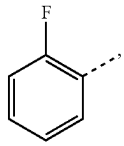

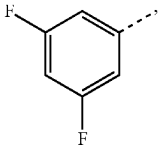

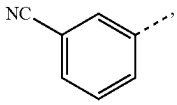

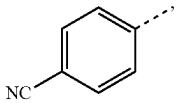

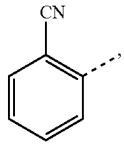

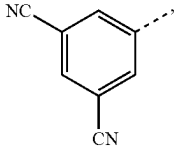

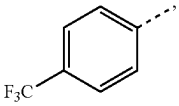

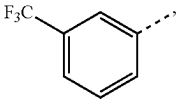

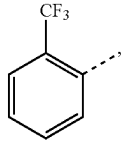

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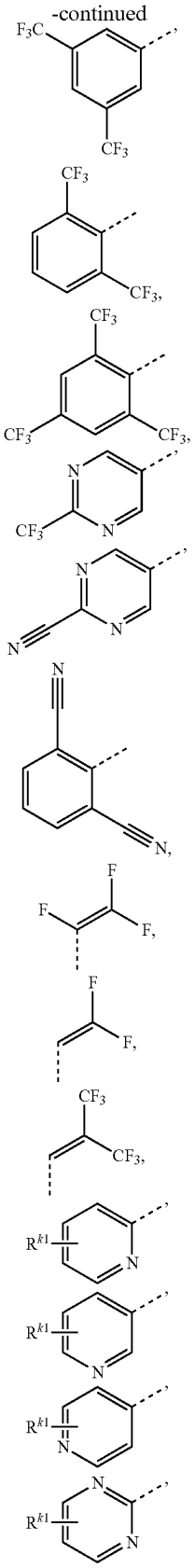

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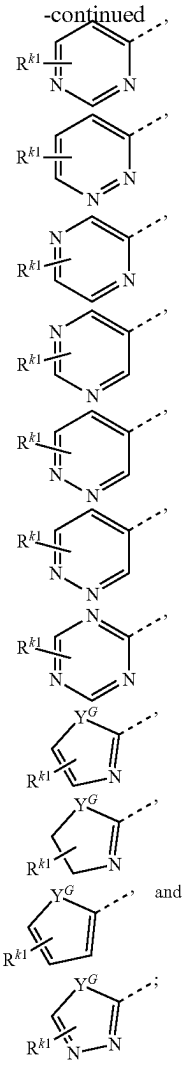


wherein the variables are the same as previously defined.

[0115] In some embodiments, the compound comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, the compound comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, the compound comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, the compound comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, the compound comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0116] In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some

embodiments, at least one R^A is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0117] In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0118] In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0119] In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0120] In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0121] In some embodiments, at least one R^A is not hydrogen. In some embodiments, at least one R^A comprises at least one C atom. In some embodiments, at least one R^A comprises at least two C atoms. In some embodiments, at least one R^A comprises at least three C atoms. In some embodiments, at least one R^A comprises at least four C atoms.

[0122] In some embodiments, at least one R^A comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0123] In some embodiments, two R^A are joined or fused to form a ring A1. In some embodiments, ring A1 is benzene. In some embodiments, ring A1 is selected from the group consisting of benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, imidazole derived carbene, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, triazole, naphthalene, quinoline, isoquinoline, quinazoline, benzofuran, aza-benzofuran, benzoxazole, aza-benzoxazole, benzothiophene, aza-benzothiophene, benzothiazole, aza-benzothiazole, benzoselenophene, aza-benzoselenophene, indene, aza-indene, indole, aza-indole, benzimidazole, benzimidazole derived carbene, aza-benzimidazole, aza-benzimidazole derived carbene, carbazole, aza-carbazole, dibenzofuran, aza-dibenzofuran, dibenzothiophene, aza-dibenzothiophene, quinoxaline, phthalazine, phenanthrene, aza-phenanathrene, anthracene, aza-anthracene, phenanthridine, fluorene, and aza-fluorene. In some embodiments, two R^A are joined or fused to form naphthalene or aza-naphthalene.

[0124] In some embodiments, ring A1 is bonded to another bidentate ligand. In some embodiments, ring A1 is bonded to another bidentate ligand by a direct bond. In some such embodiments, the other ligand is a substituted or unsubstituted phenylpyridine. In some embodiments, the combination of the first ligand L_A and the other bidentate ligand forms a square-planartetradentate ligand.

[0125] In some embodiments, at least one R^B is not hydrogen. In some embodiments, at least one R^B comprises at least one C atom. In some embodiments, at least one R^B comprises at least two C atoms. In some embodiments, at least one R^B comprises at least three C atoms. In some embodiments, at least one R^B comprises at least four C atoms.

[0126] In some embodiments, at least one R^B comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0127] In some embodiments, an R^B bonded to an atom adjacent to the bond with ring A comprises at least one C atom. In some embodiments, each atom adjacent to the bond with ring A comprises at least one C atom. In some embodiments, each atom adjacent to the bond with ring A comprises aryl. In some embodiments, each atom adjacent to the bond with ring A comprises substituted or unsubstituted phenyl.

[0128] In some embodiments, moiety C is bonded to an atom adjacent to the bond with ring A.

[0129] In some embodiments, moiety B is a 6-membered ring, and moiety C is bonded to an atom para to the bond with ring A.

[0130] In some embodiments, moiety B has a structure of Formula II fused thereto. In some such embodiments, the structure of Formula II is not fused to either atom adjacent to the bond with ring A.

[0131] In some embodiments, at least one R^C is not hydrogen.

[0132] In some embodiments, at least one R^C comprises at least one C atom. In some embodiments, at least one R^C comprises at least two C atoms. In some embodiments, at least one R^C comprises at least three C atoms. In some embodiments, at least one R^C comprises at least four C atoms.

[0133] In some embodiments, at least one R^C comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0134] In some embodiments, an R^C bonded to an atom adjacent to the bond with moiety B comprises at least one C atom. In some embodiments, the R^C bonded to each atom adjacent to the bond with moiety B comprises at least one C atom. In some embodiments, the R^C bonded to each atom adjacent to the bond with moiety B comprises aryl. In some

embodiments, the R^C bonded to each atom adjacent to the bond with moiety B comprises a substituted or unsubstituted phenyl.

[0135] In some embodiments, moiety C has a structure of Formula II fused thereto.

[0136] In some embodiments, at least one R^D is not hydrogen.

[0137] In some embodiments, at least one R^D comprises at least one C atom. In some embodiments, at least one R^D comprises at least two C atoms. In some embodiments, at least one R^D comprises at least three C atoms. In some embodiments, at least one R^D comprises at least four C atoms.

[0138] In some embodiments, at least one R^D comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0139] In some embodiments, at least one R^E is not hydrogen.

[0140] In some embodiments, at least one R^E comprises at least one C atom. In some embodiments, at least one R^E comprises at least two C atoms. In some embodiments, at least one R^E comprises at least three C atoms. In some embodiments, at least one R^E comprises at least four C atoms.

[0141] In some embodiments, at least one R^E comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0142] In some embodiments, at least two R^E independently comprise a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

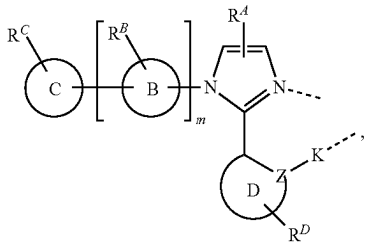
[0143] In some embodiments, if two R^E are attached to the same carbon are the same. In some embodiments, two R^E are attached to the same carbon and are the same.

[0144] In some embodiments, if two R^E are attached to the same carbon are different. In some embodiments, two R^E are attached to the same carbon and are different.

[0145] In some embodiments, two R^E bonded to adjacent carbons are joined or fused to form a ring. In some embodiments, two R^E bonded to adjacent carbons are joined or fused to form a saturated ring.

[0146] In some embodiments, two R^E bonded to the same carbon are joined to form a spiro ring.

[0147] In some embodiments, the first ligand L_A comprises a structure of Formula IA,



wherein each of X^1 to X^5 is independently C or N.

[0148] In some embodiments of Formula IA, each of X^1 to X^5 is C.

[0149] In some embodiments of Formula IA, at least one of X^1 to X^5 is C. In some embodiments of Formula IA, exactly one of X^1 to X^5 is C.

[0150] In some embodiments of Formula IA, the structure of Formula II is bonded to X^2 and X^3.

[0151] In some embodiments of Formula IA, the structure of Formula II is bonded to X^3 and X^4.

[0152] In some embodiments of Formula IA, moiety C is bonded to X. In some embodiments of Formula IA, moiety C is bonded to X^2. In some embodiments of Formula IA, moiety C is bonded to X^3.

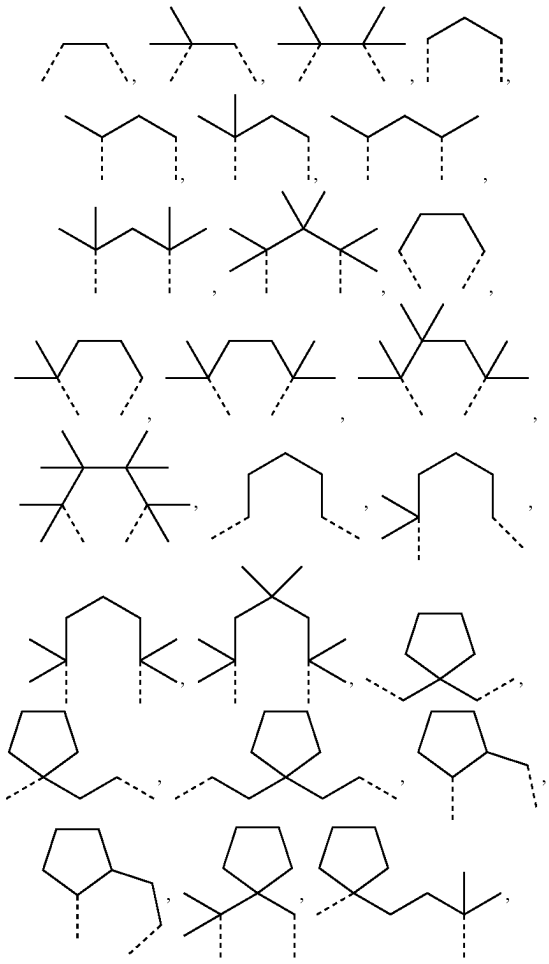
[0153] In some embodiments of Formula IA, R^B bonded to X^5 is an aromatic ring with a structure of Formula II fused thereto, and moiety C is bonded to one of X^1 to X^4.

[0154] In some embodiments of Formula IA, R^B bonded to X^5 is identical to the combination of moiety C and R^C. In some such embodiments, the combination of moiety C and R^C is bonded to XV.

[0155] In some embodiments of Formula IA, moiety D is fused with a structure of Formula II.

[0156] In some embodiments, moiety C is a 6-membered aromatic ring. In some embodiments, moiety C is phenyl. In some embodiments, moiety C is pyridine.

[0157] In some embodiments, the Formula II is selected from the structures of the following LIST 1:



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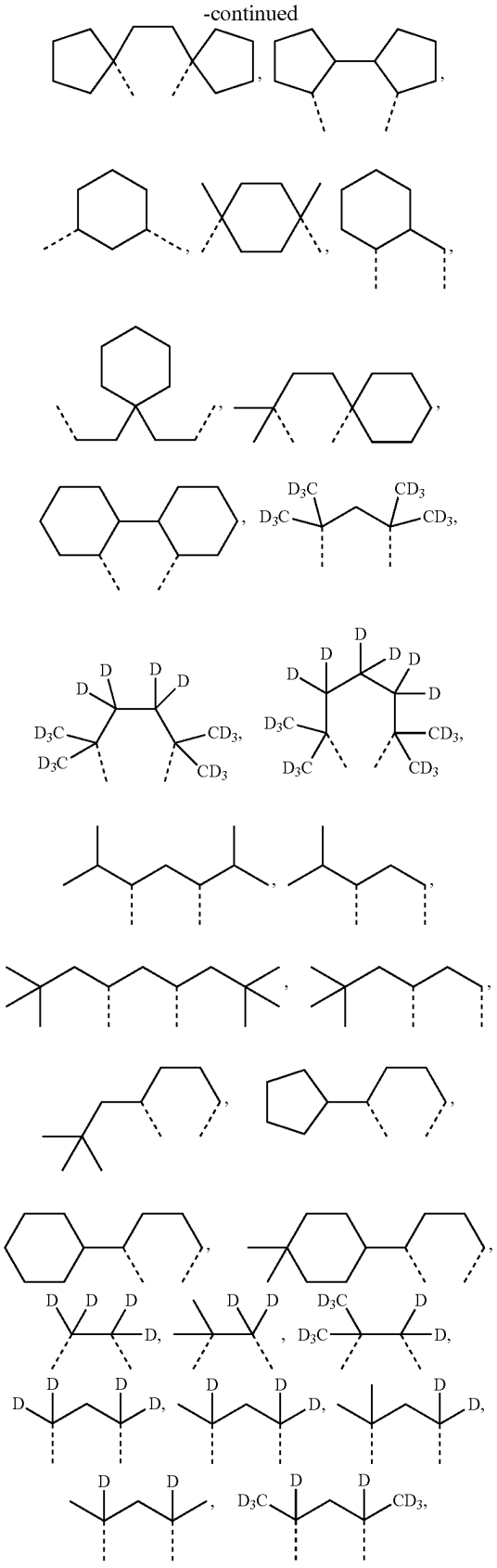

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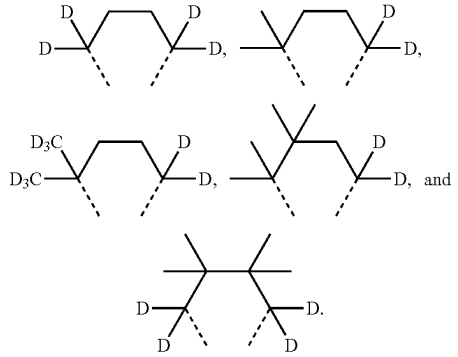
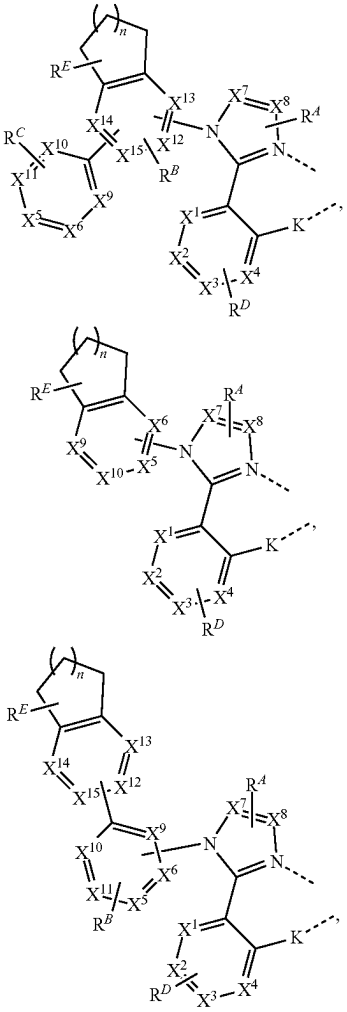


[0158] In some embodiments wherein Formula II is selected from the structures of LIST 1, each structure may be partially or fully deuterated.

[0159] In some embodiments, the ligand L_A is Selected from the group consisting of the structures of the following LIST 2:



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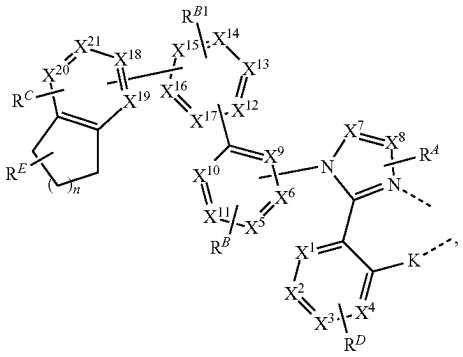

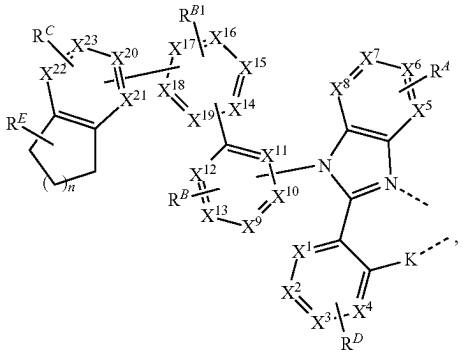

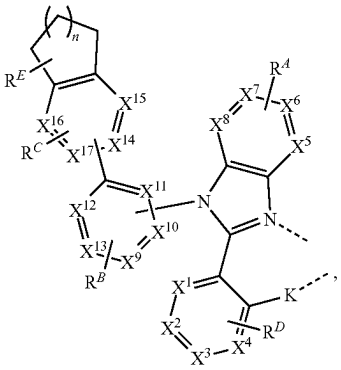

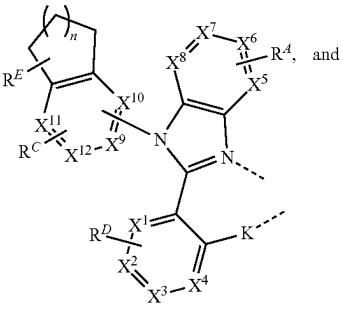

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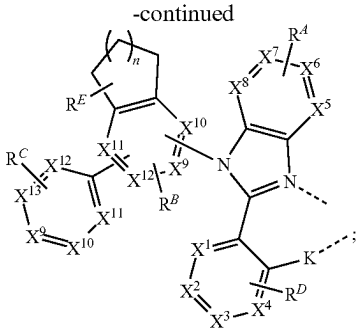


[0160] wherein

[0161] each of X^1 to X^{23} is independently C or N;

[0162] R^{B1} independently represents mono to the maximum allowable substitutions, or no substitutions;

[0163] each R^{B1} is independently hydrogen or a substituent selected from the group consisting of the General Substituents defined herein; and any two substituents may be joined or fused to form a ring, or with other ligand to form a multidentate ligand.

[0164] In some embodiments where ligand L_A is selected from LIST 2, both X^5 and X^6 of the fused benzene ring of the benzimidazole in a structure are carbon, and two R^A attached thereto respectively are fused to form a ring. Similarly, in some embodiments, both X^6 and X^7 of the fused benzene ring of the benzimidazole in a structure are carbon, and two R^A attached thereto respectively are fused to form a ring. Likewise, in some embodiments, both X^7 and X^8 of the fused benzene ring of the benzimidazole in a structure are carbon, and two R^A attached thereto respectively are fused to form a ring. In some such embodiments, the fused ring may be benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, or triazole. In some such embodiments, the fused ring may be benzene.

[0165] In some embodiments where ligand L_A is selected from LIST 2, at least one R^A, R^B, R^{B1}, R^C, R^D or R^E is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^A is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^B is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^{B1} is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^C is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^D is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^E is a substituent selected from the group consisting of the General Substituents defined herein.

[0166] In some embodiments where ligand L_A is selected from LIST 2, at least one of R^A, R^B, R^{B1}, R^C, R^D or R^E is partially or fully deuterated. In some embodiments, at least one R^A is partially or fully deuterated. In some embodiments, at least one R^B is partially or fully deuterated. In some embodiments, at least one R^{B1} is partially or fully deuterated. In some embodiments, at least one R^C is partially or fully deuterated. In some embodiments, at least one R^D is

partially or fully deuterated. In some embodiments, at least one R^E is partially or fully deuterated.

[0167] In some embodiments where ligand L_A is selected from LIST 2, at least one R^A is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0168] In some embodiments where ligand L_A is selected from LIST 2, at least one R^B is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0169] In some embodiments where ligand L_A is selected from LIST 2, at least one R^{B1} is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^{B1} is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^{B1} is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^{B1} is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^{B1} is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0170] In some embodiments where ligand L_A is selected from LIST 2, at least one R^C is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0171] In some embodiments where ligand L_A is selected from LIST 2, at least one R^D is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0172] In some embodiments where ligand L_A is selected from LIST 2, at least one R^E is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0173] In some embodiments where ligand L_A is selected from LIST 2, K is a direct bond.

[0174] In some embodiments where ligand L_A is selected from LIST 2, at least two of R^A are joined to form a ring. In some embodiments at least two of R^A are joined to form a 5-10 membered ring. In some embodiments at least two of R^A are joined to form an aromatic or heteroaromatic ring. In some embodiments two of R^A are joined to form a 6-membered aromatic or heteroaromatic ring. In some embodiments, two of R^A are joined to form a benzene ring. In some embodiments, two R^A are joined or fused to form naphthalene or aza-naphthalene. In some embodiments at least two of R^A are joined to form a 6-membered aromatic or heteroaromatic ring fused to X^7 and X^8.

[0175] In some embodiments where ligand L_A is selected from LIST 2, at least two of R^D are joined to form a ring. In some embodiments at least two of R^D are joined to form a 5-10 membered ring. In some embodiments at least two of R^D are joined to form a polycyclic fused ring system, F, comprising the ring containing X^1-X^4.

[0176] In some embodiments, the fused ring(s) of the polycyclic fused ring system, F', are fused to X^1 and X^2. In some embodiments X^1 is bound to a heteroatom comprised within a heterocyclic ring. In some embodiments X^1 is bound to an O, S, or N atom comprised within a heterocyclic ring. In some embodiments X^1 is bound to the O comprised within a dibenzofuran moiety.

[0177] In some embodiments, the fused ring system of the moiety F' comprises at least two 6-membered rings. In some embodiments, where the fused ring system of the moiety F' comprises at least two 6-membered rings, the fused ring system comprises at least two rings selected from the group consisting of benzene, pyridine, pyrimidine, pyrazine, dihydropyridine, oxazine, thiazine, azaborinine. In some embodiments, the at least two 6-membered rings are fused together.

[0178] In some embodiments, the fused ring system of the moiety F' comprises two or more 5-10 membered carbocyclic or heterocyclic rings. In some embodiments, the fused ring system of the moiety F' comprises at least one 7-10 membered carbocyclic or heterocyclic ring.

[0179] In some embodiments, the fused ring system of the moiety F' comprises at least one ring that is fully or partially saturated.

[0180] In some embodiments, the fused ring system of the moiety F' comprises at least one 5-membered ring. Where the fused ring system of the moiety F' comprises at least one 5-membered ring, the fused ring system comprises at least one ring selected from the group consisting of furan, thiophene, pyrrole, oxazole, thiazole, oxadiazole, triazole, imidazole.

[0181] In some embodiments of the OLED, the fused ring system of the moiety F' comprises a group consisting of phenanthridine imidazole, diazaborinine, substituted or

unsubstituted dibenzothiophene, substituted or unsubstituted dibenzoselenophene, substituted or unsubstituted carbazole, substituted dibenzofuran, azaphenanthridine imidazole, substituted or unsubstituted azadibenzothiophene, substituted or unsubstituted azadibenzoselenophene, substituted or unsubstituted azacarbazole, substituted or unsubstituted azadibenzofuran, substituted or unsubstituted benzothiophene, substituted or unsubstituted benzoselenophene, substituted or unsubstituted indole, substituted or unsubstituted benzofuran, substituted or unsubstituted benzimidazole, substituted or unsubstituted benzoxazole, substituted or unsubstituted benzothiazole, substituted or unsubstituted benzoxadiazole, substituted or unsubstituted benzothiadiazole, and a group comprising 4 or more fused rings.

[0182] In some embodiments, the fused ring system of the moiety F' can be further substituted with nitrile, aryl, or heteroaryl.

[0183] In some embodiments, the moiety F' is not dibenzofuran. In some embodiments, the at least one moiety F does not comprise a carbazole.

[0184] In some embodiments, the first ligand L_A comprises at least 4 carbocyclic or heterocyclic rings. In some embodiments, the first ligand L_A comprises at least 5 carbocyclic or heterocyclic rings. In some embodiments, the first ligand L_A comprises at least 6 carbocyclic or heterocyclic rings. In some embodiments, the first ligand L_A comprises at least 7 or more carbocyclic or heterocyclic rings.

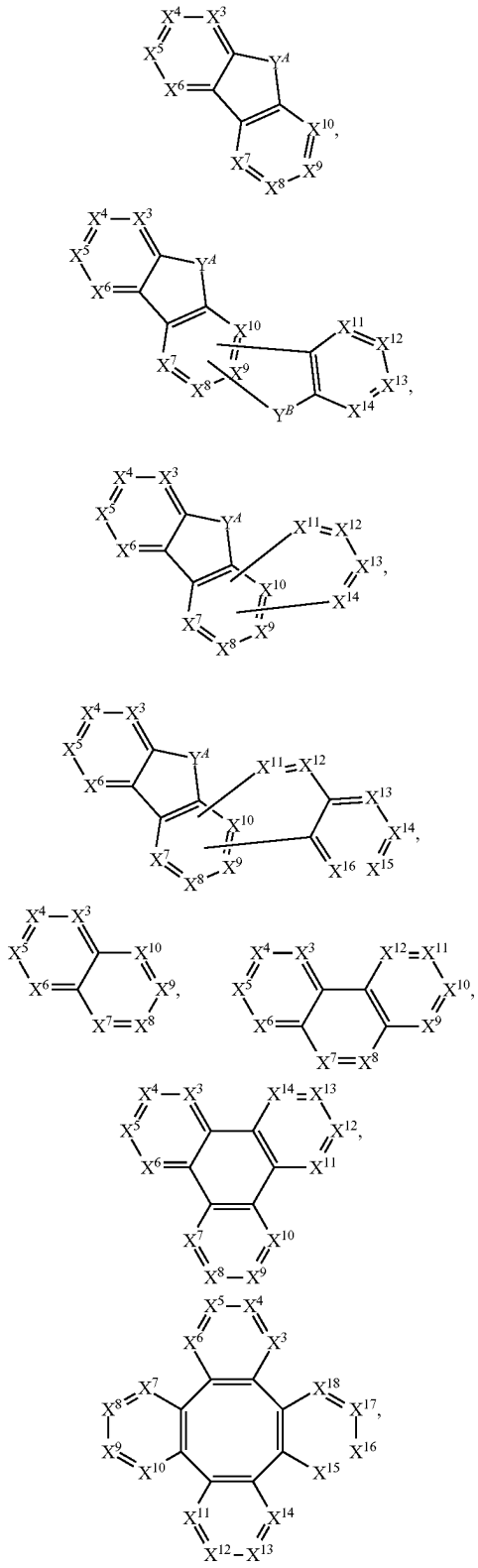
[0185] In some embodiments, the at least one moiety F' comprises a fused ring structure of at least 3 rings.

[0186] In some embodiments, the fused ring system of the moiety F' is substituted with a substituted or unsubstituted aryl or heteroaryl group, boryl, nitrile, isonitrile, acetylide, allyl, and combinations thereof.

[0187] In some embodiments, the fused ring system of the moiety F' is substituted with an electron withdrawing substituent.

[0188] In some embodiments, the fused ring system of the moiety F' is substituted with a moiety comprising at least one group selected from the group consisting of F, CF_3, CN, $COCH_3$, CHO, $COCF_3$, COOMe, $COOCF_3$, NO_2, SF_3, SiF_3, PF_4, SF_5, OCF_3, SCF_3, $SeCF_3$, $SOCF_3$, $SeOCF_3$, SO_2F, SO_2CF_3, SeO_2CF_3, $OSeO_2CF_3$, OCN, SCN, SeCN, NC, $^+N(R)_3$, $(R)_2CCN$, $(R)_2CCF_3$, $CNC(CF_3)_2$, C(O)R, BR_2, BR_3, partially and fully fluorinated alkyl, partially and fully fluorinated cycloalkyl, partially and fully fluorinated aryl, heteroaryl, partially and fully fluorinated heteroaryl, cyano-containing alkyl, cyano-containing cycloalkyl, cyano-containing aryl, cyano-containing heteroaryl, carbazole, 1-substituted carbazole, and 1,8-disubstituted carbazole; where each R is independently a hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, boryl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, selenyl, and combinations thereof.

[0189] In some embodiments, the moiety F' is selected from the group consisting of:



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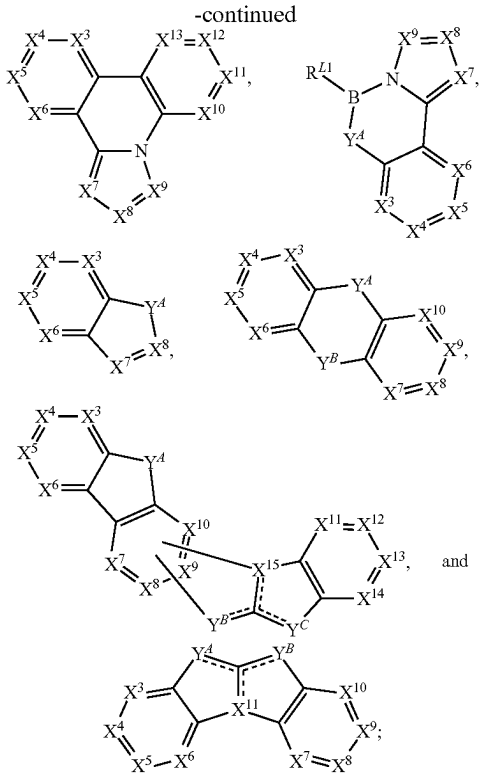


[0190] wherein:

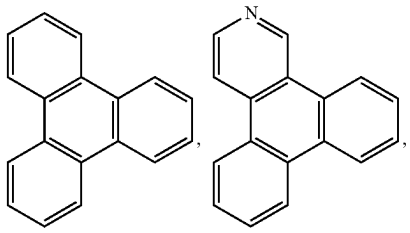
[0191] each of X^1-X^{18} can be independently C or N;

[0192] Y^A, Y^B, and Y^C are each independently selected from the group consisting of BR, BRR', NR, PR, P(O)R, O, S, Se, C═O, C═S, C═Se, C═NR, C═CRR', S═O, SO_2, CR, CRR', SiRR', GeRR', alkylene, cycloalkyl, aryl, cycloalkylene, arylene, heteroarylene, and combinations thereof;

[0193] each R^{L1}, R, and R' is independently a hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, selenyl, and combinations thereof; and

[0194] any two substituents can be joined or fused to form a ring.

[0195] In some embodiments, the moiety F' is selected from the group consisting of:



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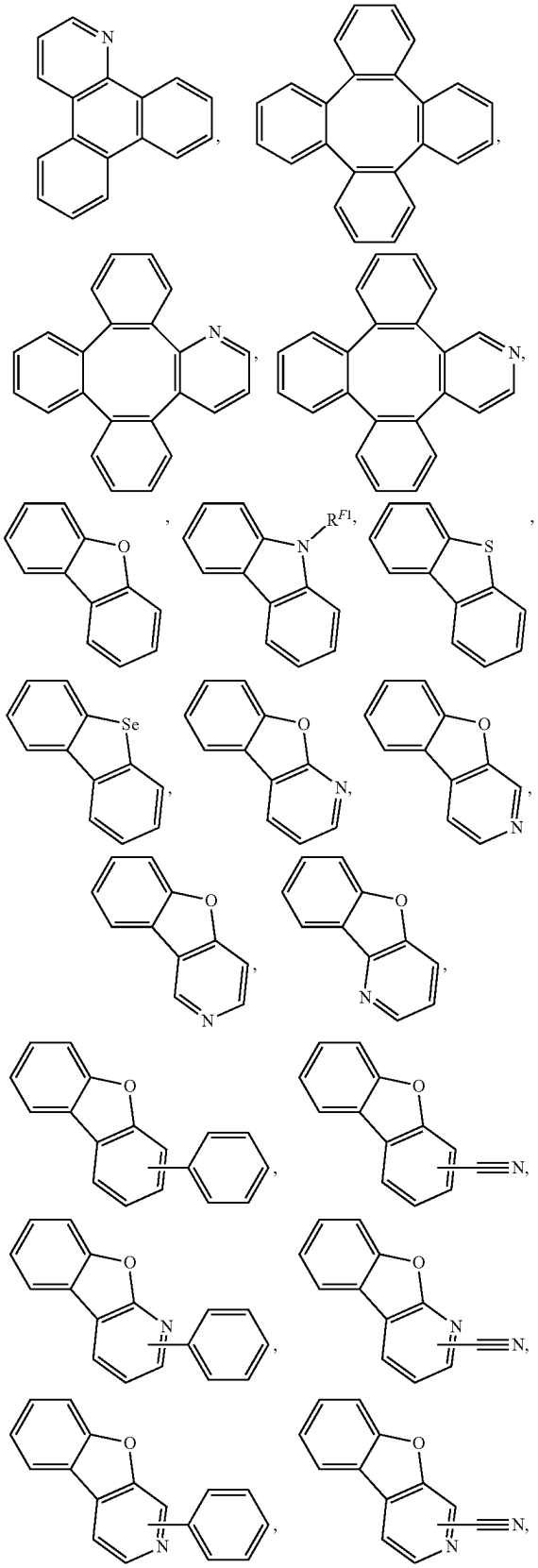

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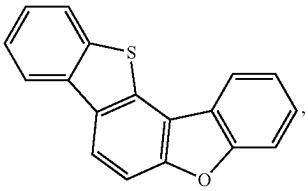

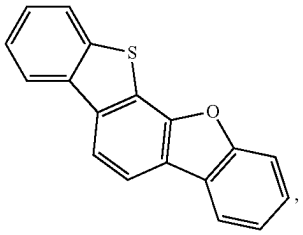

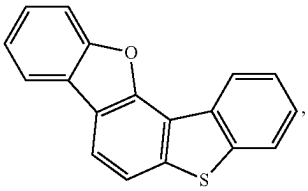

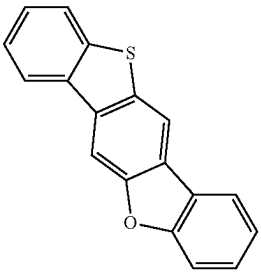

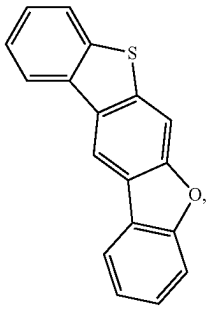

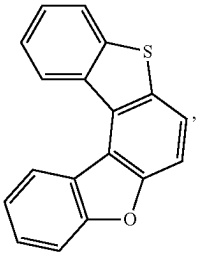

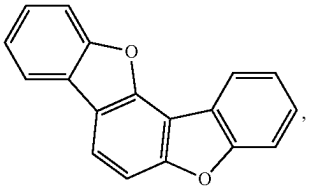

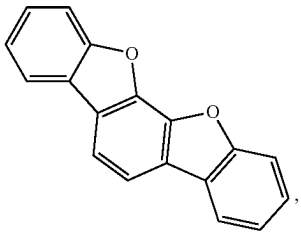

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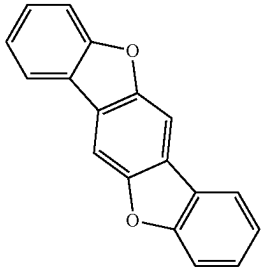

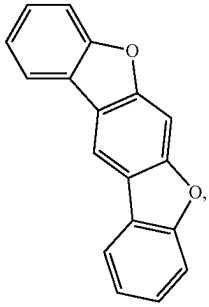

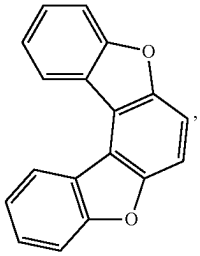

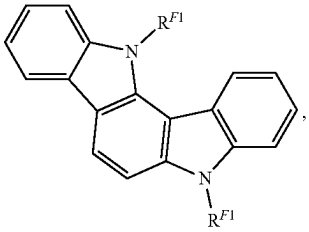

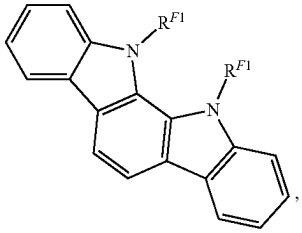

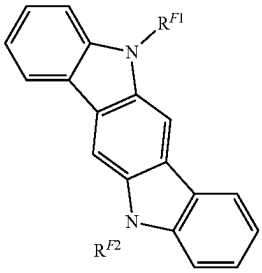

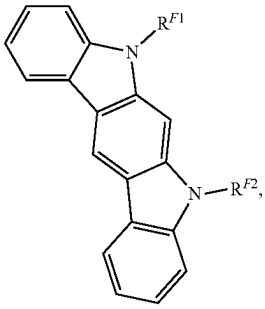

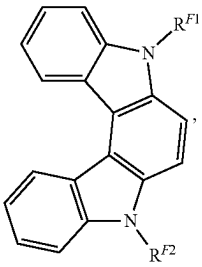

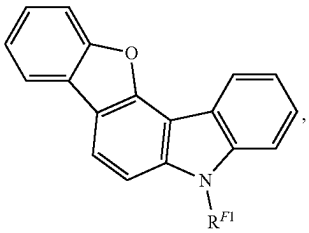

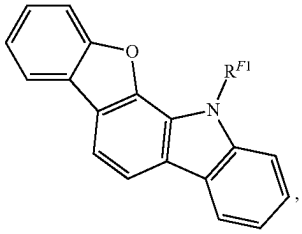

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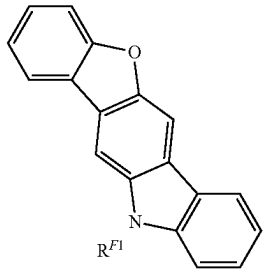
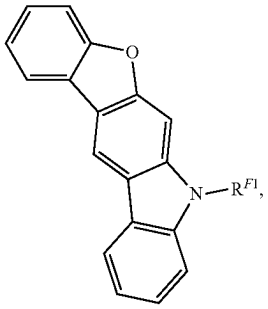
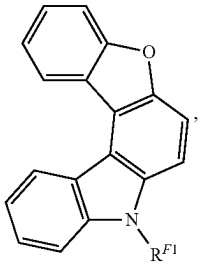
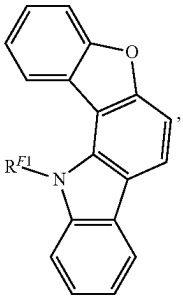
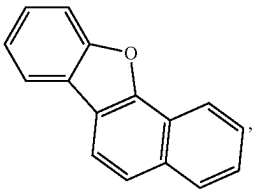
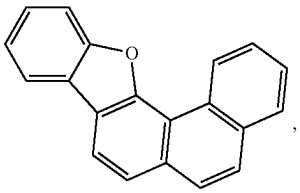
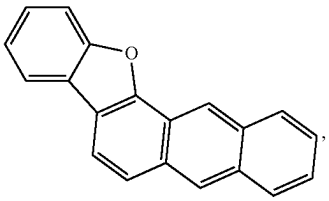
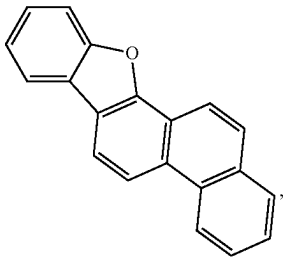
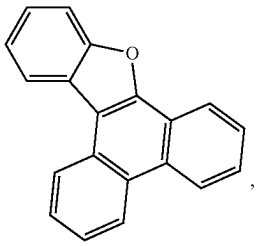
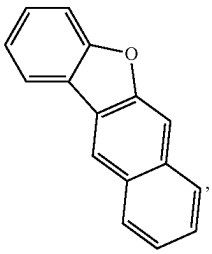
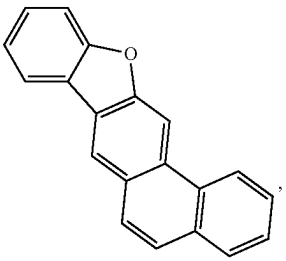

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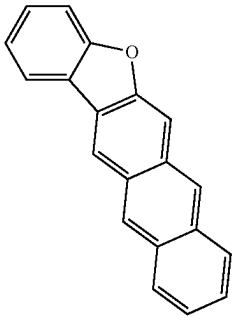
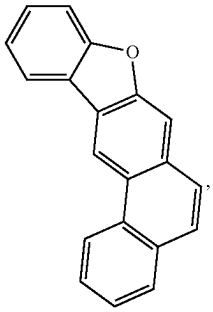
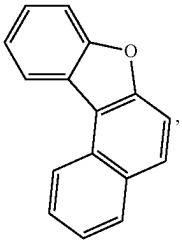
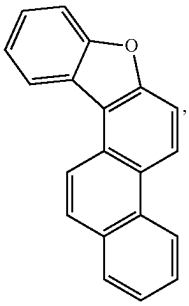
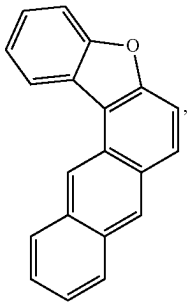
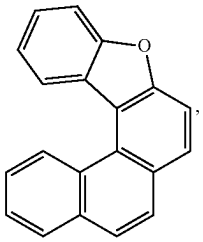
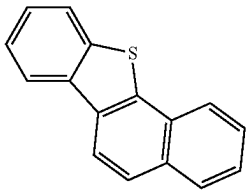
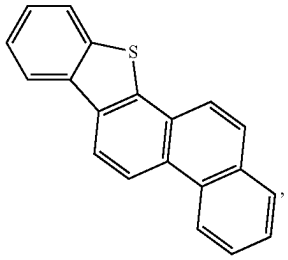
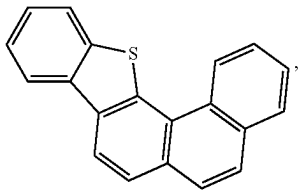
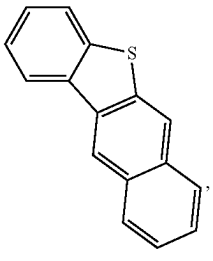
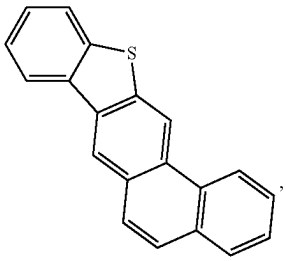

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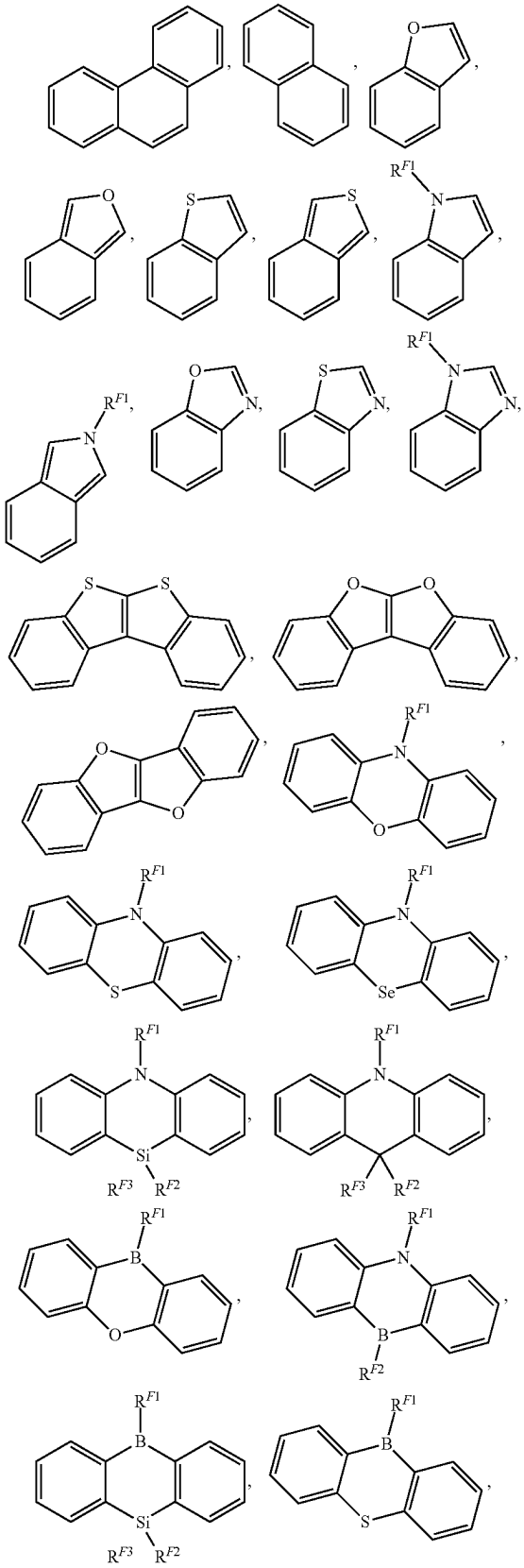

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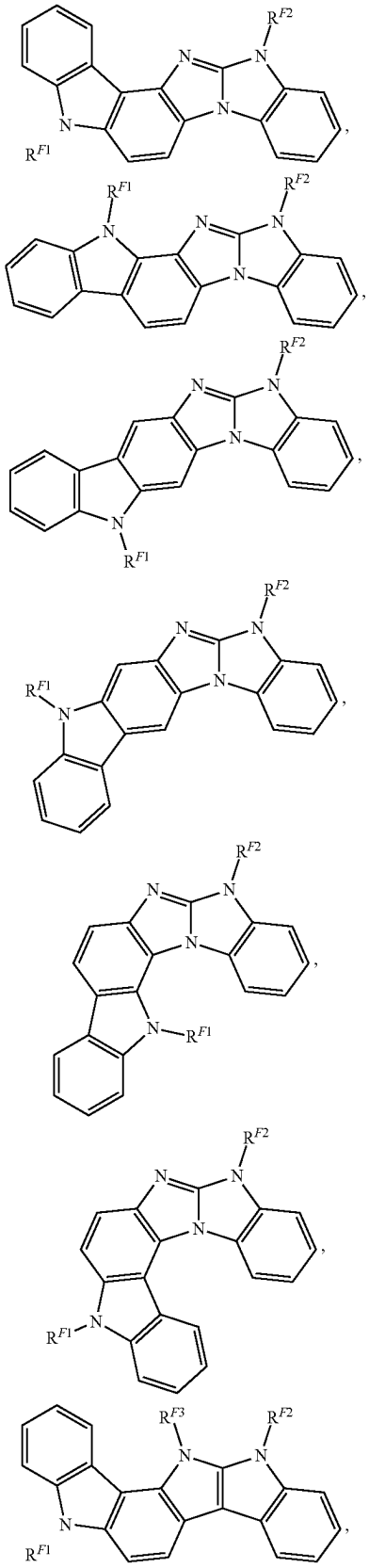

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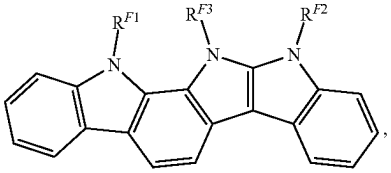

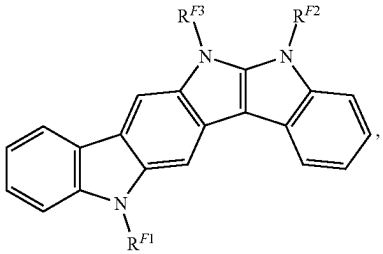

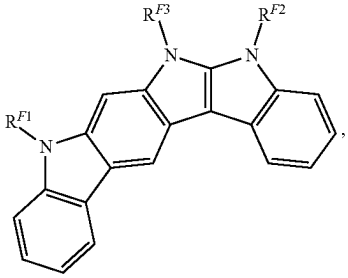

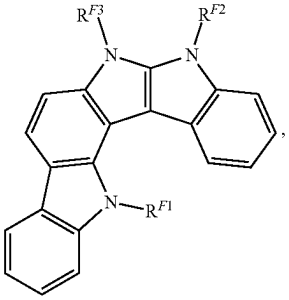

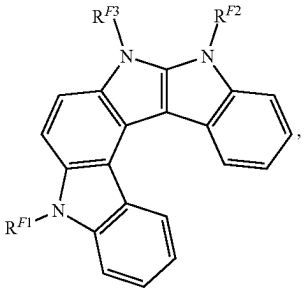

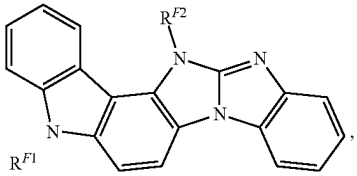

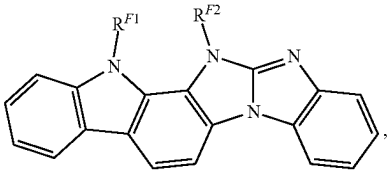

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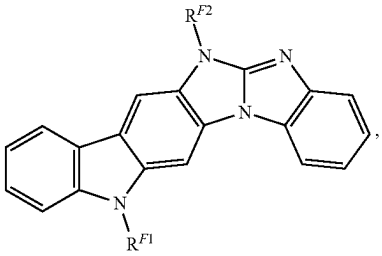

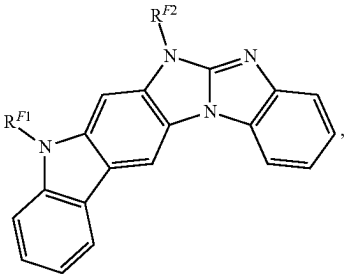

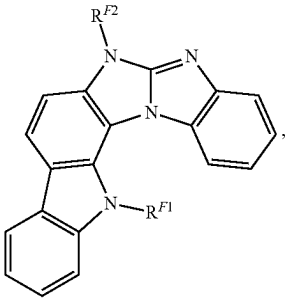

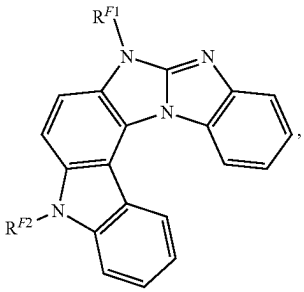

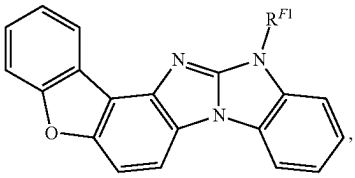

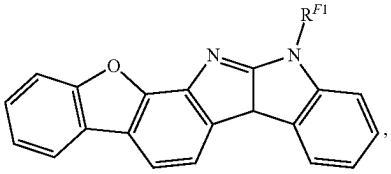

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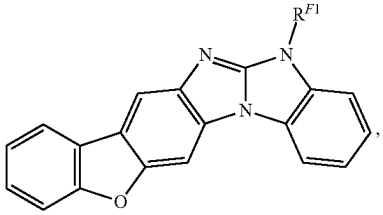

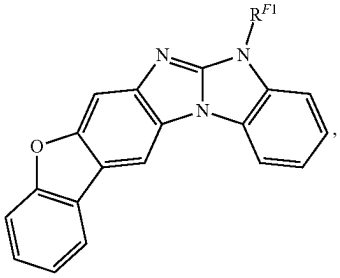

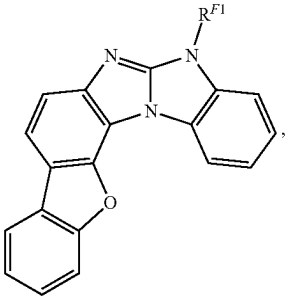

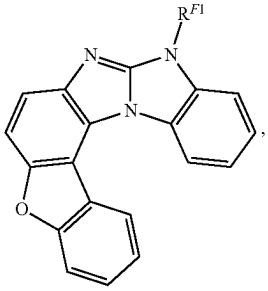

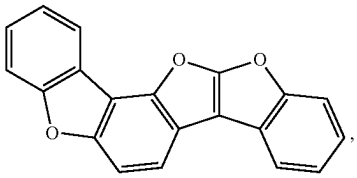

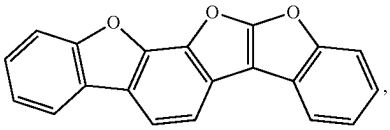

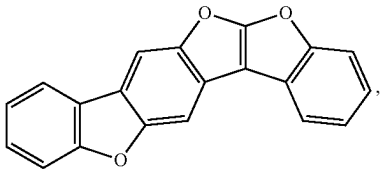

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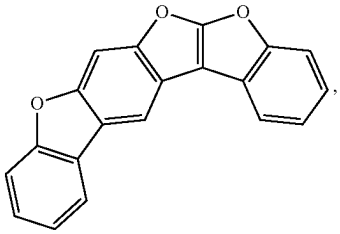

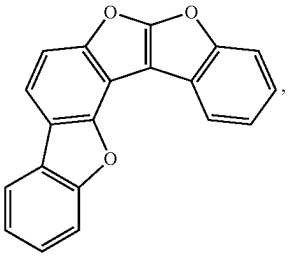

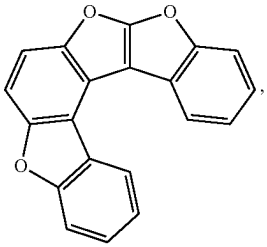

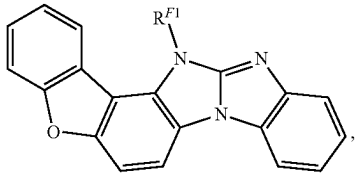

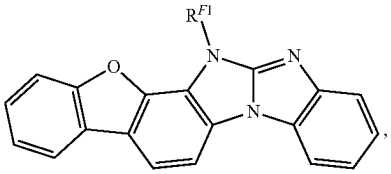

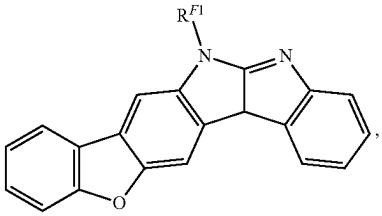

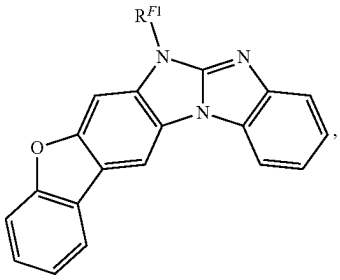

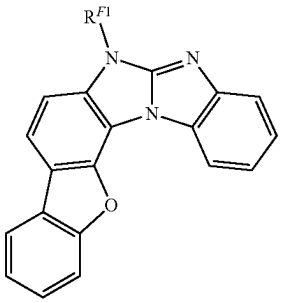

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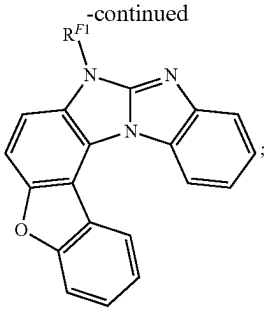
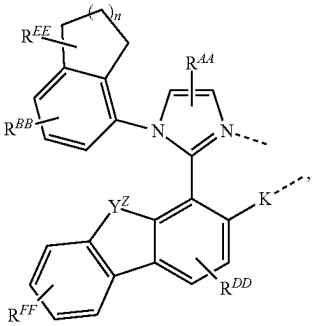
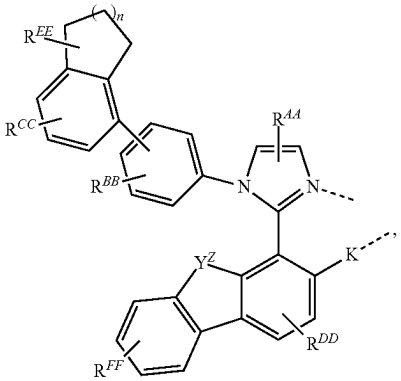
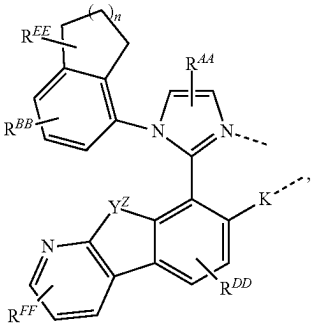


wherein R^{F1}, R^{F2}, and R^{F3} are each independently selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, selenyl, and combinations thereof.

[0196] In some embodiments, ligand L_A is selected from the group consisting of the structures of the following LIST 2a:







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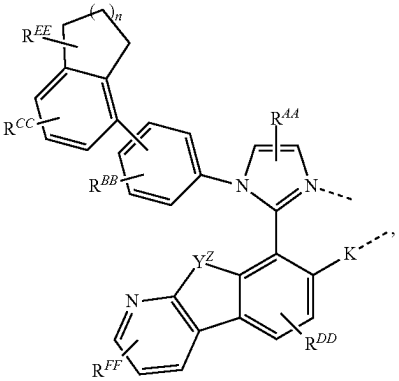

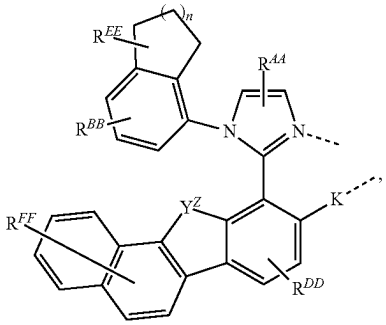

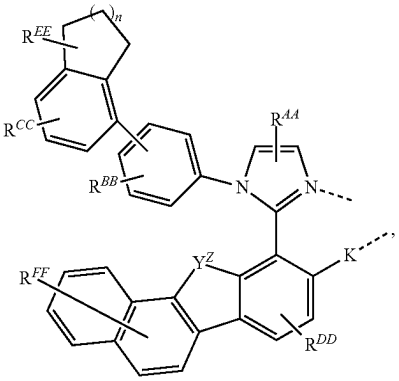

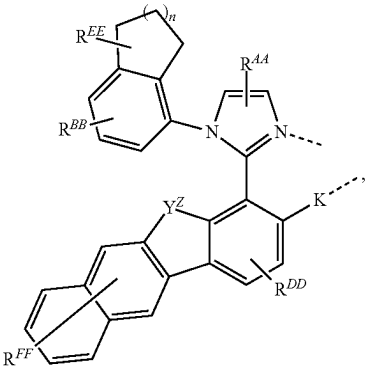

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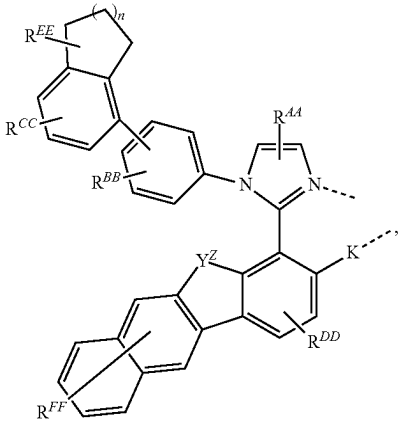

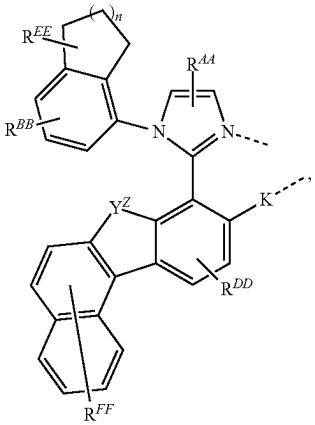

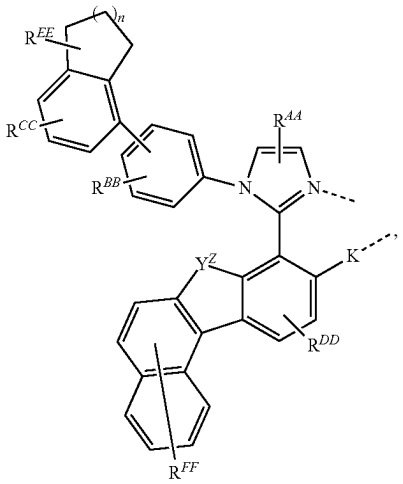

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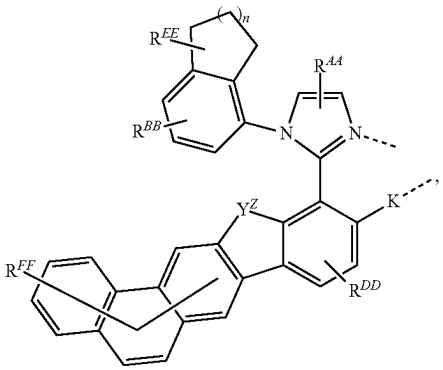

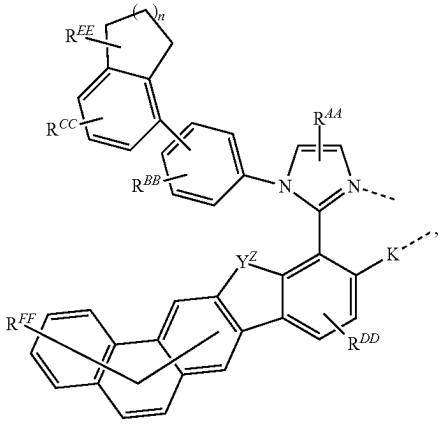

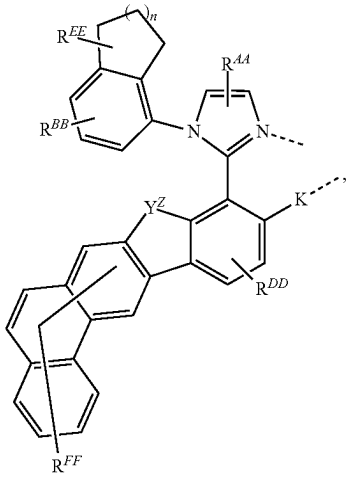

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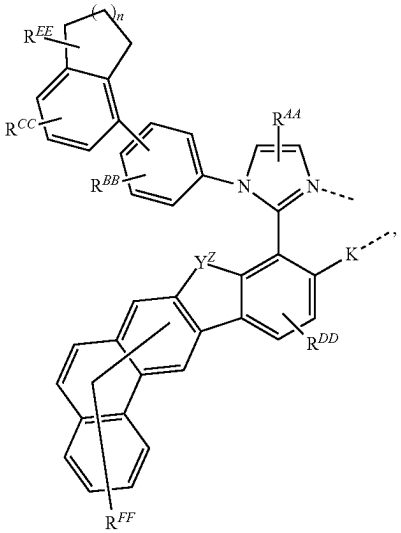

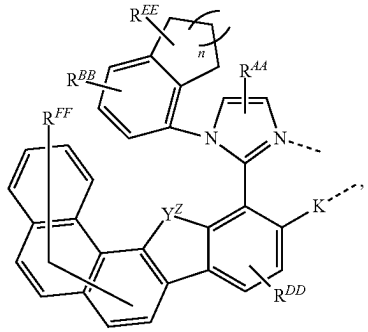

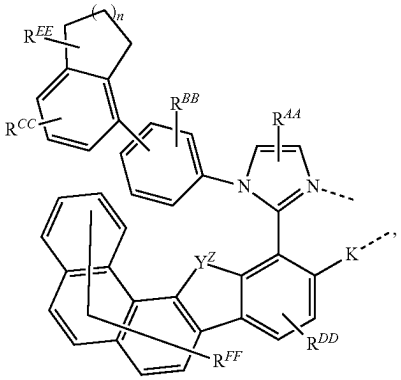

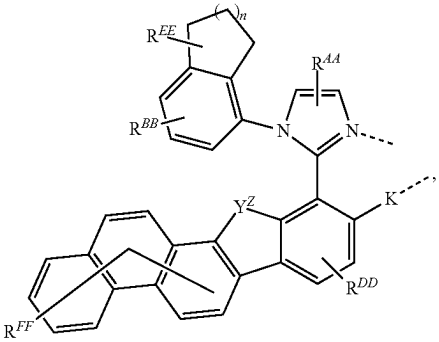

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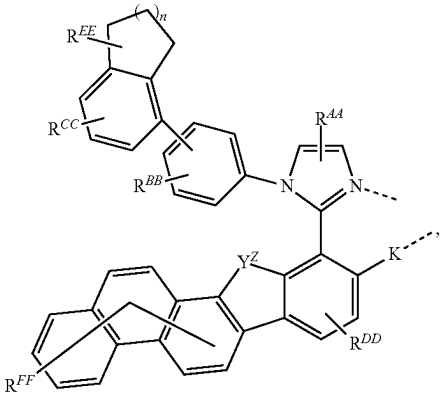

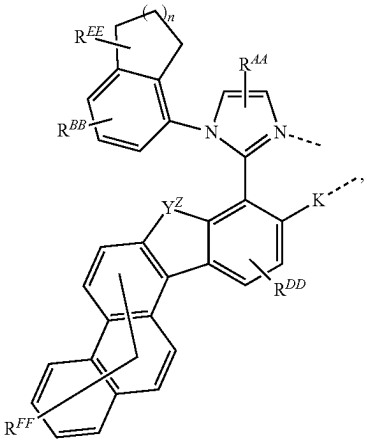

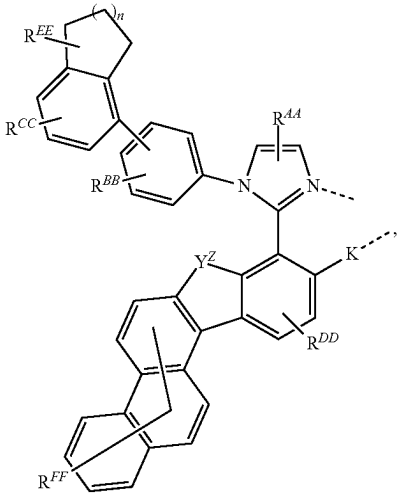

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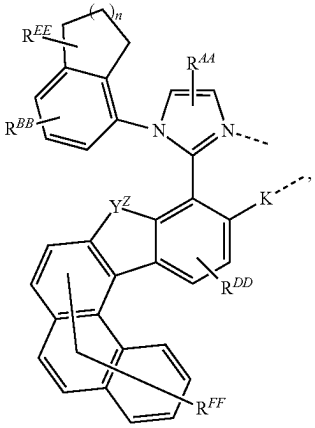

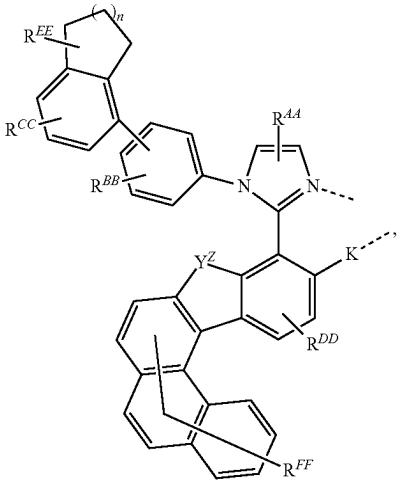

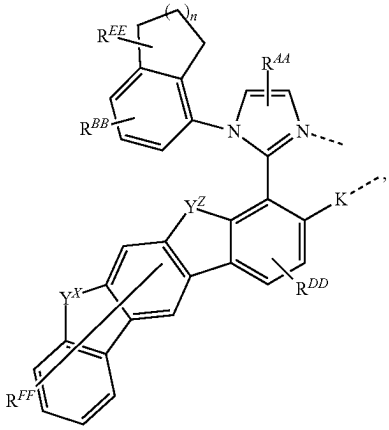

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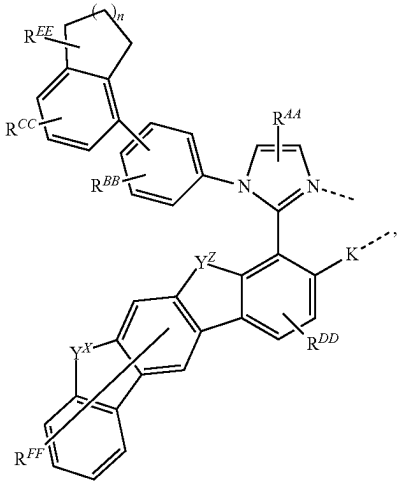

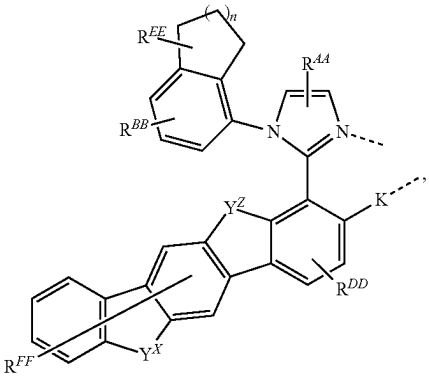

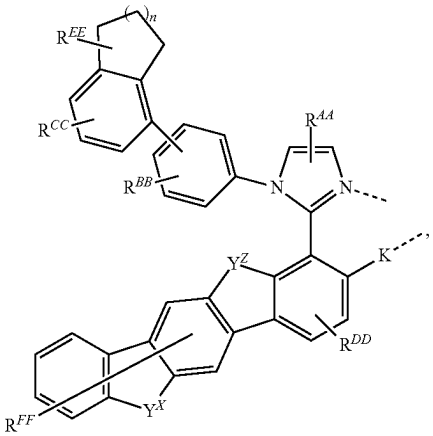

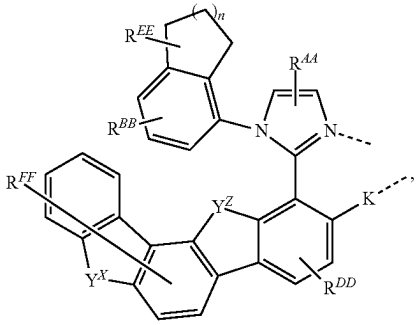

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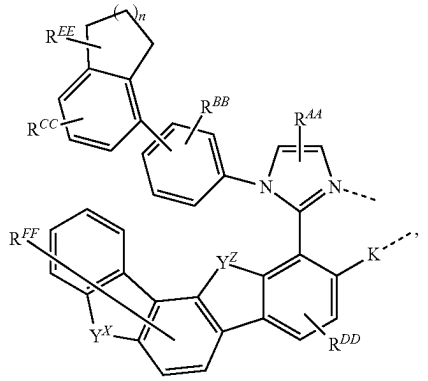

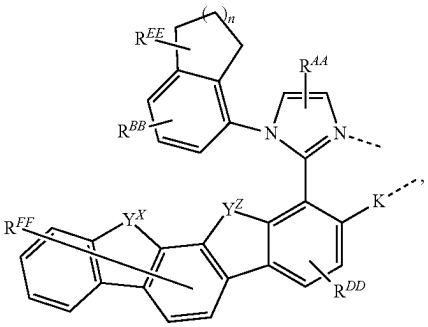

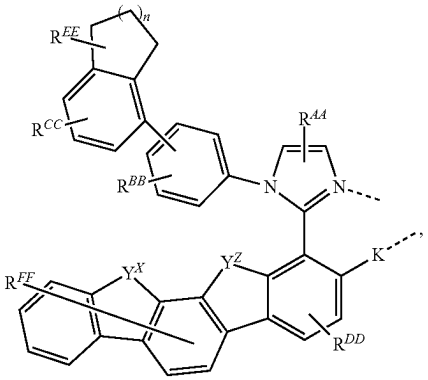

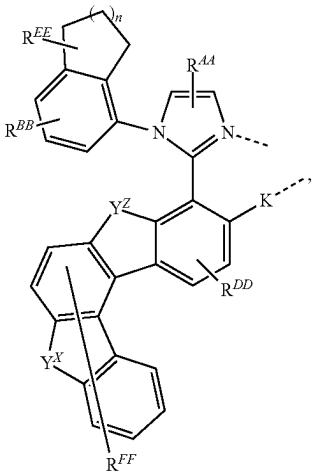

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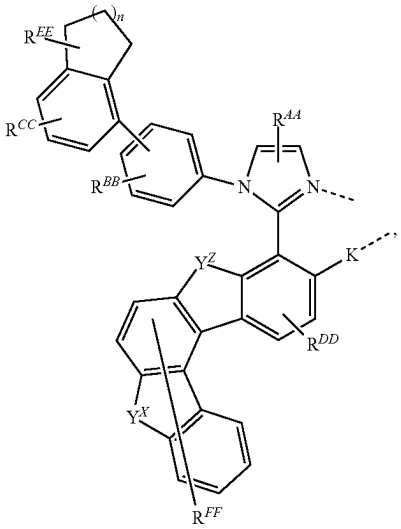

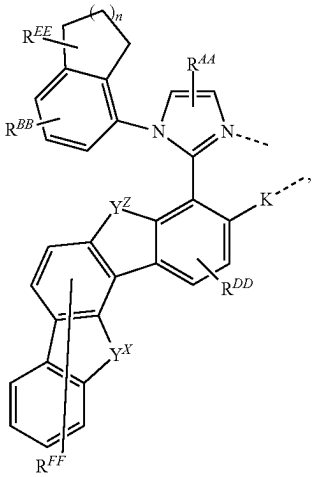

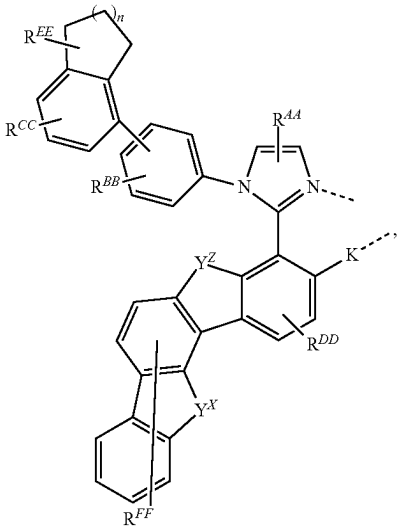

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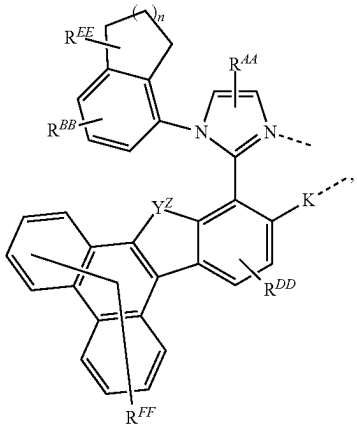

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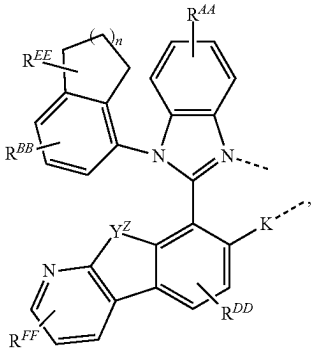

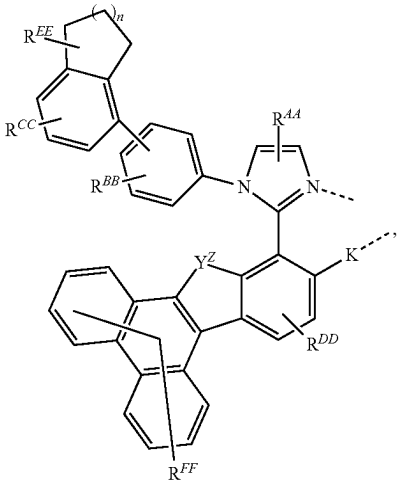

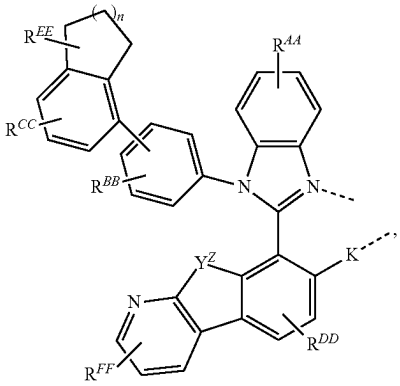

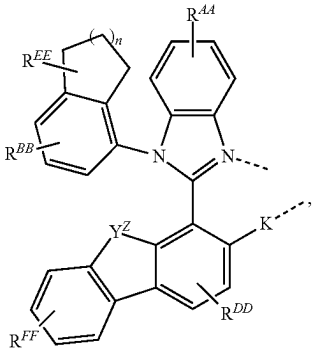

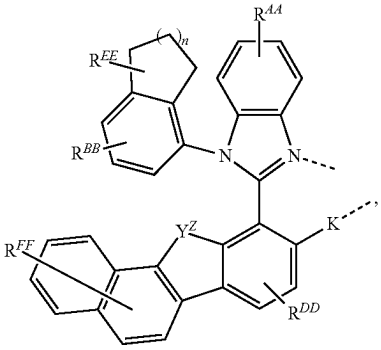

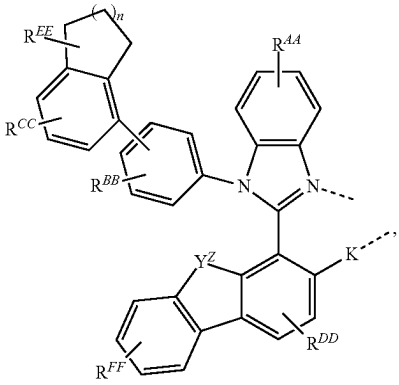

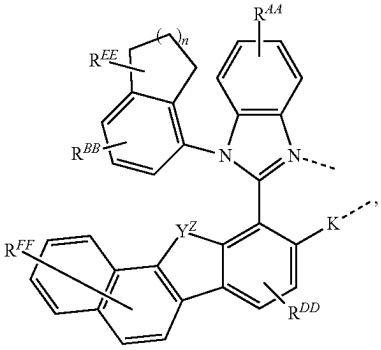

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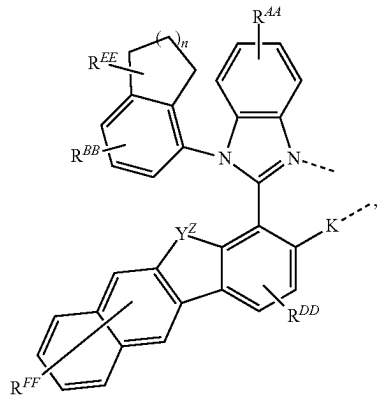

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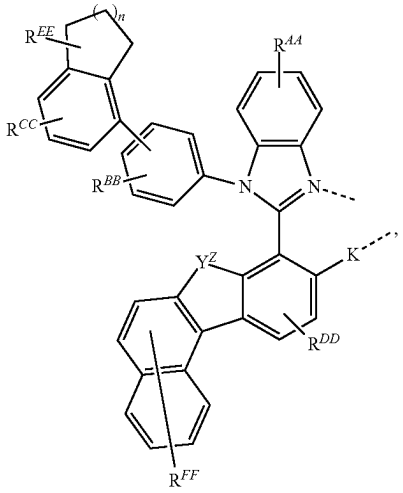

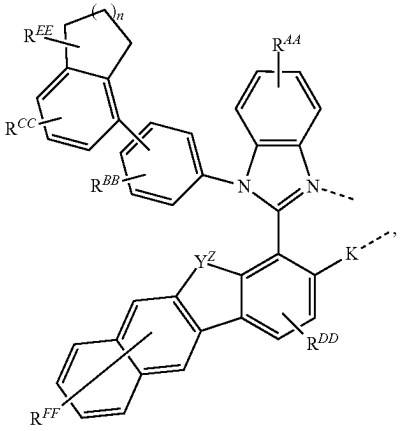

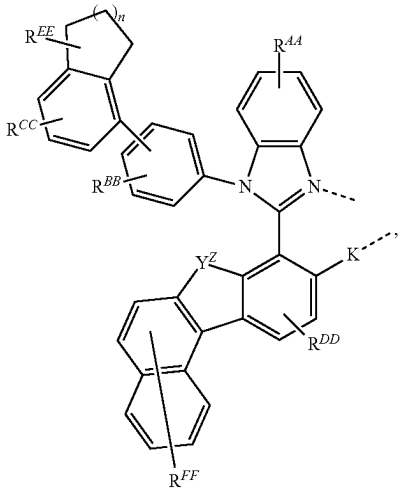

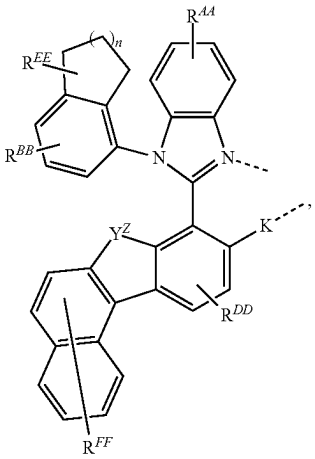

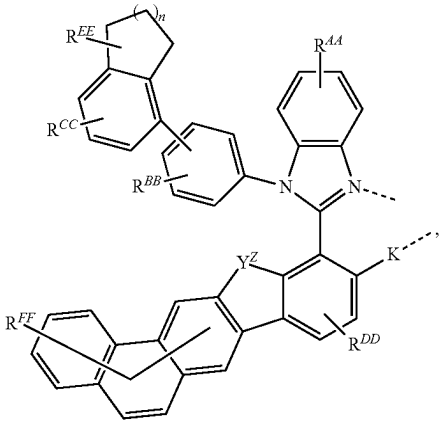

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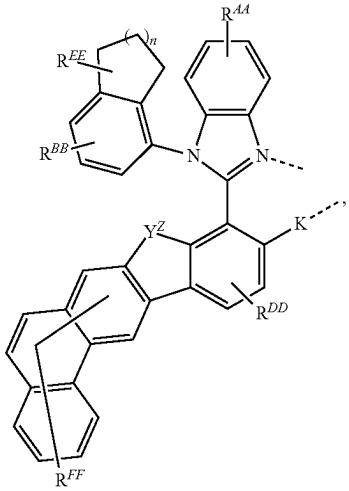

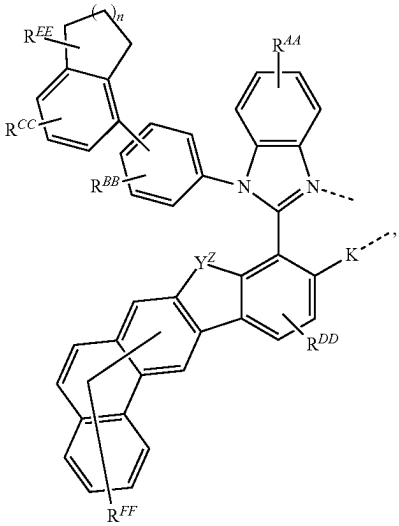

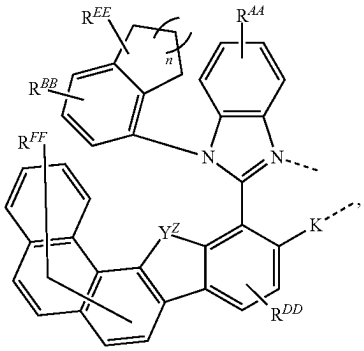

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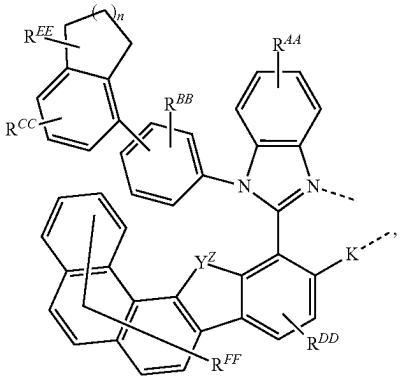

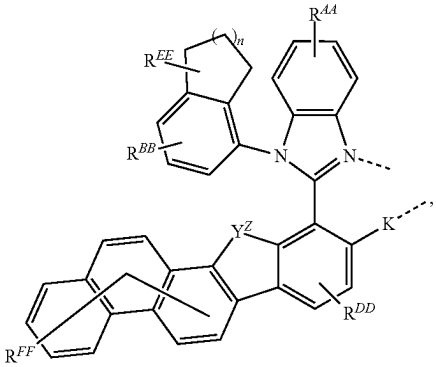

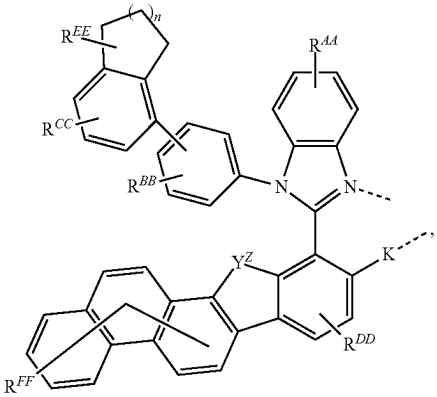

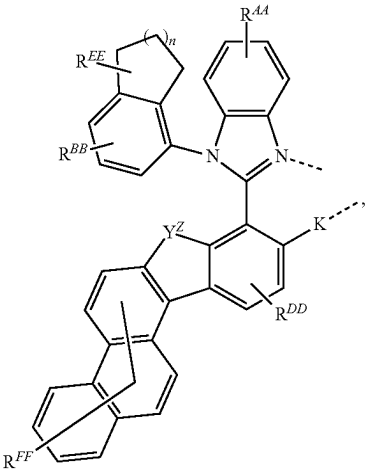

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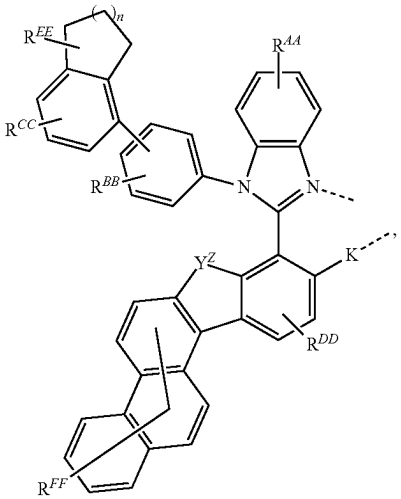

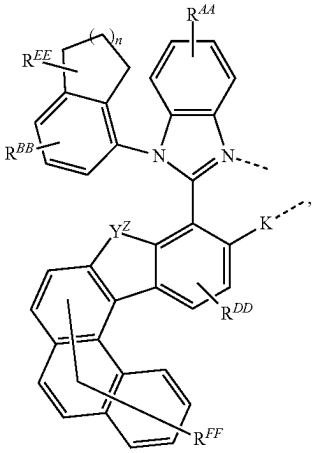

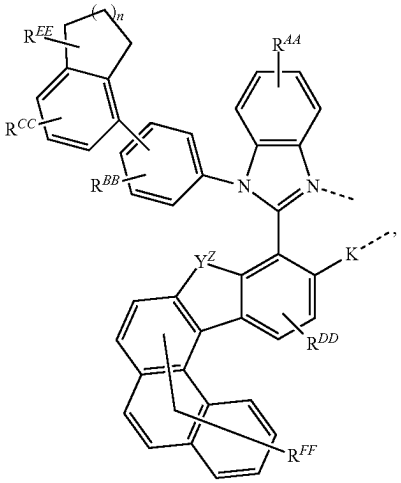

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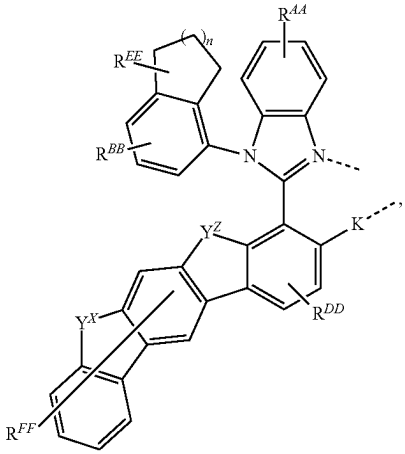

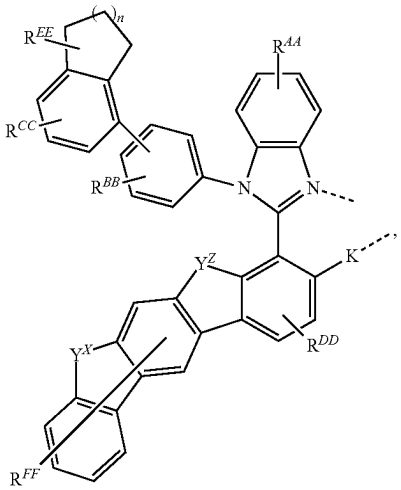

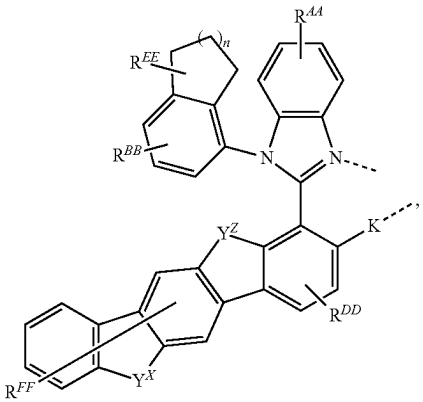

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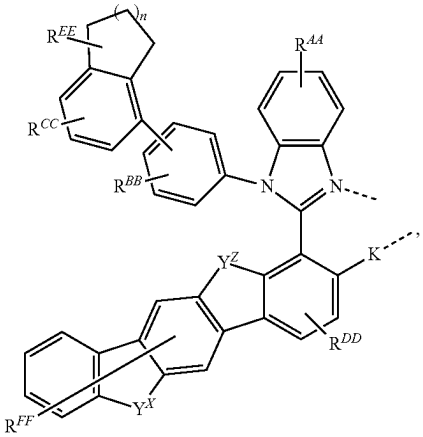

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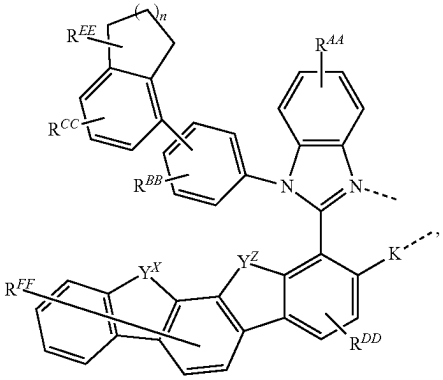

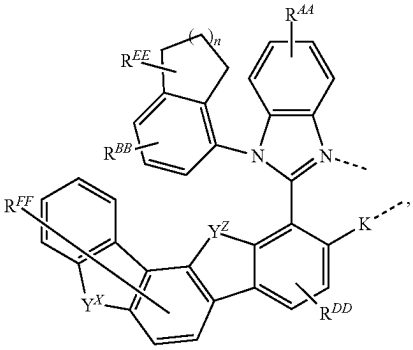

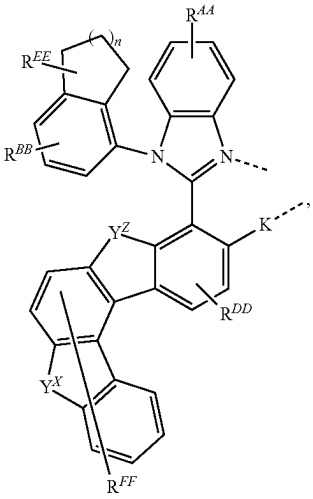

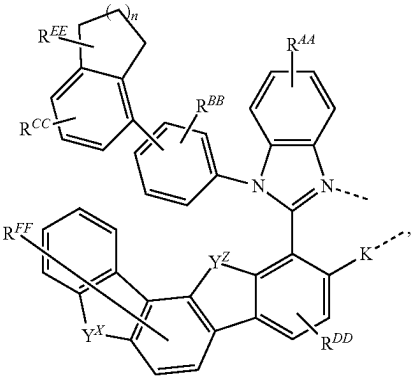

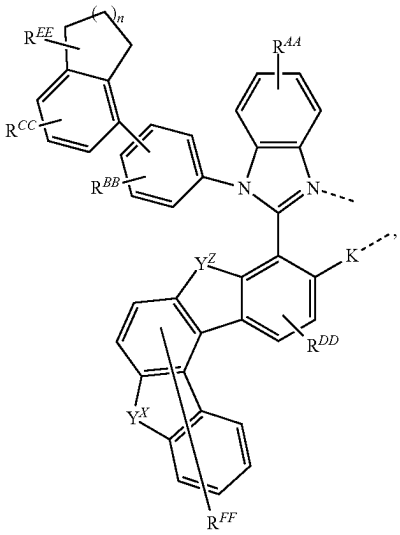

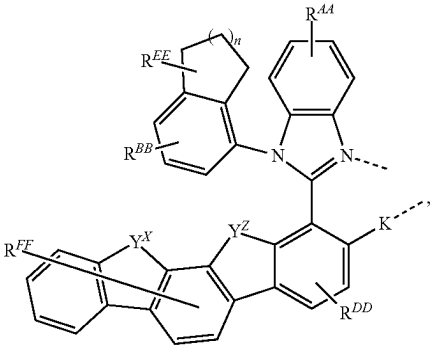

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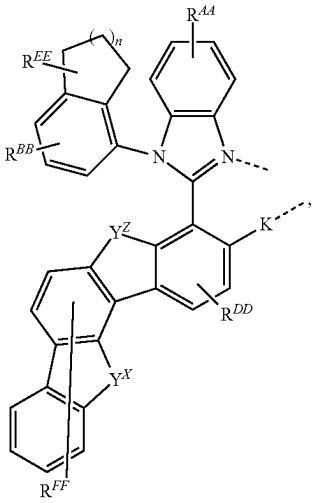

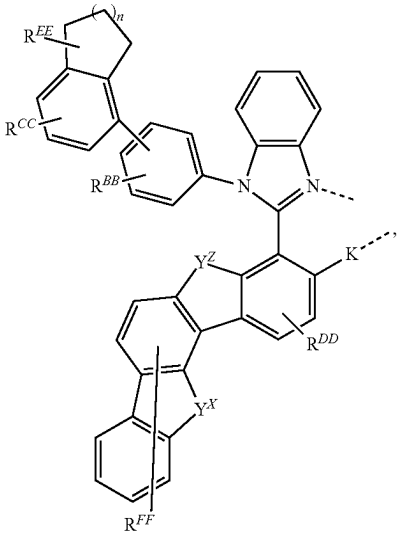

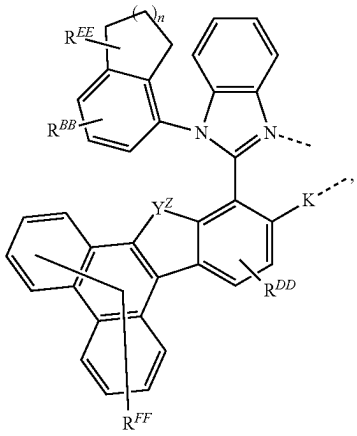

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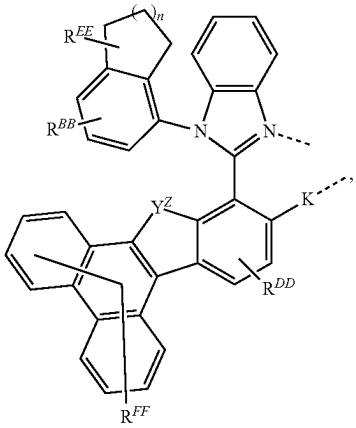

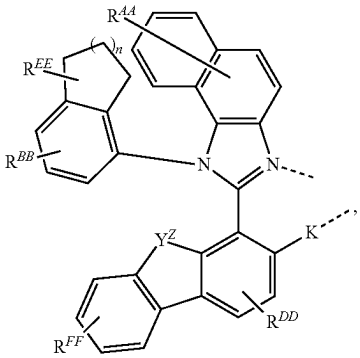

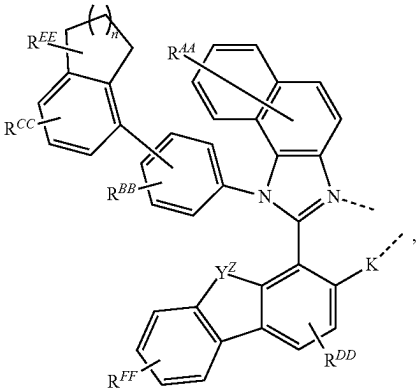

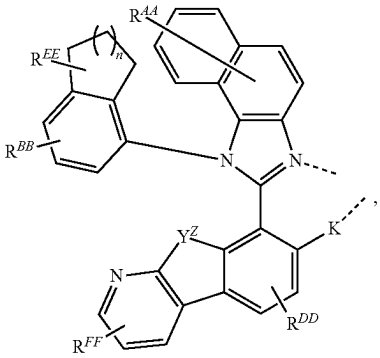

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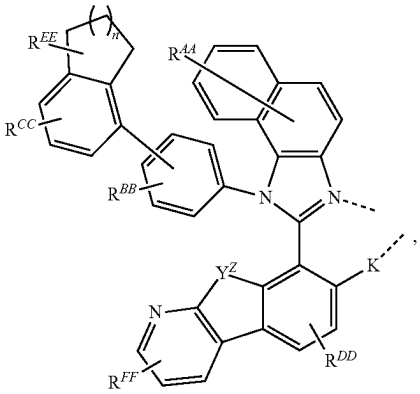

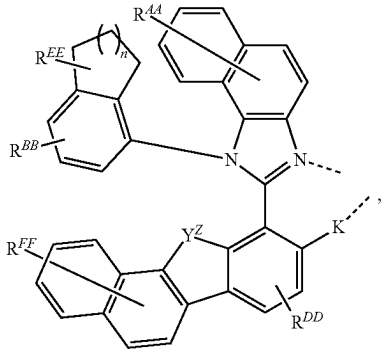

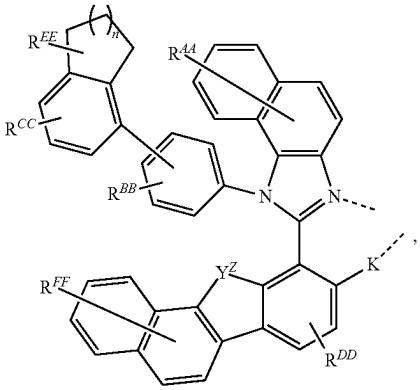

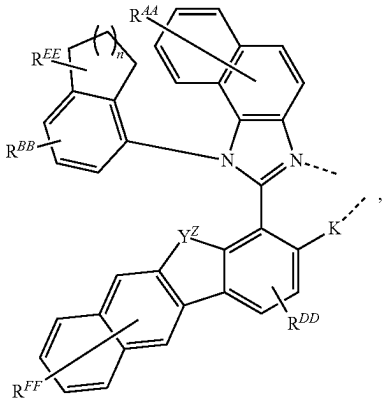

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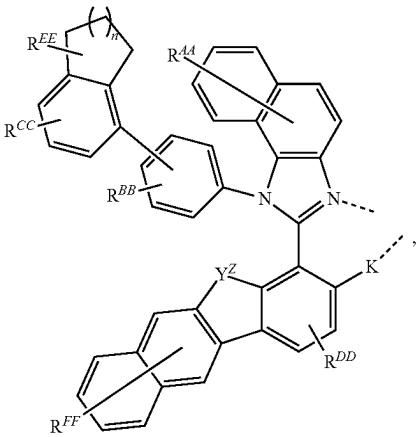

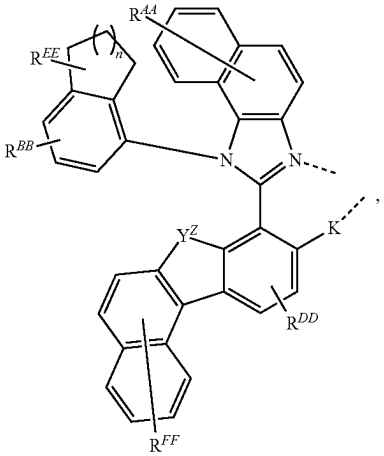

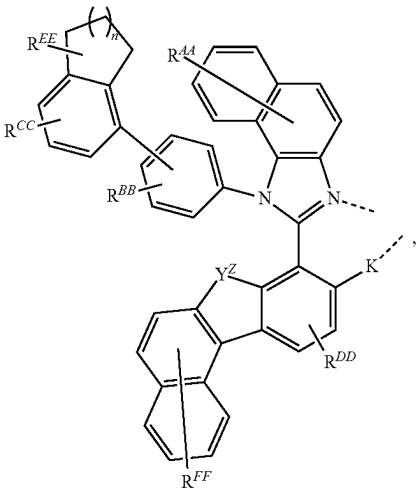

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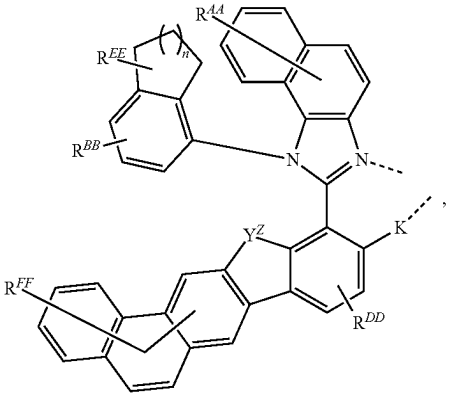

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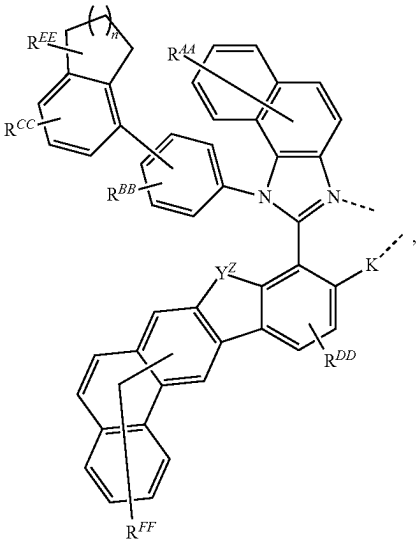

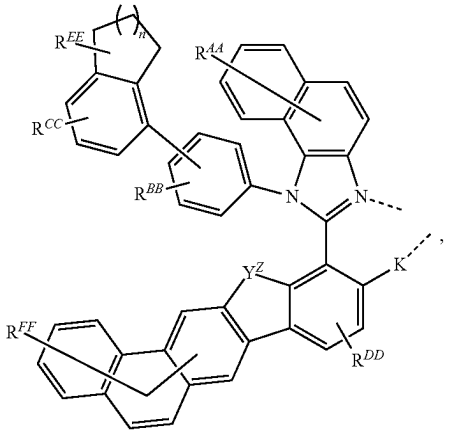

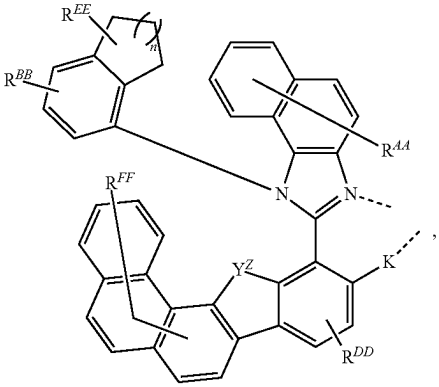

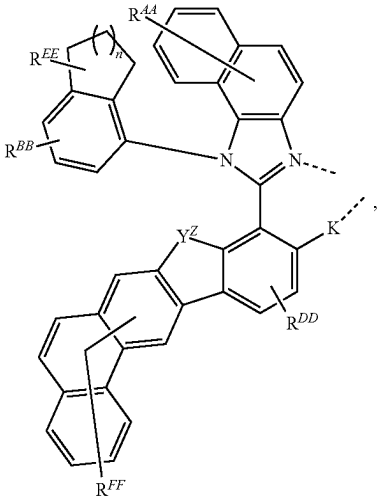

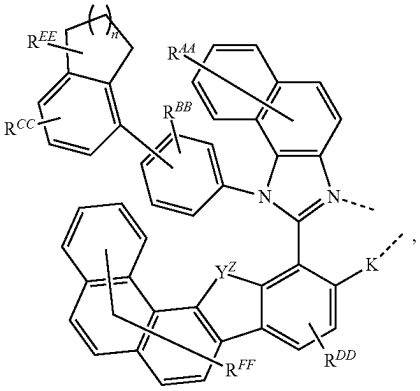

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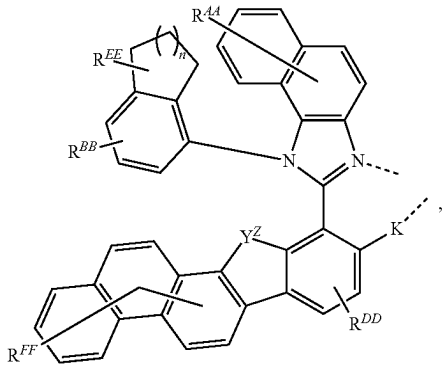

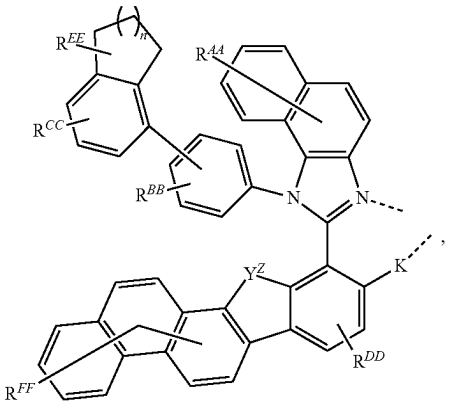

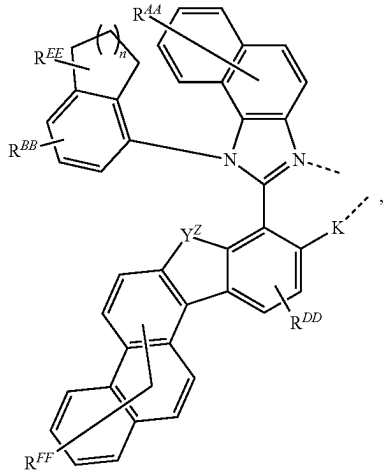

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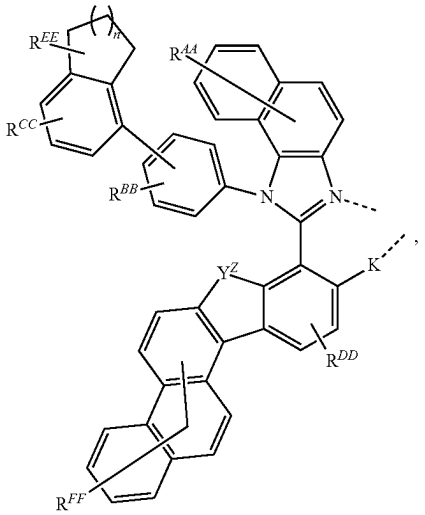

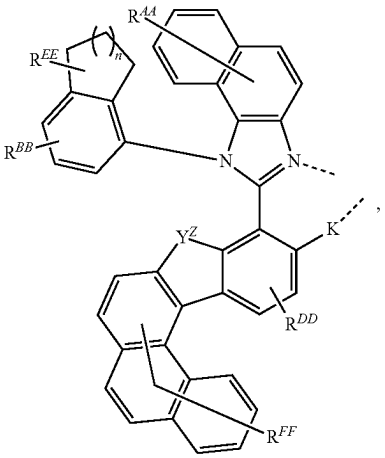

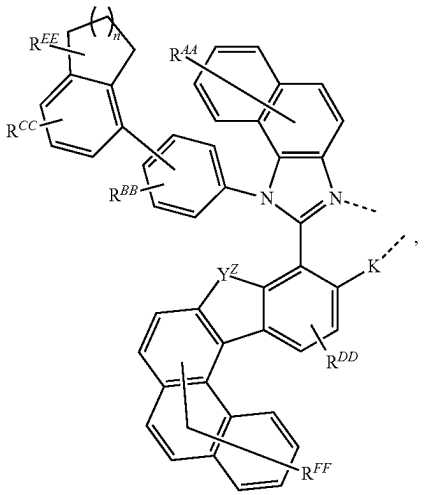

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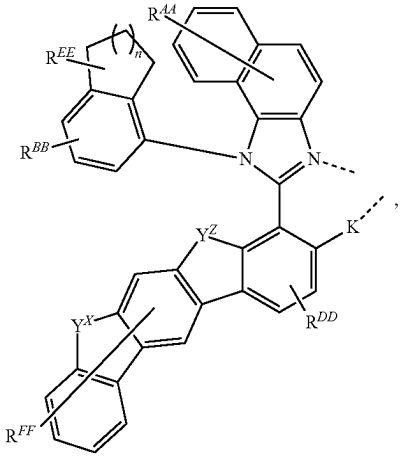

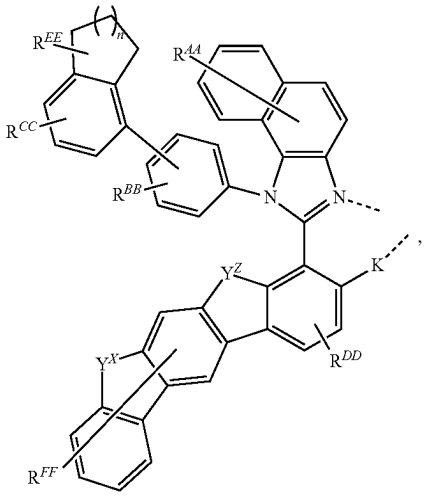

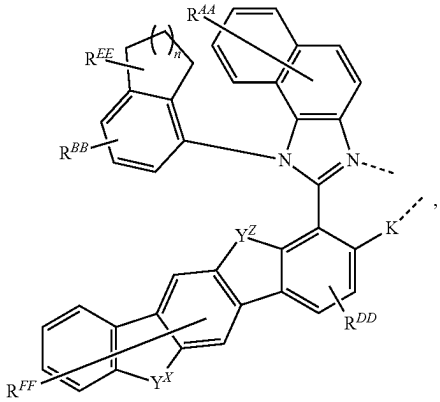

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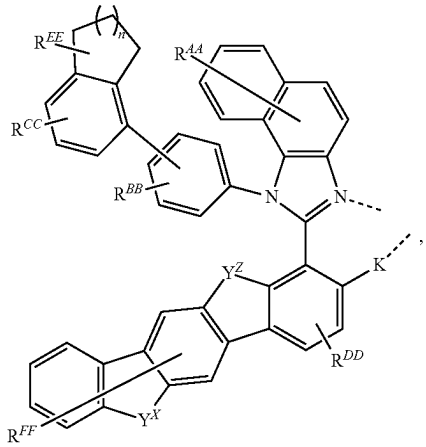

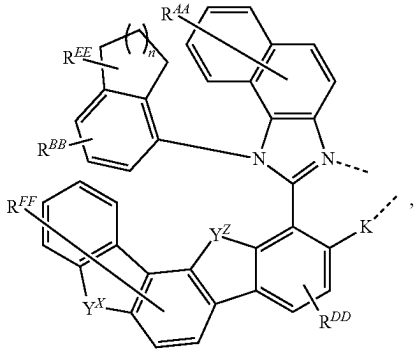

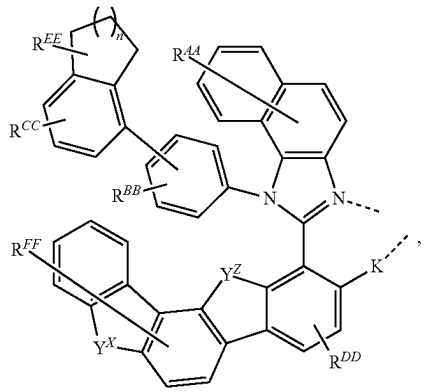

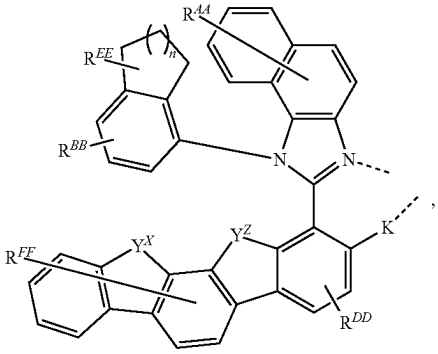

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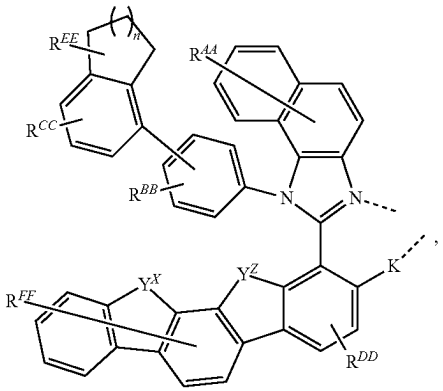

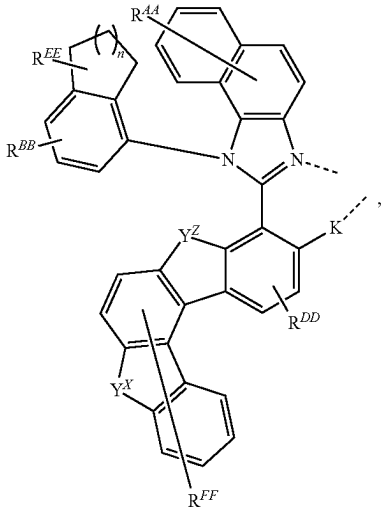

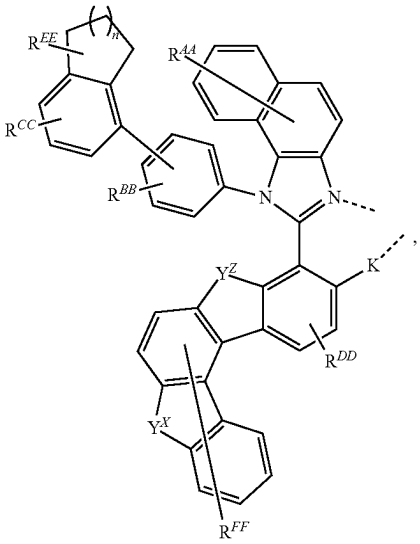

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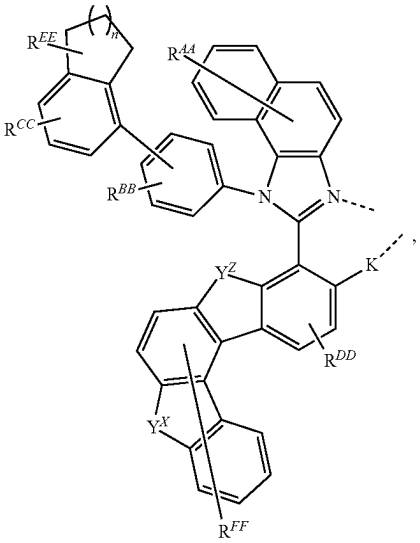

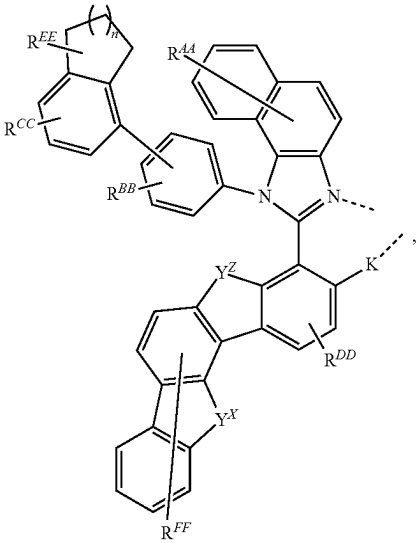

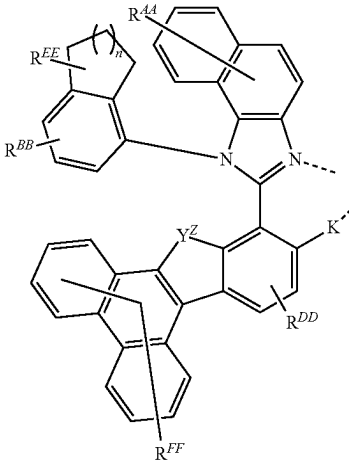

and

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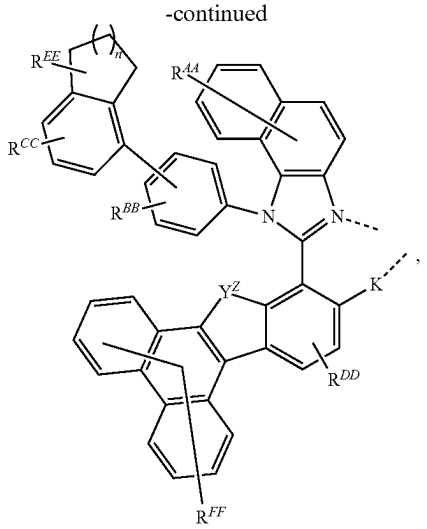


wherein:

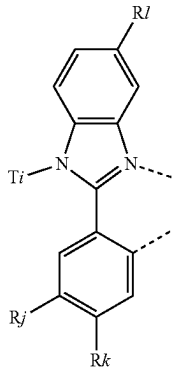
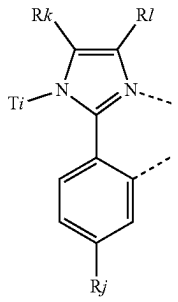
[0197] each of Y^Z and Y^X is independently selected from the group consisting of BR_e, NR_e, PR_e, O, S, Se, C═O, S═O, SO_2, CR_eR_f, SiR_eR_f, and GeR_eR_f;

[0198] each R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, and R^{FF} independently represent from mono to the maximum possible number of substitutions, or no substitution;

[0199] each R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, and R^{FF} is independently a hydrogen or a substituent selected from the group consisting of the General Substituents defined herein; and any two substituents can be joined or fused to form a ring.

[0200] In some embodiments where ligand L_A is selected from LIST 2a, K is a direct bond. In some embodiments where ligand L_A is selected from LIST 2a, at least one R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, or R^{FF} is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments where ligand L_A is selected from LIST 2a, at least one of R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE} or R^{FF} is partially or fully deuterated. In some embodiments where ligand L_A is selected from LIST 2a, at least one R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, or R^{FF} is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, or R^{FF} is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, or R^{FF} is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, or R^{FF} is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, or R^{FF} is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0201] In some embodiments, the first ligand L_A is selected from L_Ai-(Ti)(Rj)(Rk)(Rl), wherein i is an integer from 1 to 24, Ti is selected from the group consisting of T1 to T76, and each Rj, Rk, and Rl is independently selected from the group consisting of R1 to R468; wherein each of L_A i-(T1)(R1)(R1)(R1) to L_A 24-(T76)(R468)(R468)(R468) is defined in the following LIST 3:

Compound	Structure of compound
L_A 1-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 1-(T1)(R1)(R1)(R1) to L_A 1-(T76)(R468)(R468)(R468) have the structure	
L_A 2-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 2-(T1)(R1)(R1)(R1) to L_A 2-(T76)(R468)(R468)(R468) have the structure	

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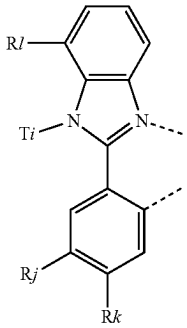
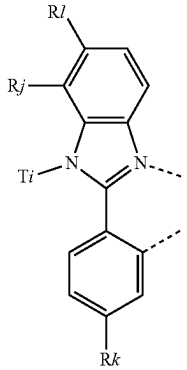
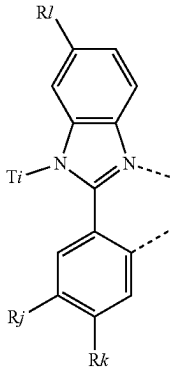
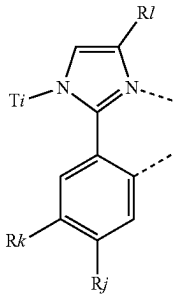
Compound	Structure of compound
L_A 3-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 3-(T1)(R1)(R1)(R1) to L_A 3-(T76)(R468)(R468)(R468) have the structure	
L_A 4-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 4-(T1)(R1)(R1)(R1) to L_A 4-(T76)(R468)(R468)(R468) have the structure	
L_A 5-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 5-(T1)(R1)(R1)(R1) to L_A 5-(T76)(R468)(R468)(R468) have the structure	
L_A 6-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 6-(T1)(R1)(R1)(R1) to L_A 6-(T76)(R468)(R468)(R468) have the structure	

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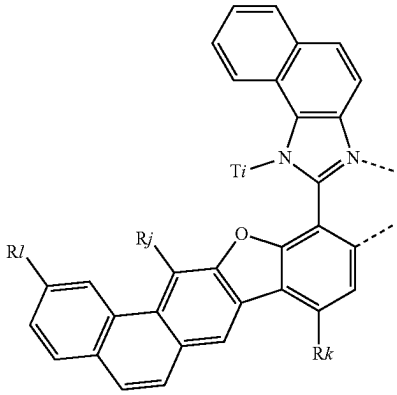
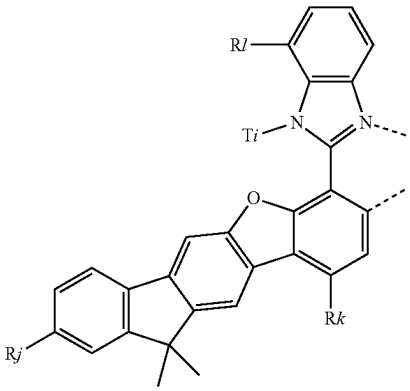
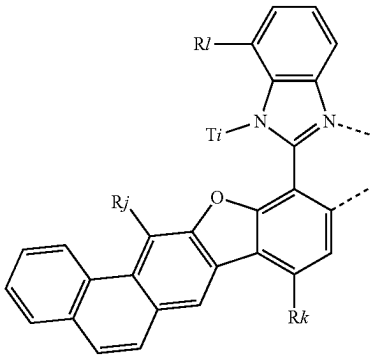
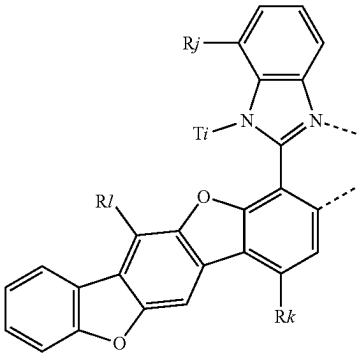
Compound	Structure of compound
L_A 7-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 7-(T1)(R1)(R1)(R1) to L_A 7-(T76)(R468)(R468)(R468) have the structure	
L_A 8-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 8-(T1)(R1)(R1)(R1) to L_A 8-(T76)(R468)(R468)(R468) have the structure	
L_A 9-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 9-(T1)(R1)(R1)(R1) to L_A 9-(T76)(R468)(R468)(R468) have the structure	
L_A 10-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 10-(T1)(R1)(R1)(R1) to L_A 10-(T76)(R468)(R468)(R468) have the structure	

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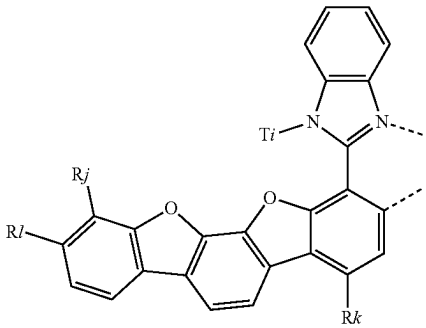
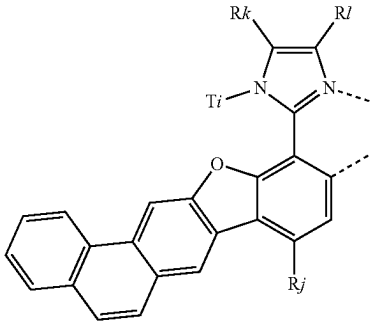
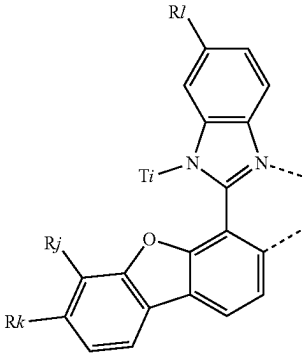
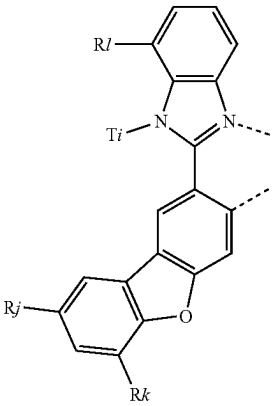
Compound	Structure of compound
L_A 11-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 11-(T1)(R1)(R1)(R1) to L_A 11-(T76)(R468)(R468)(R468) have the structure	
L_A 12-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 12-(T1)(R1)(R1)(R1) to L_A 12-(T76)(R468)(R468)(R468) have the structure	
L_A 13-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 13-(T1)(R1)(R1)(R1) to L_A 13-(T76)(R468)(R468)(R468) have the structure	
L_A 14-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 14-(T1)(R1)(R1)(R1) to L_A 14-(T76)(R468)(R468)(R468) have the structure	

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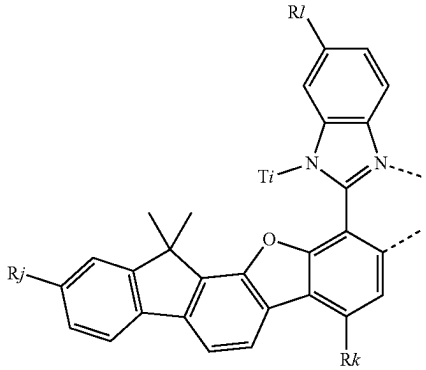
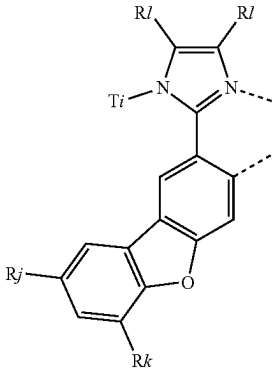
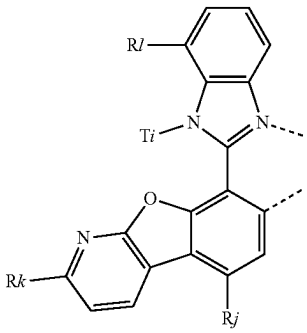
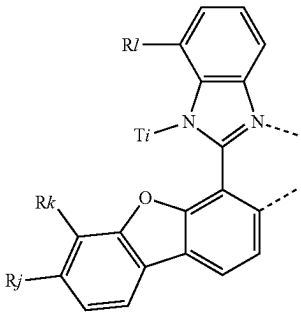
Compound	Structure of compound
L_A 15-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 15-(T1)(R1)(R1)(R1) to L_A 15-(T76)(R468)(R468)(R468) have the structure	
L_A 16-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 16-(T1)(R1)(R1)(R1) to L_A 16-(T76)(R468)(R468)(R468) have the structure	
L_A 17-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 17-(T1)(R1)(R1)(R1) to L_A 17-(T76)(R468)(R468)(R468) have the structure	
L_A 18-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 18-(T1)(R1)(R1)(R1) to L_A 18-(T76)(R468)(R468)(R468) have the structure	

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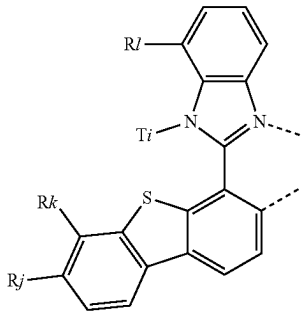
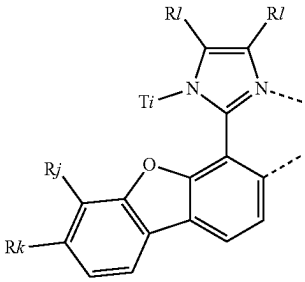
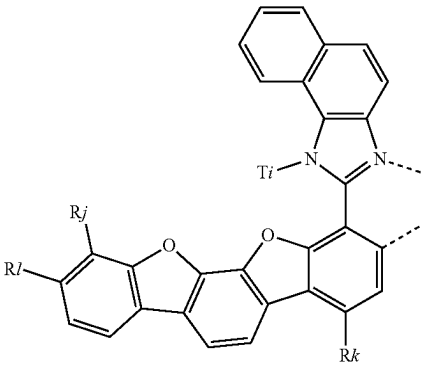
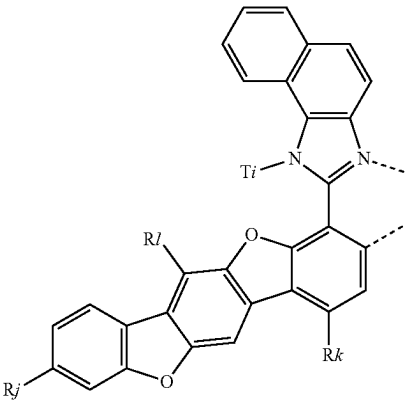
Compound	Structure of compound
L_A 19-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 19-(T1)(R1)(R1)(R1) to L_A 19-(T76)(R468)(R468)(R468) have the structure	
L_A 20-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 20-(T1)(R1)(R1)(R1) to L_A 20-(T76)(R468)(R468)(R468) have the structure	
L_A 21-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 21-(T1)(R1)(R1)(R1) to L_A 21-(T76)(R468)(R468)(R468) have the structure	
L_A 22-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 22-(T1)(R1)(R1)(R1) to L_A 22-(T76)(R468)(R468)(R468) have the structure	

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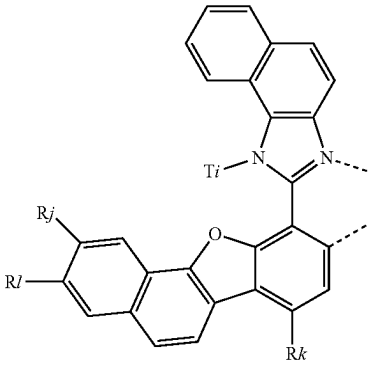
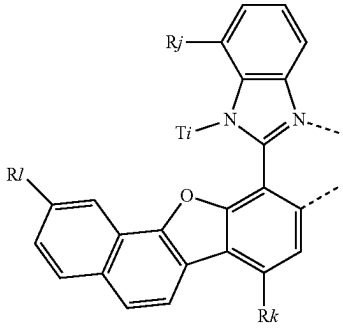
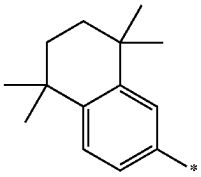
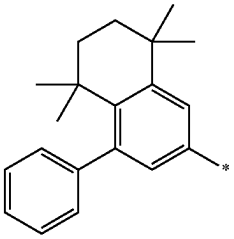
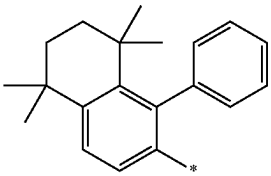
Compound	Structure of compound
L_A 23-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 23-(T1)(R1)(R1)(R1) to L_A 23-(T76)(R468)(R468)(R468) have the structure	
L_A 24-(T*i*)(R*j*)(R*k*)(R*l*), wherein L_A 24-(T1)(R1)(R1)(R1) to L_A 24-(T76)(R468)(R468)(R468) have the structure	

[0202] wherein each of T1 to T76 is defined in the following LIST 4:

Structure
T1 
T2 
T3 

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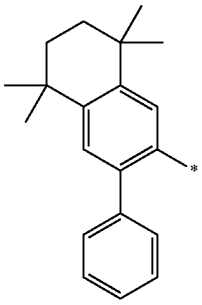
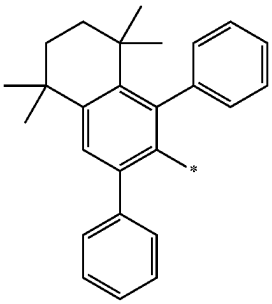
Structure
T4 
T5 

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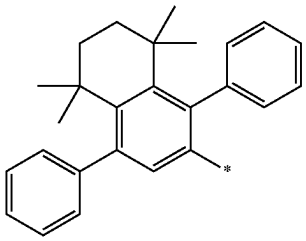
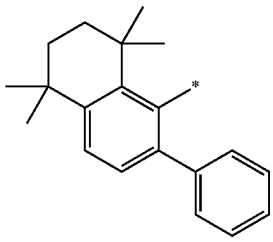
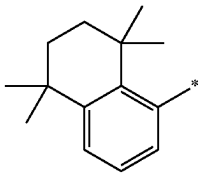
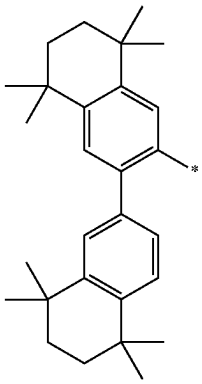
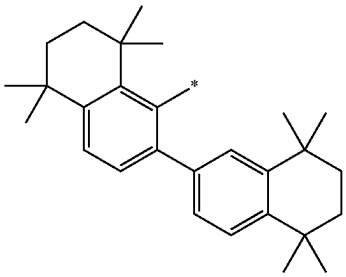
	Structure
T6	
T7	
T8	
T9	
T10	

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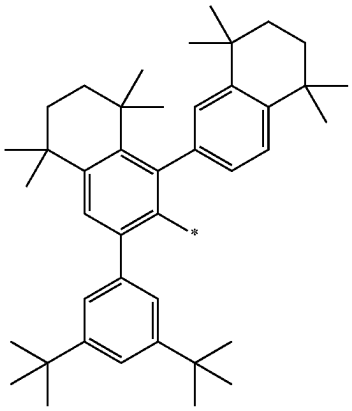
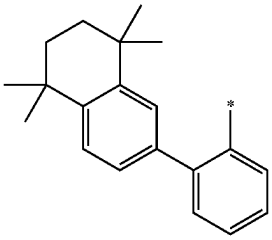
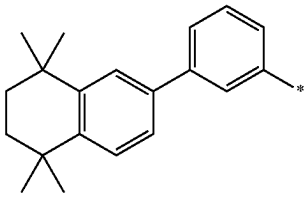
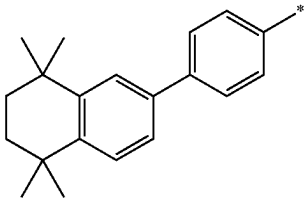
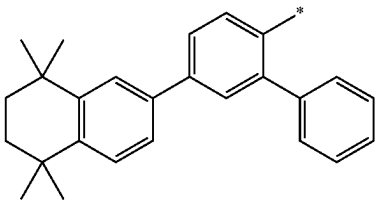
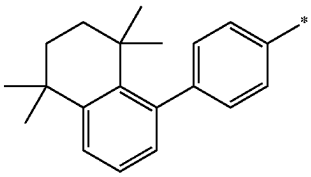
	Structure
T11	
T12	
T13	
T14	
T15	
T16	

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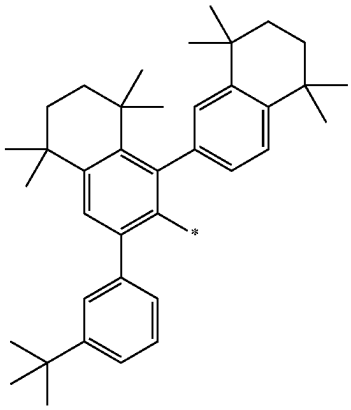
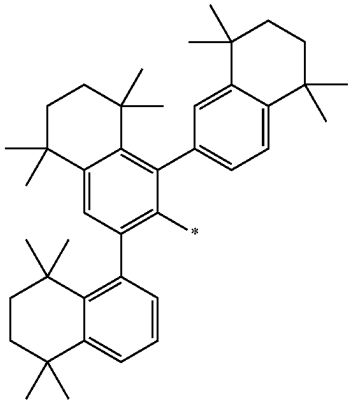
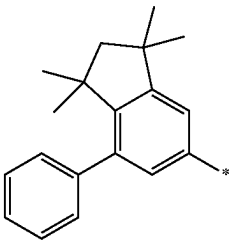
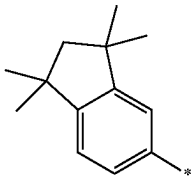
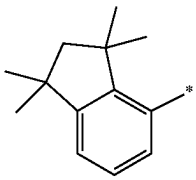
T17	
T18	
T19	
T20	
T21	

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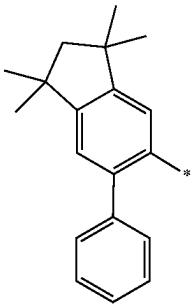
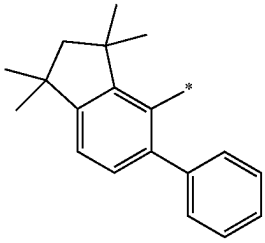
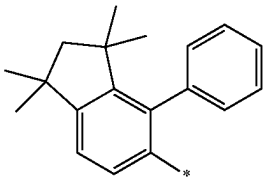
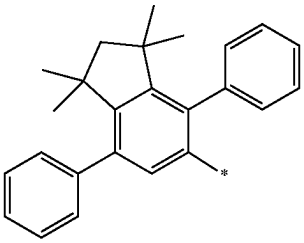
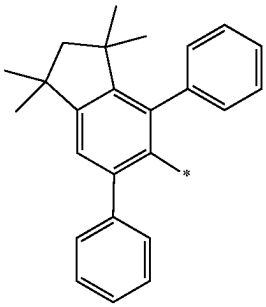
T22	
T23	
T24	
T25	
T26	

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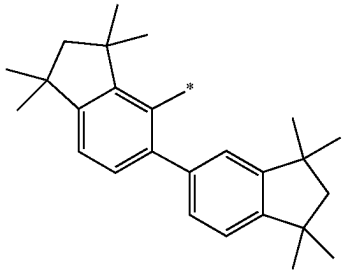
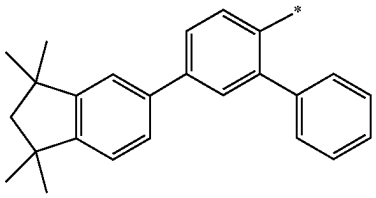
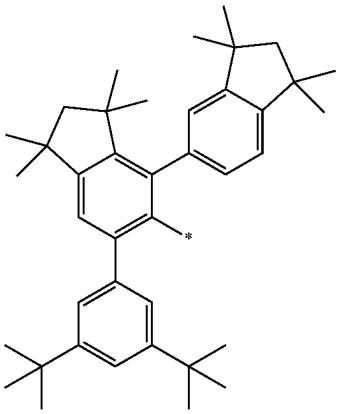
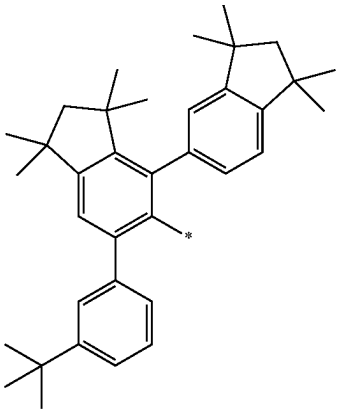
T27	
T28	
T29	
T30	

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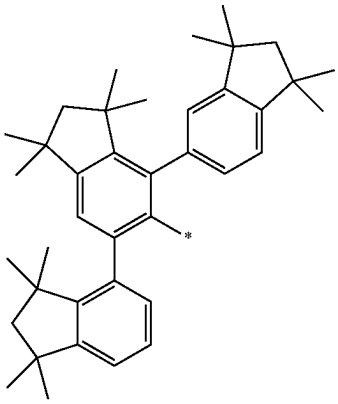
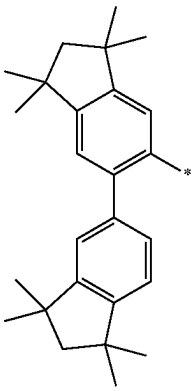
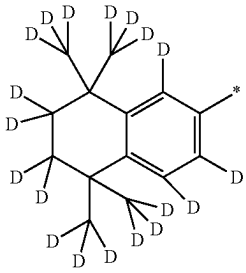
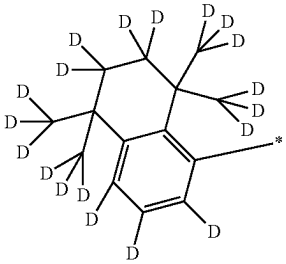
T31	
T32	
T33	
T34	

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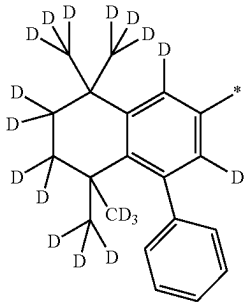
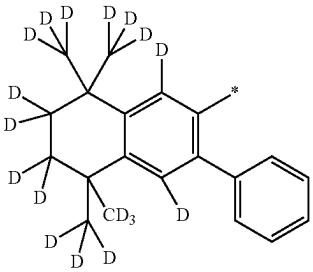
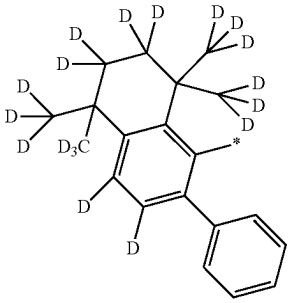
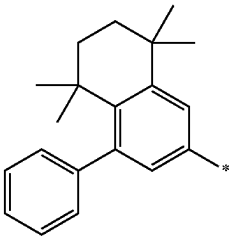
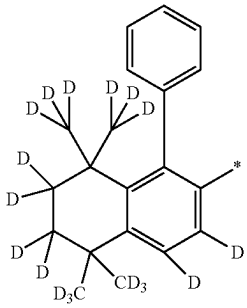
T35	
T36	
T37	
T38	
T39	

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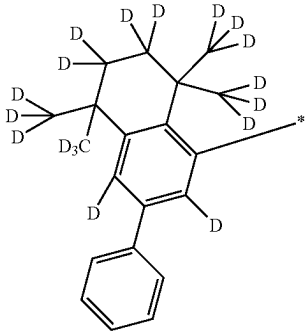
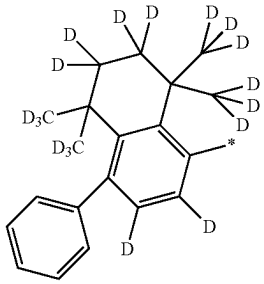
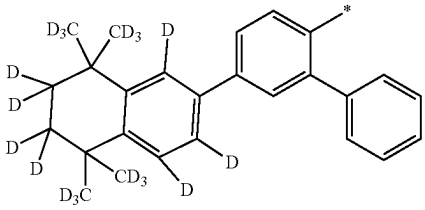
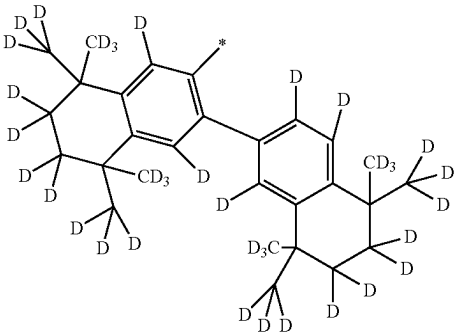
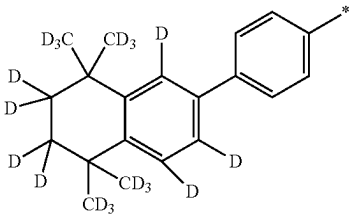
T40	
T41	
T42	
T43	
T44	

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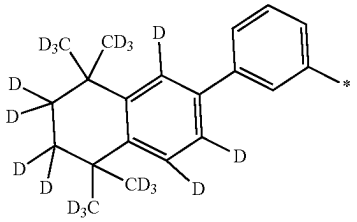
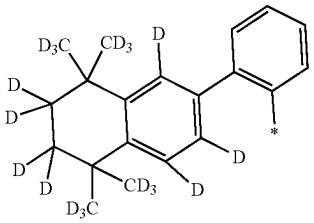
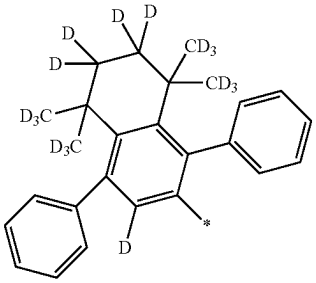
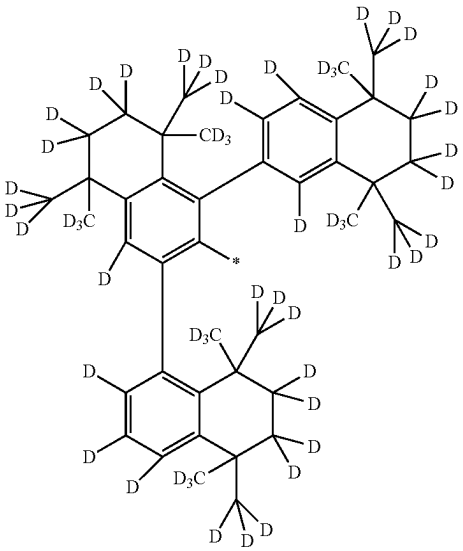
T45	
T46	
T47	
T48	

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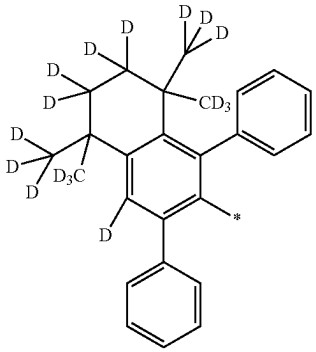
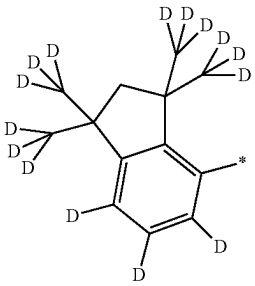
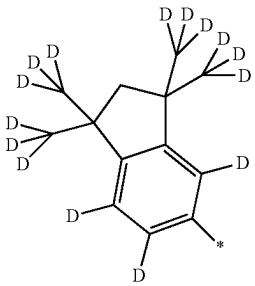
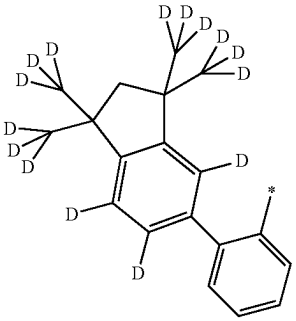
T49	
T50	
T51	
T52	

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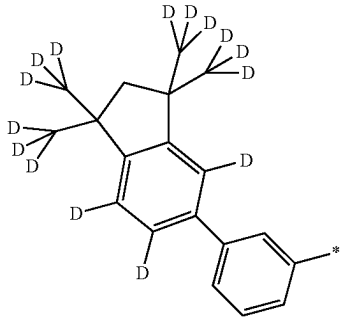
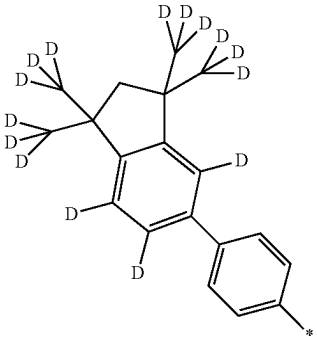
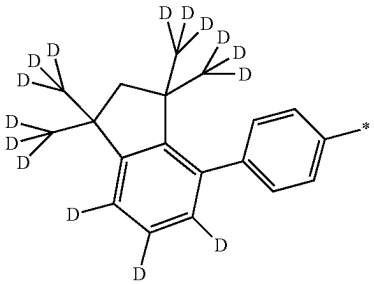
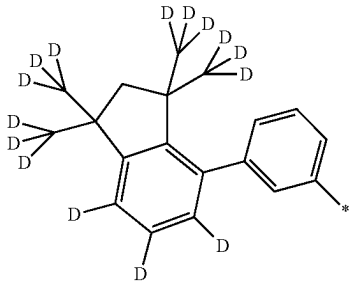
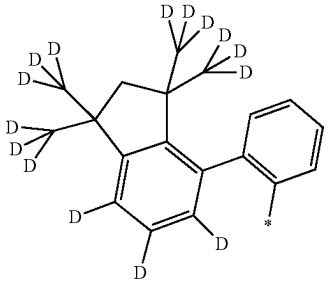
T53	
T54	
T55	
T56	
T57	

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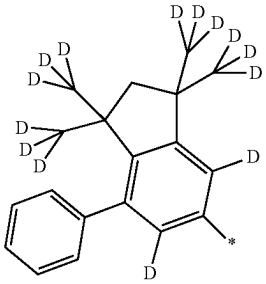
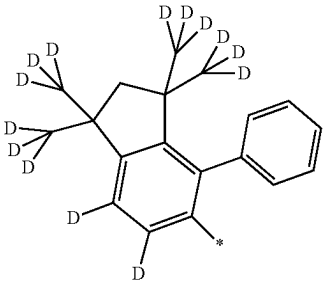
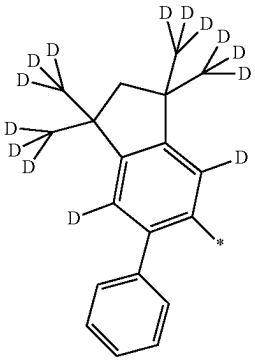
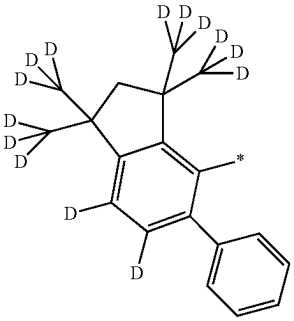
T58	
T59	
T60	
T61	

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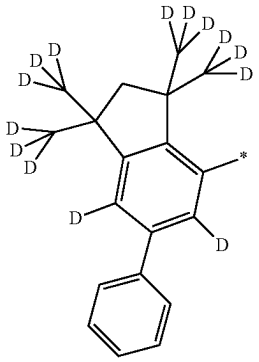
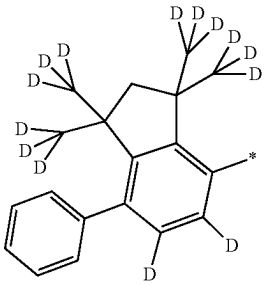
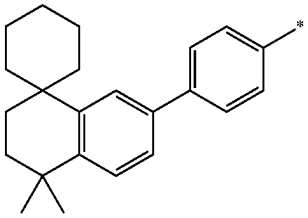
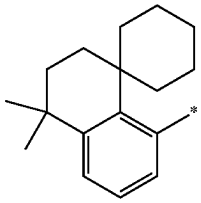
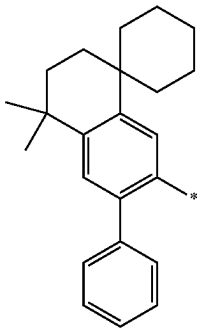
T62	
T63	
T64	
T65	
T66	

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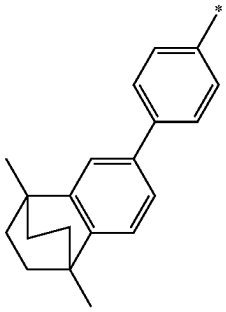
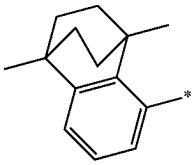
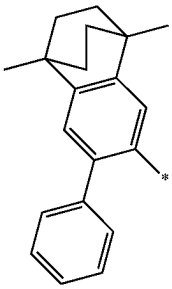
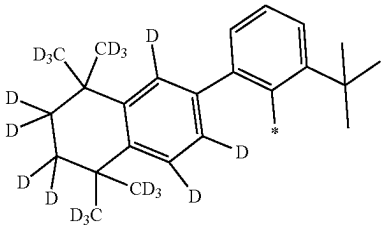
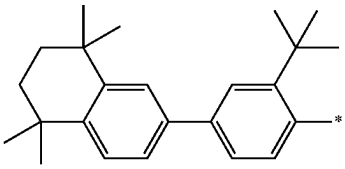
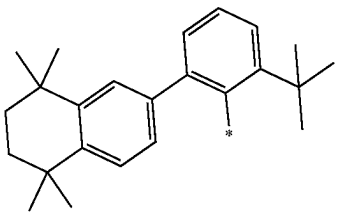
	Structure
T67	
T68	
T69	
T70	
T71	
T72	

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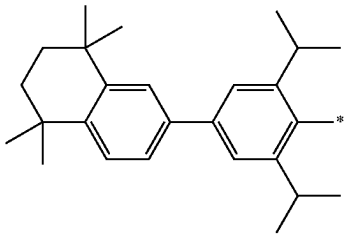
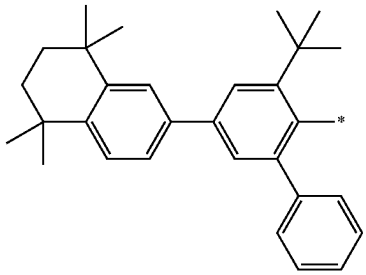
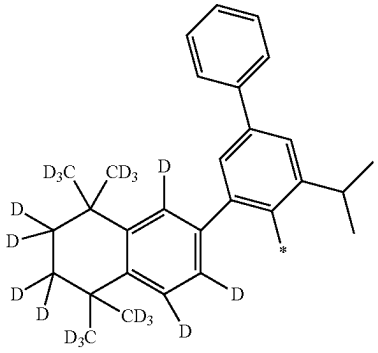
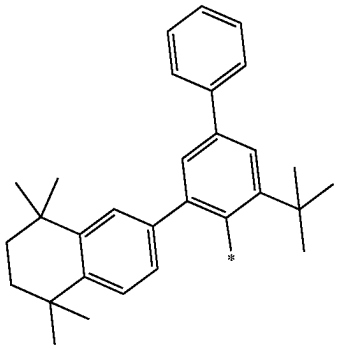
Structure	
T73	
T74	
T75	
T76	

[0203] wherein R1 to R468 are defined in the following LIST 5:

Structure	
R1	
R2	

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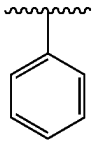
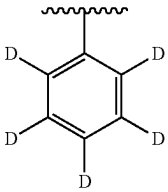
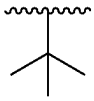
Structure	
R3	
R4	
R5	
R6	
R7	
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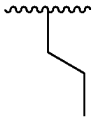
R9	
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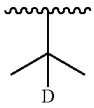
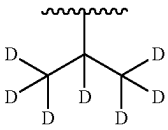
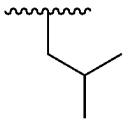
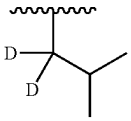
R11	
R12	
R13	
R14	

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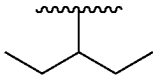
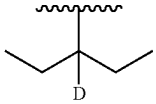
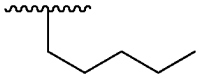
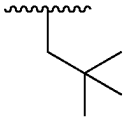
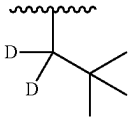
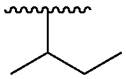
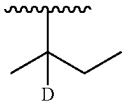
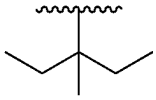
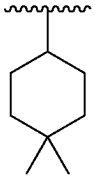
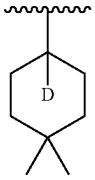
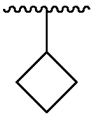
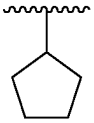
R15	
R16	
R17	
R18	
R19	
R20	
R21	
R22	
R23	
R24	
R25	
R26	

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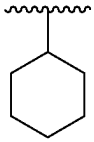
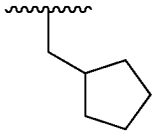
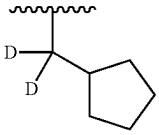
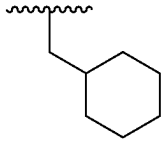
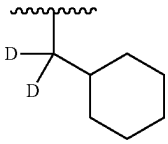
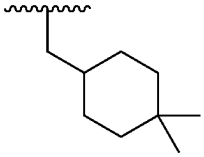
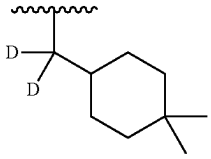
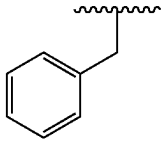
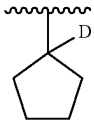
	Structure
R27	
R28	
R29	
R30	
R31	
R32	
R33	
R34	
R35	

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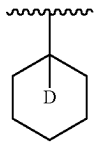
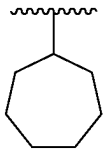
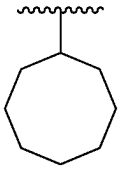
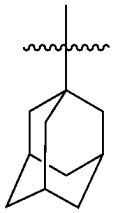
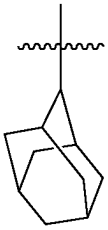
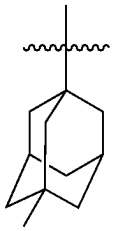
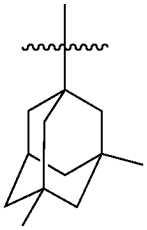
R36	
R37	
R38	
R39	
R40	
R41	
R42	

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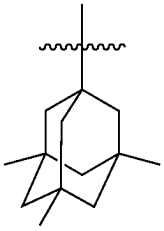
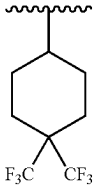
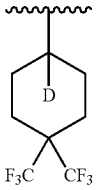
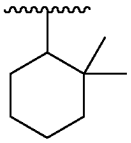
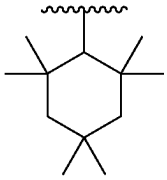
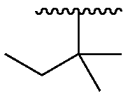
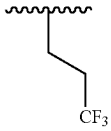
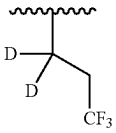
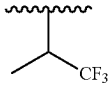
R43	
R44	
R45	
R46	
R47	
R48	
R49	
R50	
R51	

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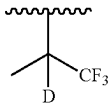
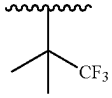
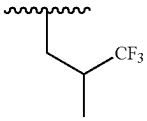
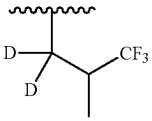
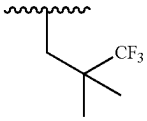
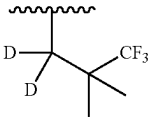
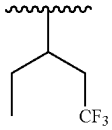
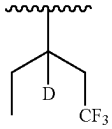
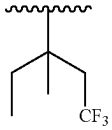
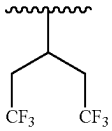
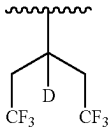
R52	
R53	
R54	
R55	
R56	
R57	
R58	
R59	
R60	
R61	
R62	

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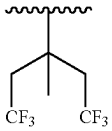
R63	
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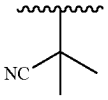
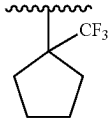
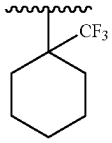
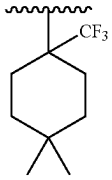
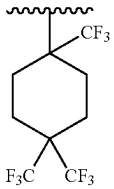
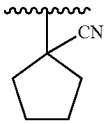
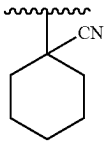
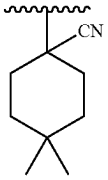
R65	
R66	
R67	
R68	
R69	
R70	
R71	
R72	

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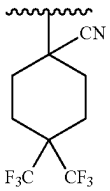
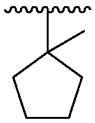
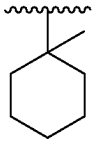
R73	
R74	
R75	
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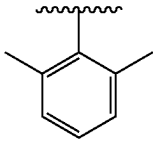
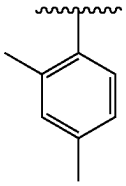
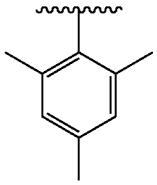
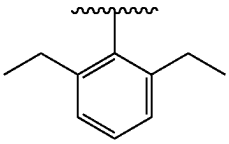
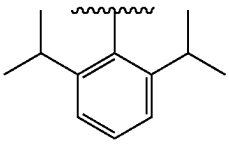
R77	
R78	
R79	
R80	
R81	

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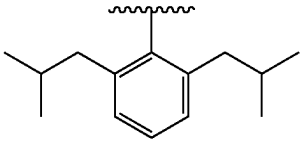
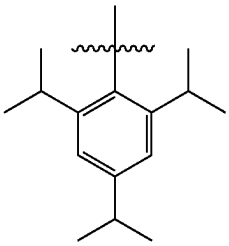
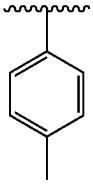
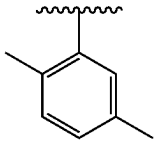
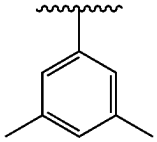
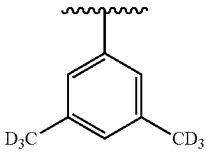
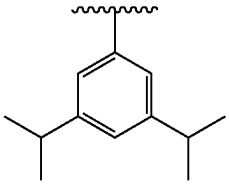
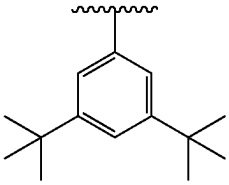
R82	
R83	
R84	
R85	
R86	
R87	
R88	
R89	

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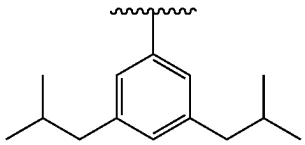
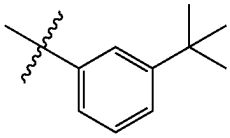
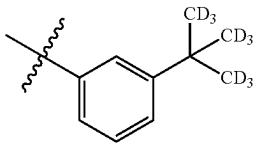
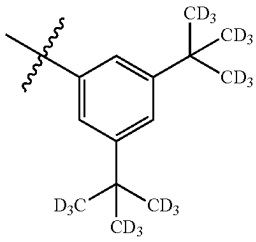
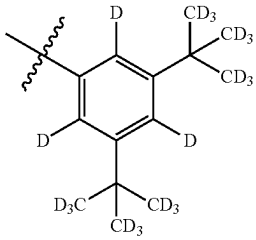
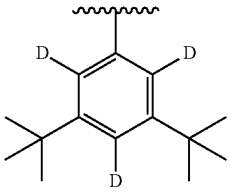
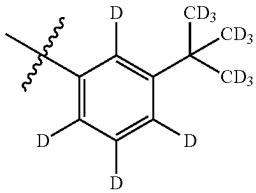
R90	
R91	
R92	
R93	
R94	
R95	
R96	

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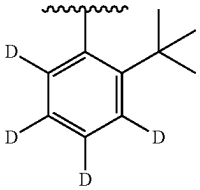
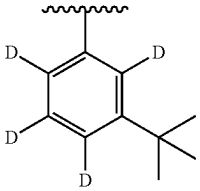
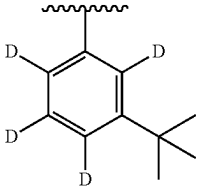
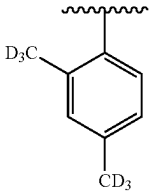
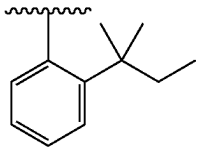
R97	
R98	
R99	
R100	
R101	
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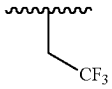
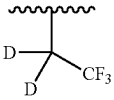
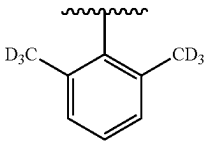
R104	
R105	
R106	

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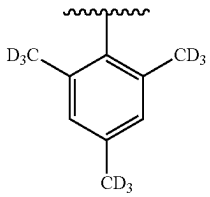
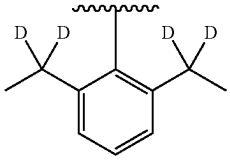
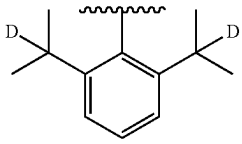
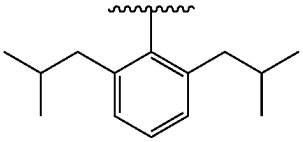
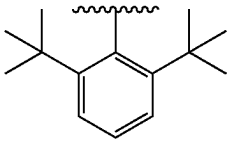
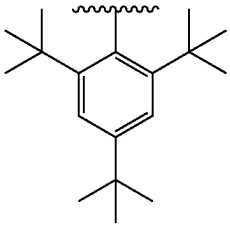
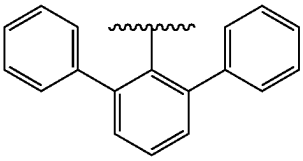
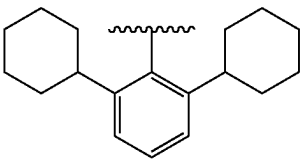
R107	
R108	
R109	
R110	
R111	
R112	
R113	
R114	

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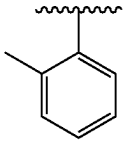
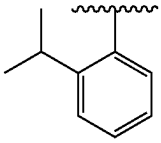
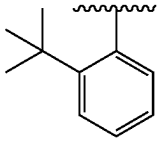
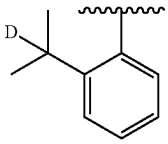
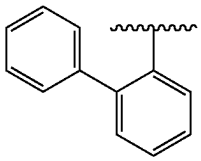
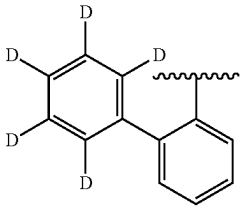
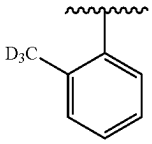
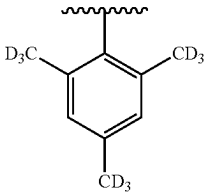
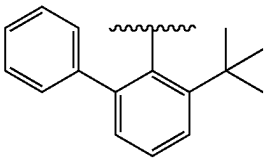
R115	
R116	
R117	
R118	
R119	
R120	
R121	
R122	
R123	

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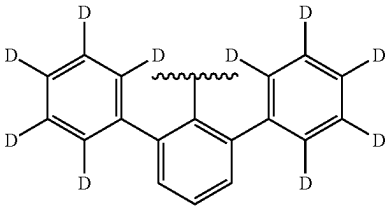
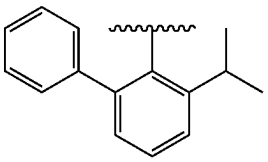
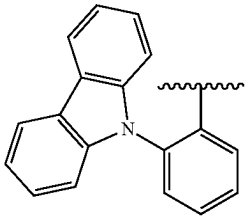
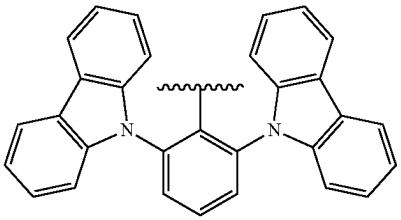
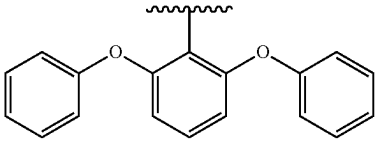
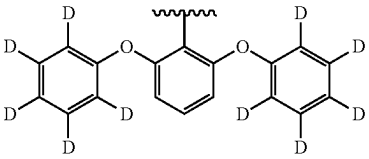
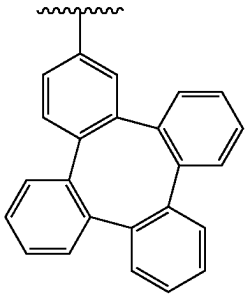
R124	
R125	
R126	
R127	
R128	
R129	
R130	

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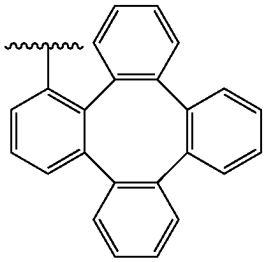
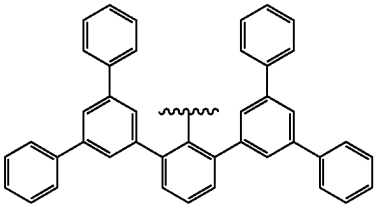
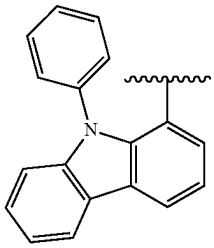
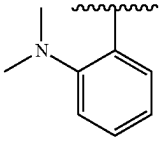
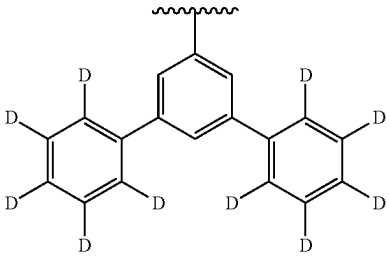
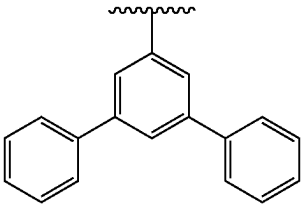
R131	
R132	
R133	
R134	
R135	
R136	

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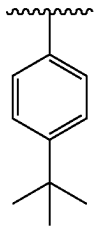
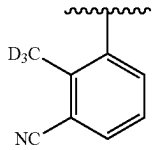
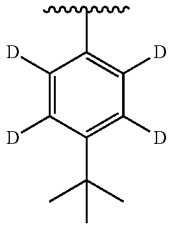
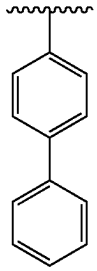
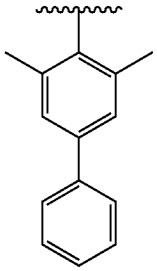
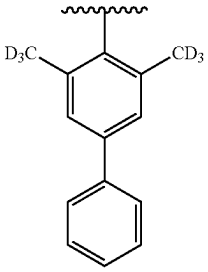
R137	
R138	
R139	
R140	
R141	
R142	

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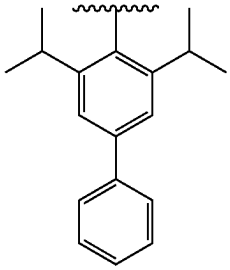
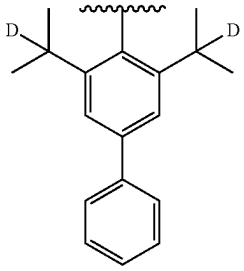
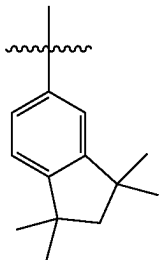
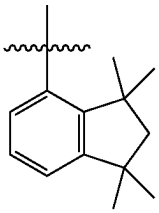
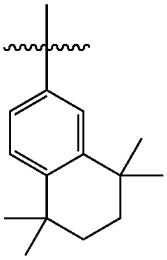
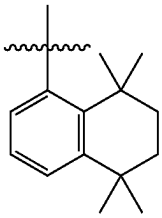
R143	
R144	
R145	
R146	
R147	
R148	

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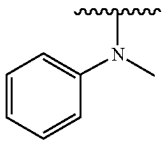
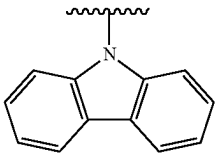
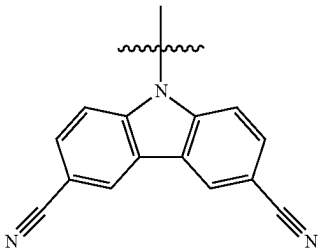
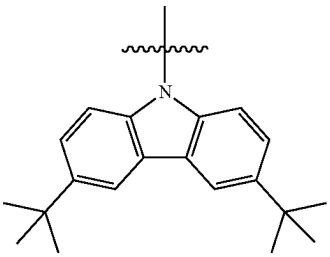
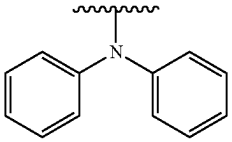
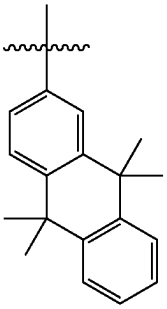
R149	
R150	
R151	
R152	
R153	
R154	

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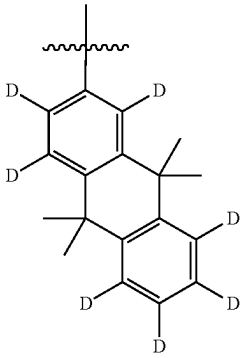
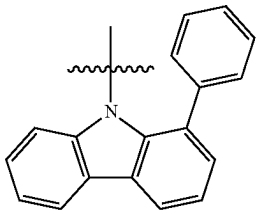
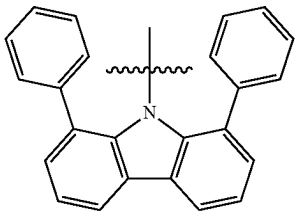
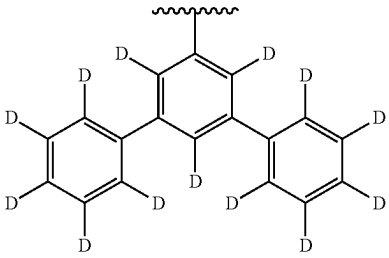
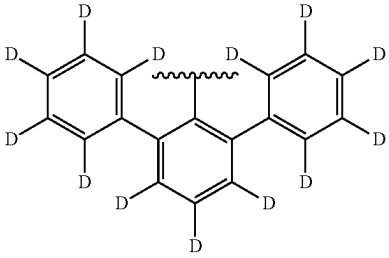
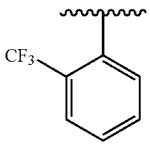
R155	
R156	
R157	
R158	
R159	
R160	

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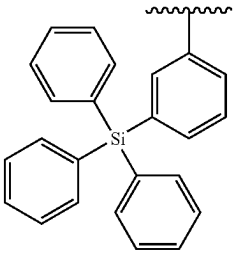
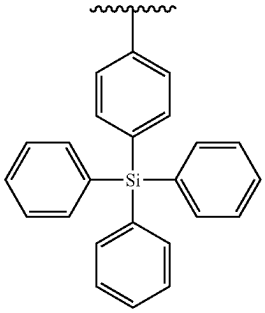
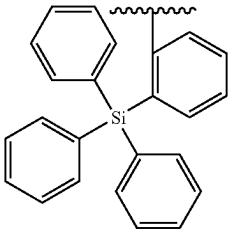
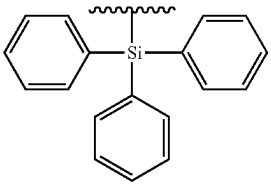
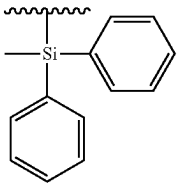
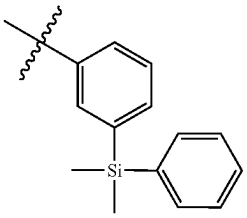
R161	
R162	
R163	
R164	
R165	
R166	

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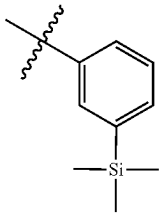
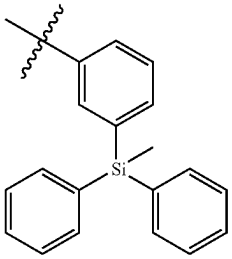
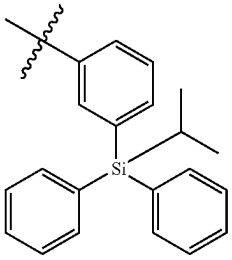
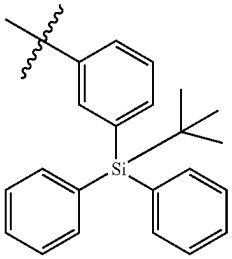
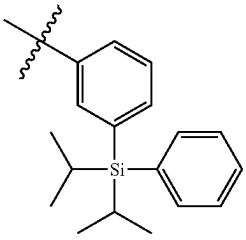
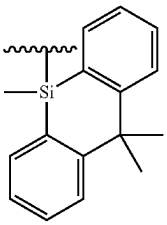
R167	
R168	
R169	
R170	
R171	
R172	

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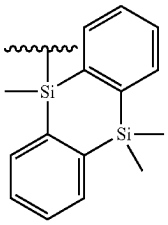
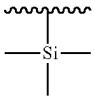
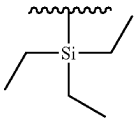
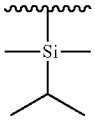
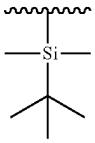
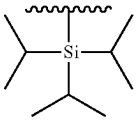
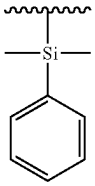
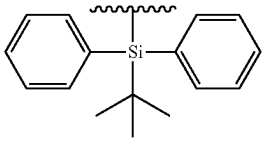
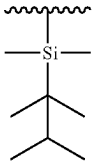
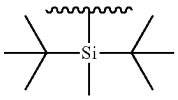
R173 
R174 
R175 
R176 
R177 
R178 
R179 
R180 
R181 
R182 

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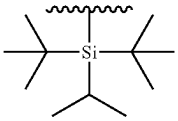
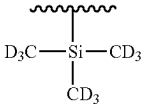
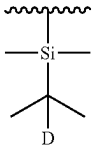
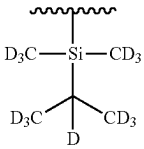
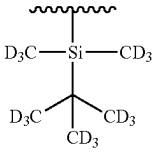
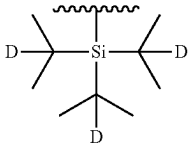
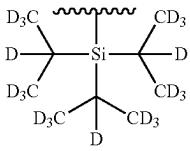
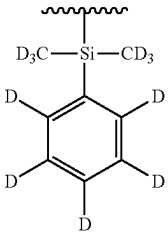
R183 
R184 
R185 
R186 
R187 
R188 
R189 
R190 

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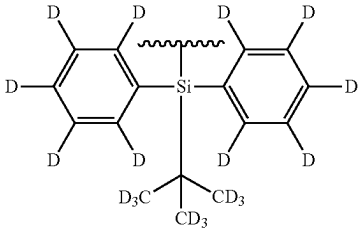
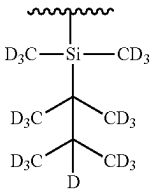
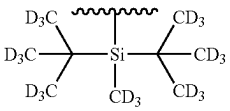
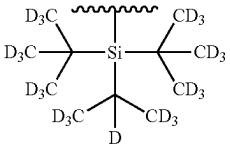
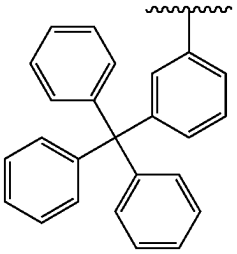
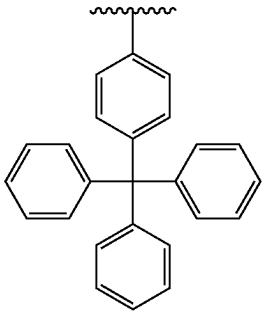
R191	
R192	
R193	
R194	
R195	
R196	

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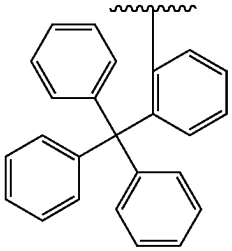
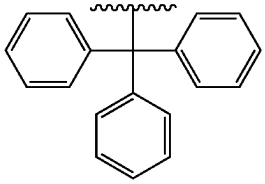
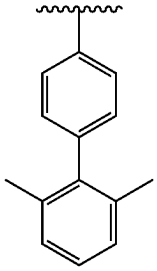
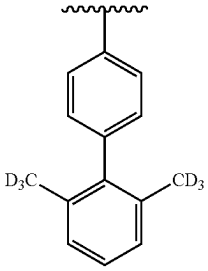
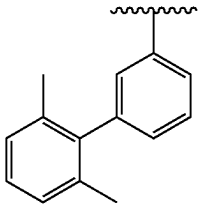
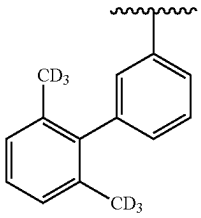
R197	
R198	
R199	
R200	
R201	
R202	

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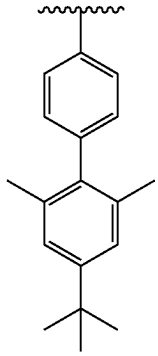
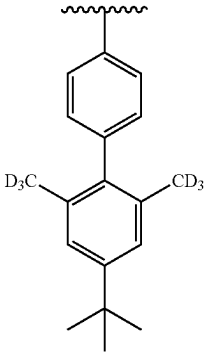
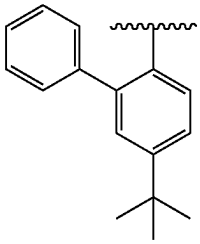
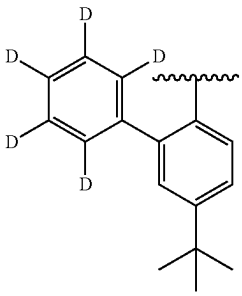
R203	
R204	
R205	
R206	

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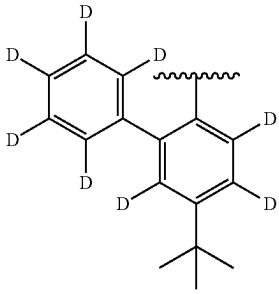
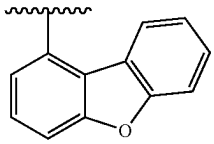
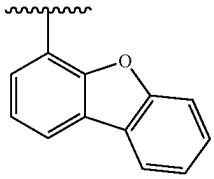
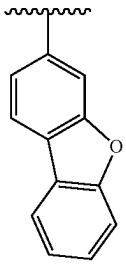
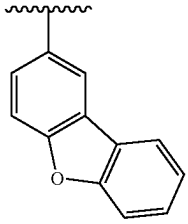
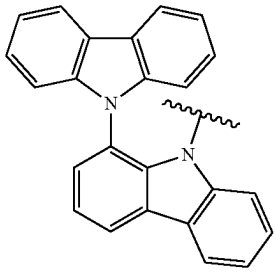
R207	
R208	
R209	
R210	
R211	
R212	

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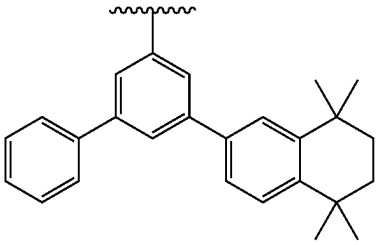
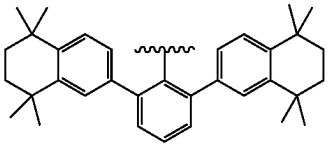
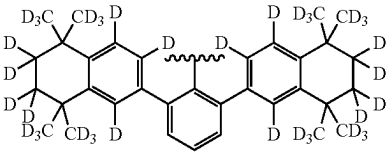
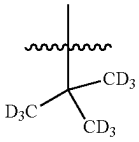
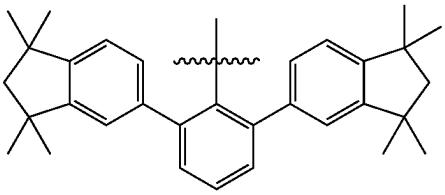
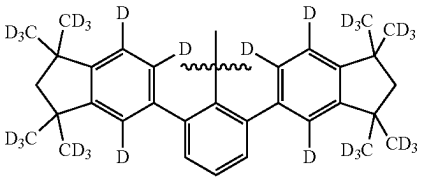
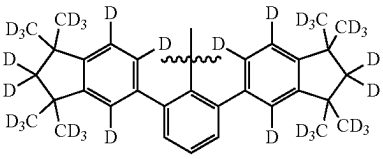
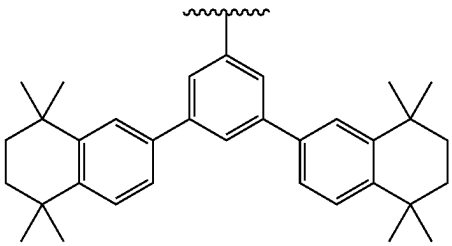
R213	
R214	
R215	
R216	
R217	
R218	
R219	
R220	

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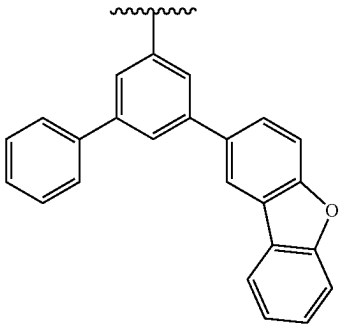
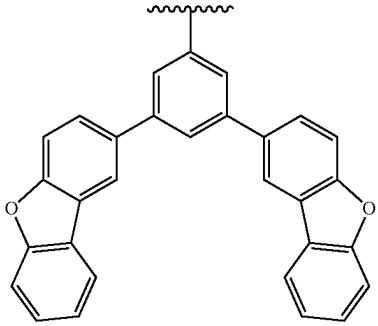
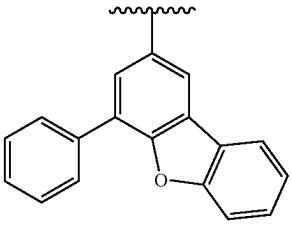
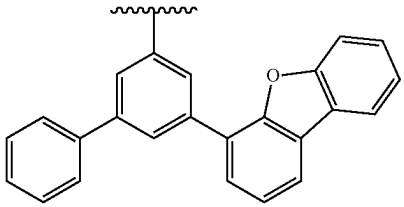
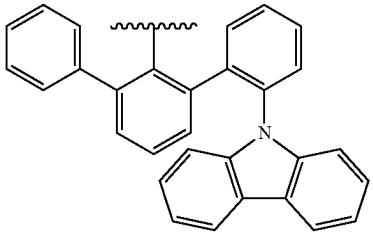
R221	
R222	
R223	
R224	
R225	

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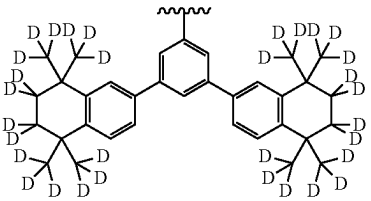
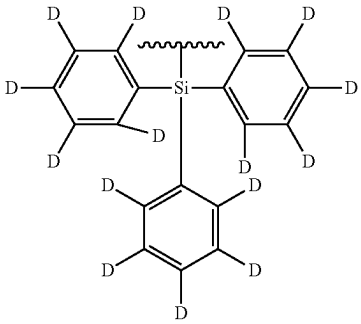
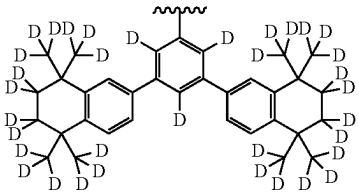
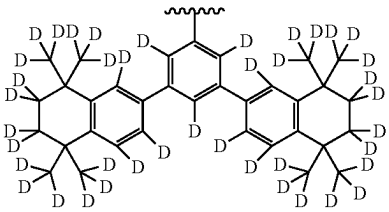
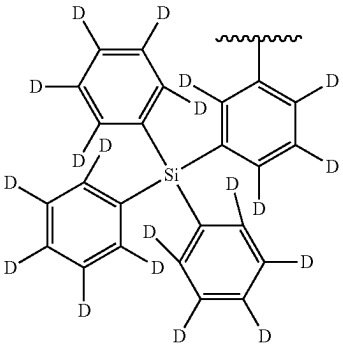
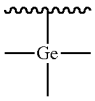
R226	
R227	
R228	
R229	
R230	
R231	

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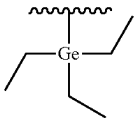
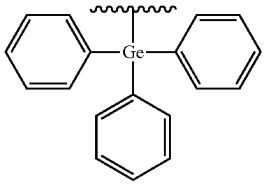
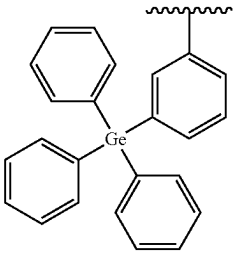
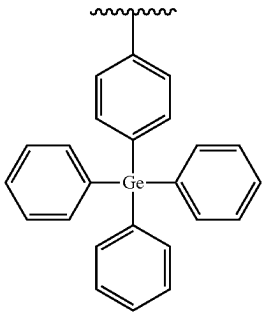
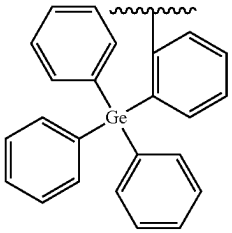
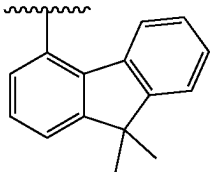
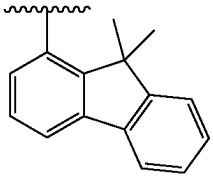
R232	
R233	
R234	
R235	
R236	
R237	
R238	

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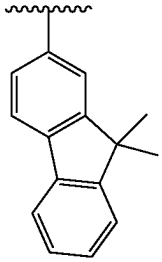
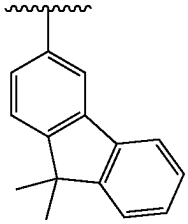
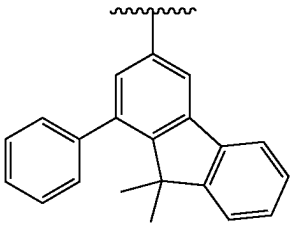
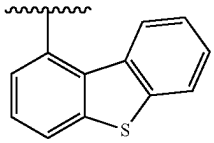
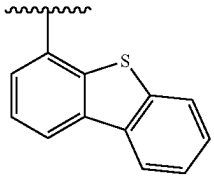
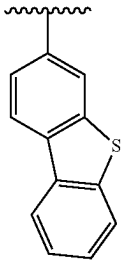
R239	
R240	
R241	
R242	
R243	
R244	

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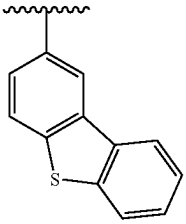
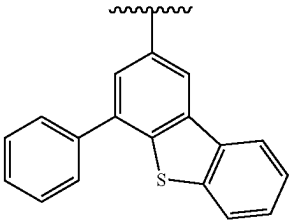
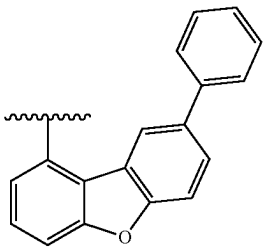
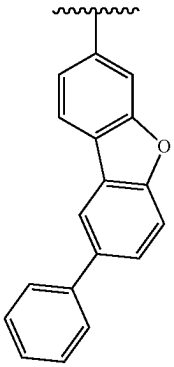
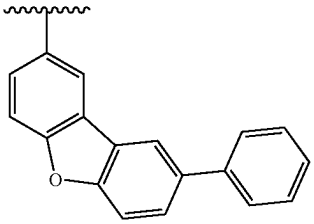
R245	
R246	
R247	
R248	
R249	

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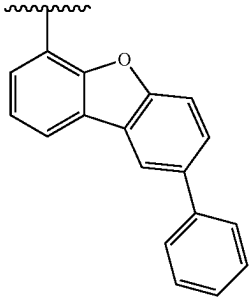
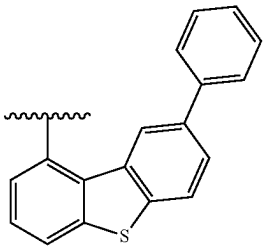
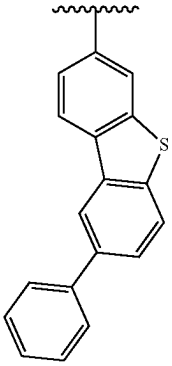
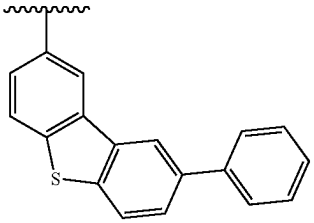
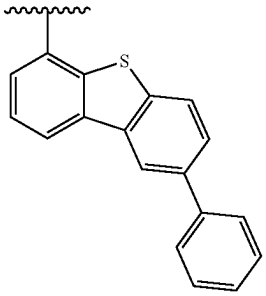
R250 
R251 
R252 
R253 
R254 

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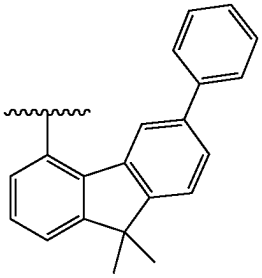
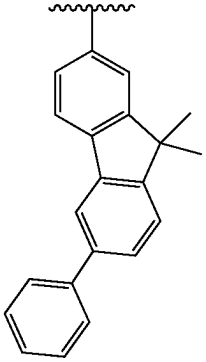
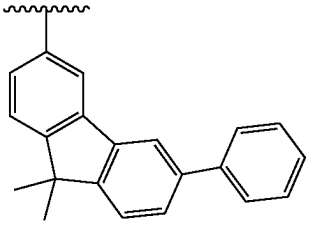
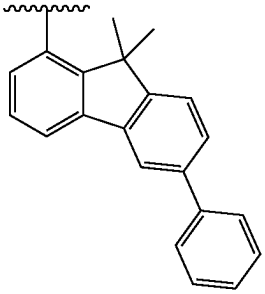
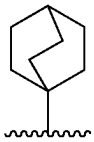
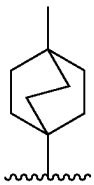
R255 
R256 
R257 
R258 
R259 
R260 

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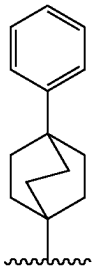
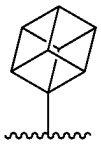
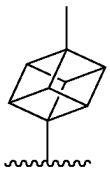
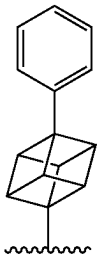
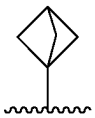
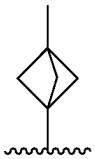
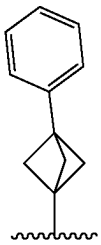
R261 
R262 
R263 
R264 
R265 
R266 
R267 

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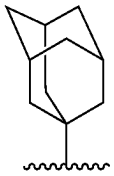
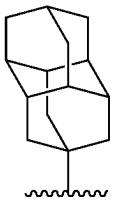
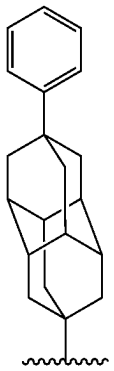
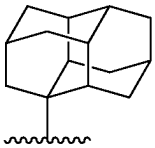
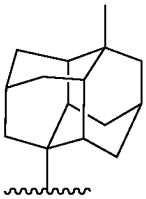
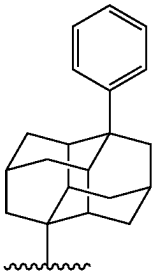
R268 
R269 
R270 
R271 
R272 
R273 

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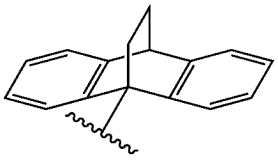
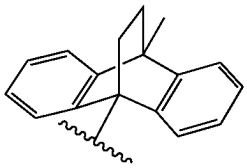
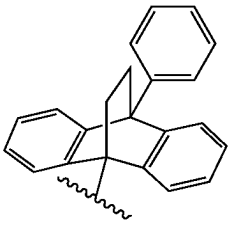
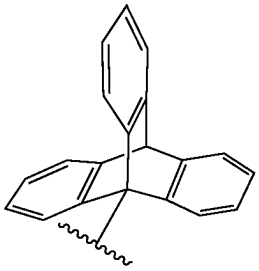
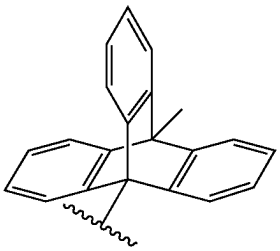
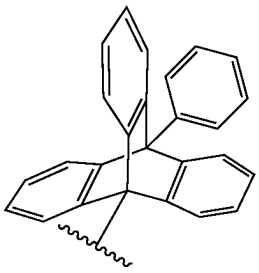
Structure
R274 
R275 
R276 
R277 
R278 
R279 
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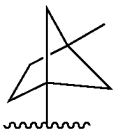
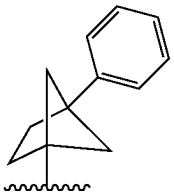
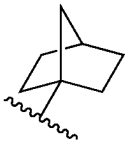
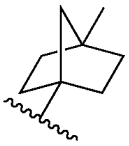
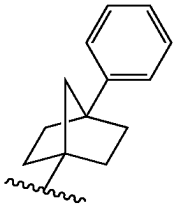
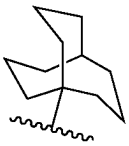
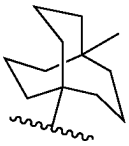
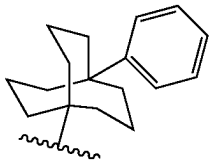
R281 
R282 
R283 
R284 
R285 
R286 
R287 
R288 

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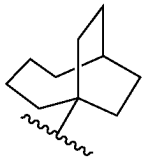
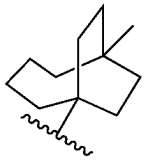
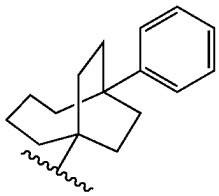
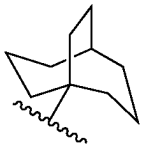
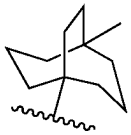
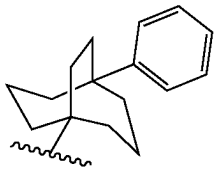
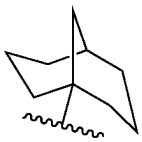
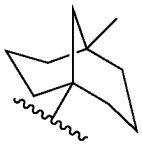
R289 
R290 
R291 
R292 
R293 
R294 
R295 
R296 

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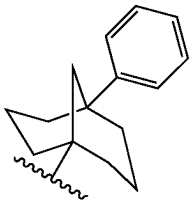
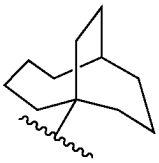
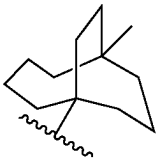
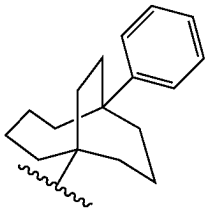
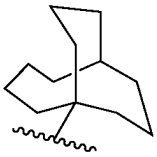
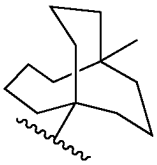
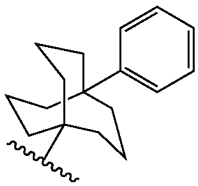
R297 
R298 
R299 
R300 
R301 
R302 
R303 
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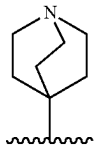
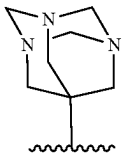
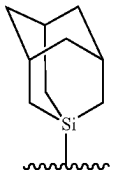
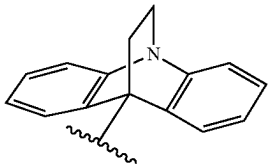
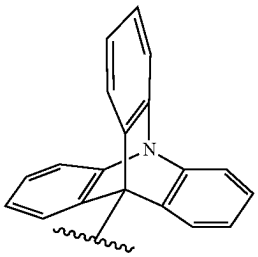
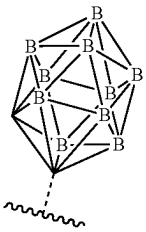
R305	
R306	
R307	
R308	
R309	
R310	

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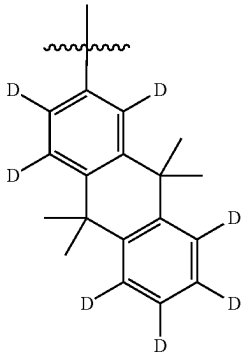
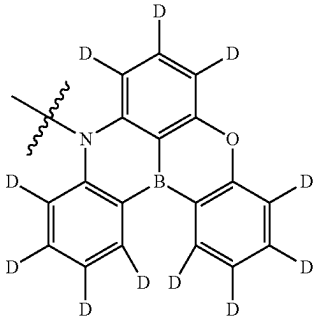
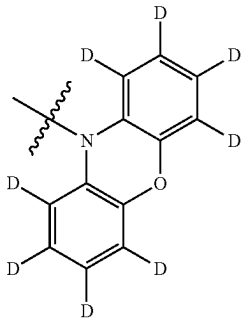
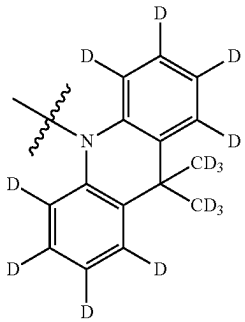
R311	
R312	
R313	
R314	

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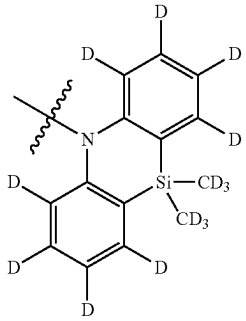
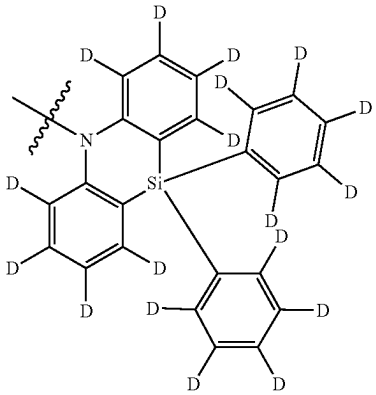
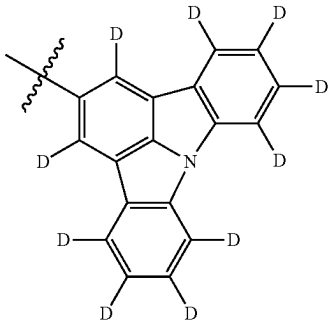
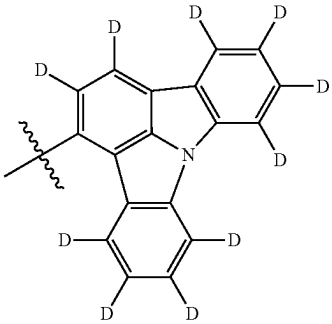
R315 
R316 
R317 
R318 

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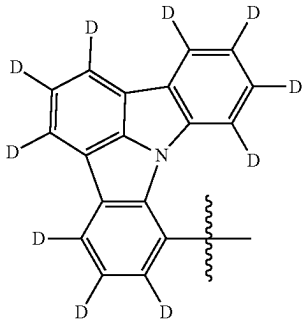
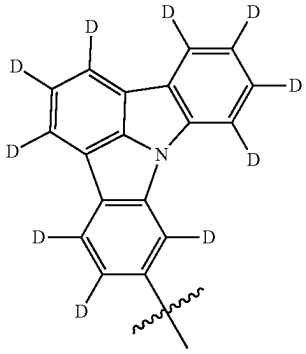
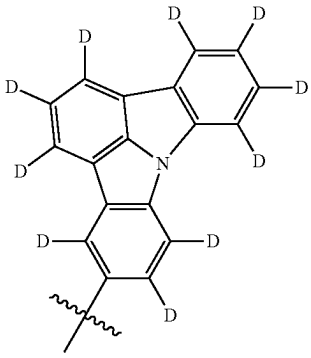
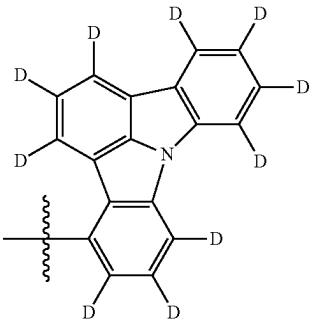
R319 
R320 
R321 
R322 

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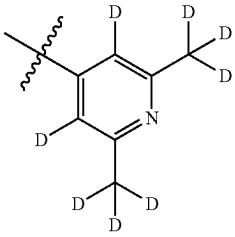
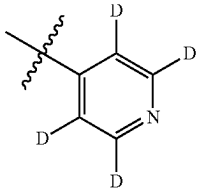
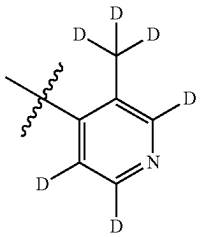
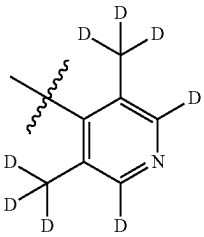
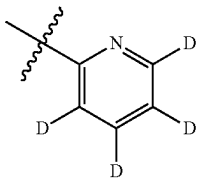
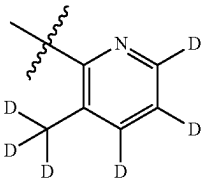
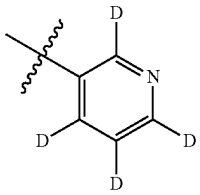
R323	
R324	
R325	
R326	
R327	
R328	
R329	

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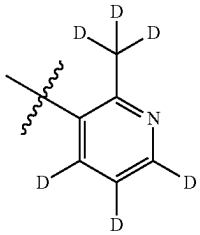
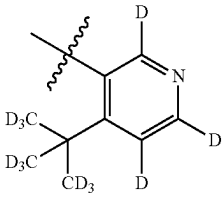
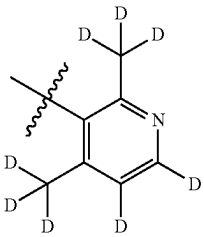
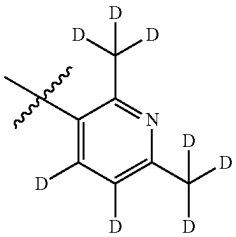
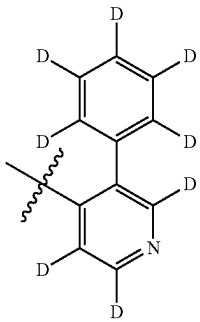
R330	
R331	
R332	
R333	
R334	

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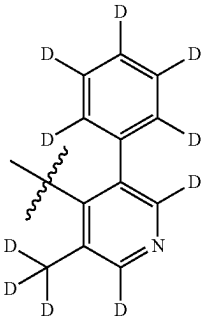
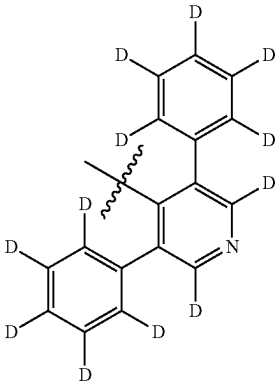
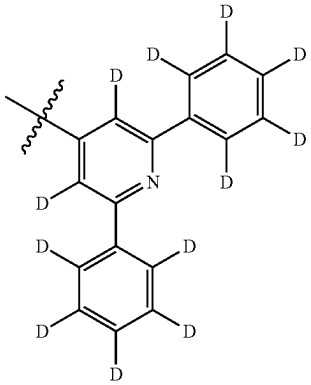
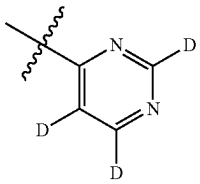
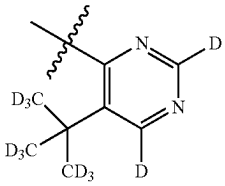
R335 
R336 
R337 
R338 
R339 

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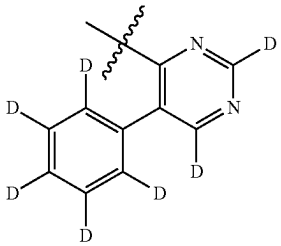
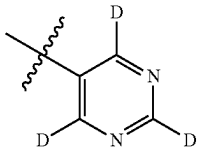
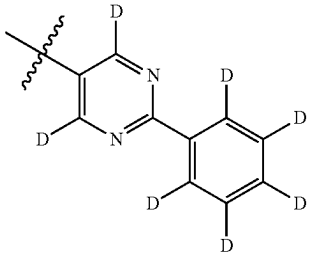
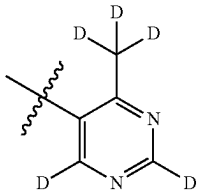
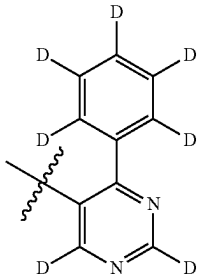
R340 
R341 
R342 
R343 
R344 

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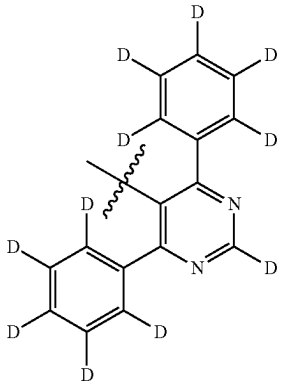
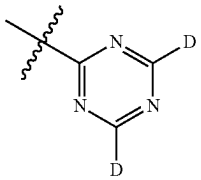
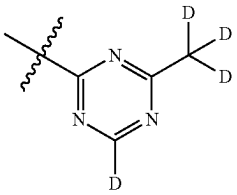
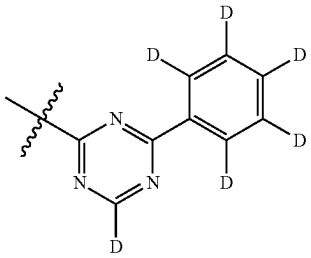
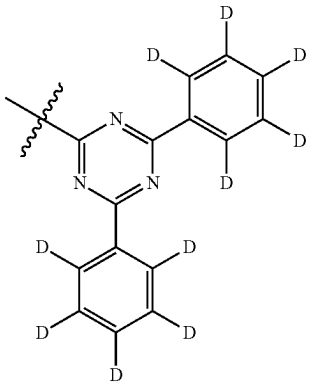
R345	
R346	
R347	
R348	
R349	

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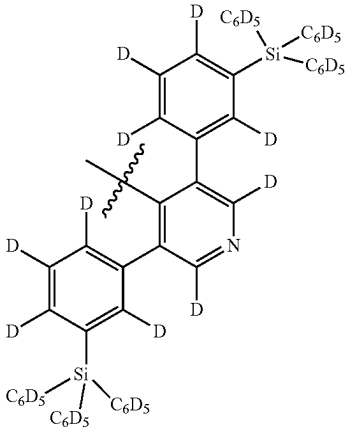
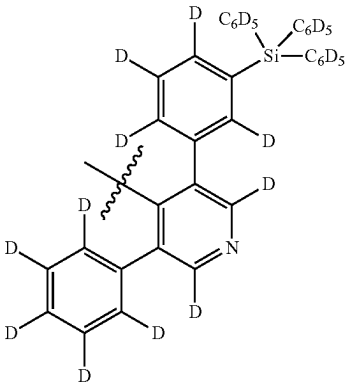
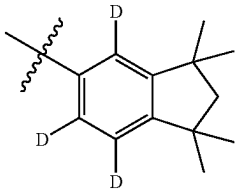
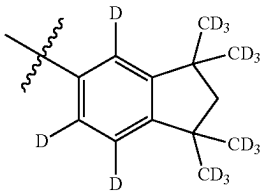
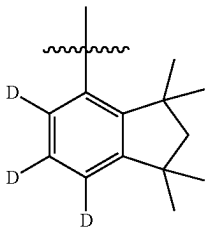
R350	
R351	
R352	
R353	
R354	

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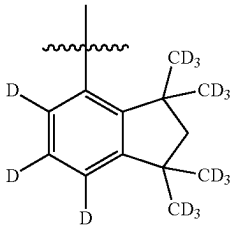
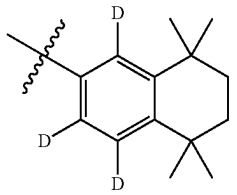
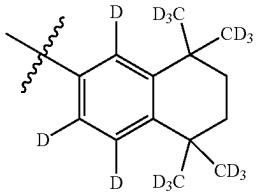
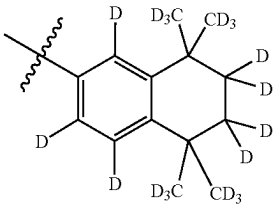
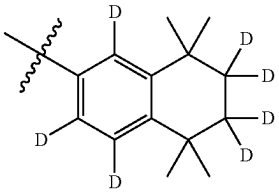
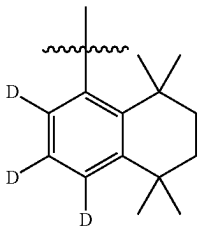
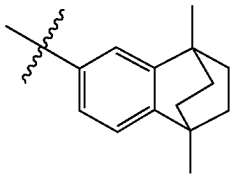
R355	
R356	
R357	
R358	
R359	
R360	
R361	

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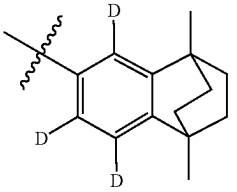
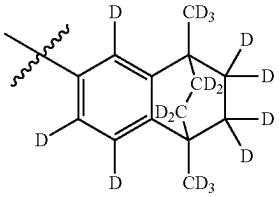
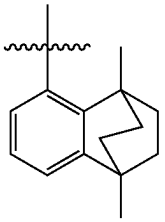
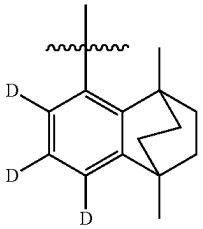
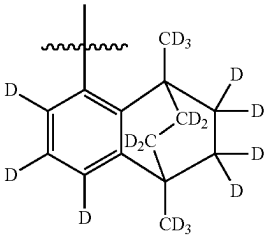
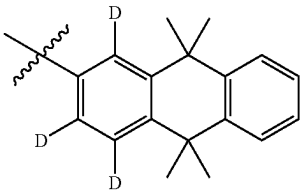
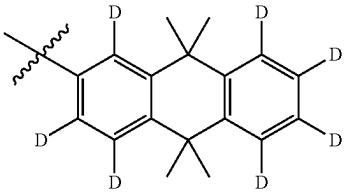
R362	
R363	
R364	
R365	
R366	
R367	
R368	

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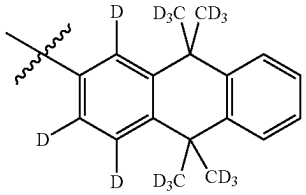
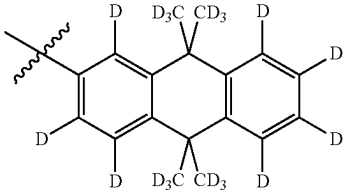
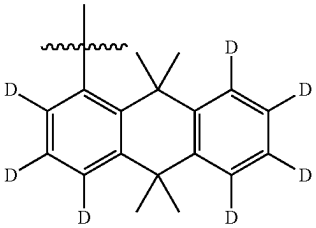
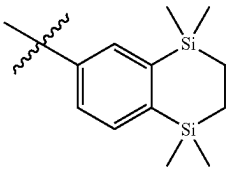
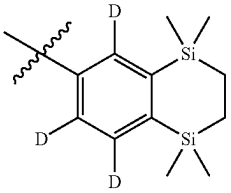
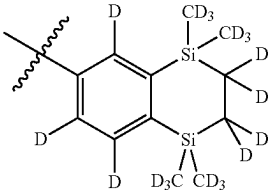
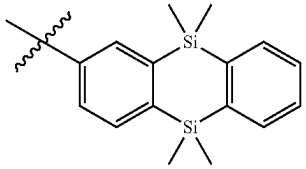
R369 
R370 
R371 
R372 
R373 
R374 
R375 

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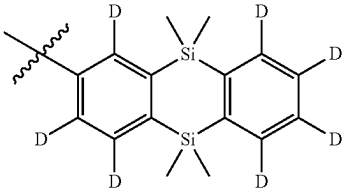
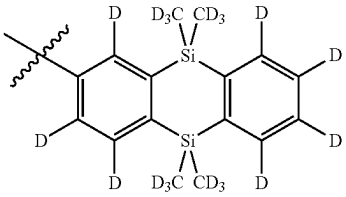
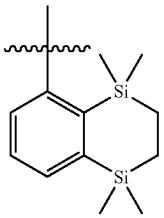
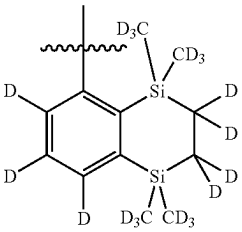
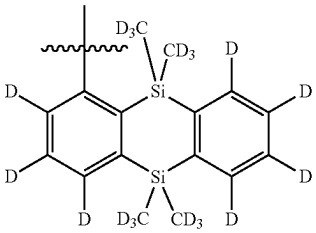
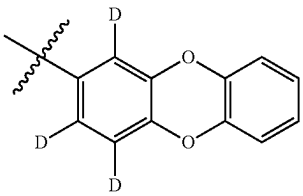
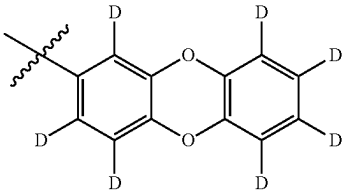
R376 
R377 
R378 
R379 
R380 
R381 
R382 

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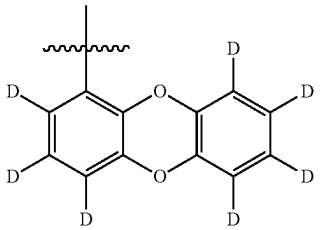
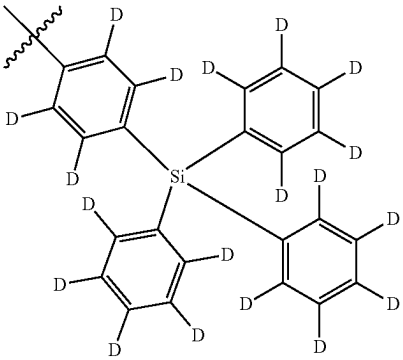
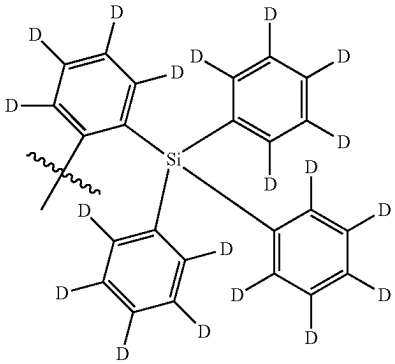
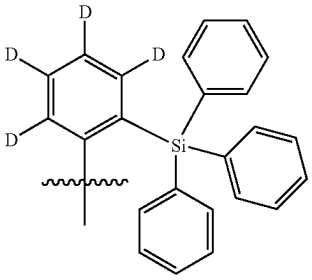
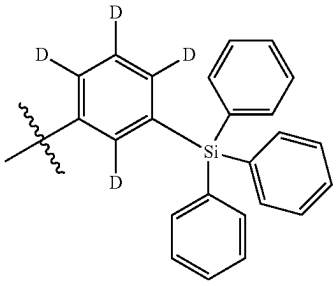
R383	
R384	
R385	
R386	
R387	

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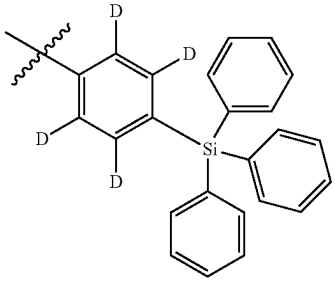
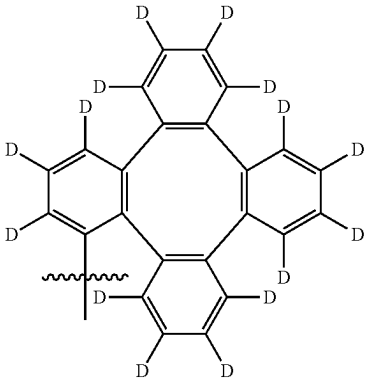
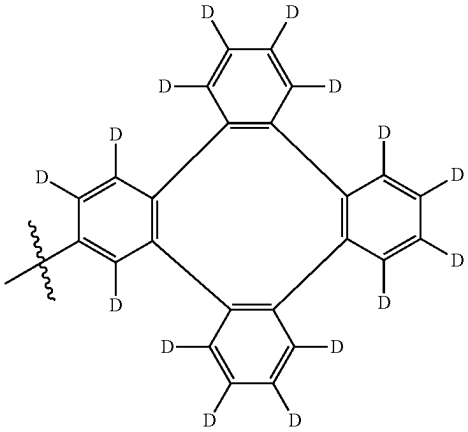
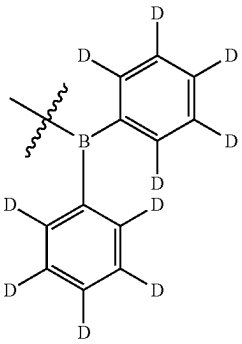
R388	
R389	
R390	
R391	

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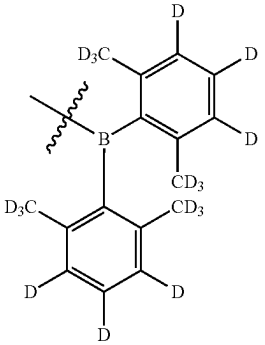
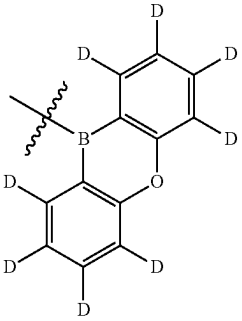
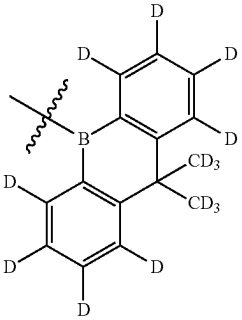
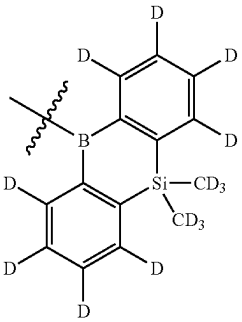
R392 
R393 
R394 
R395 

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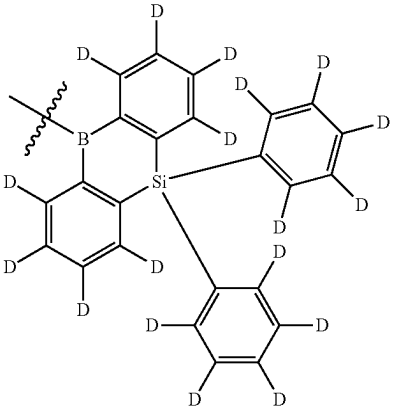
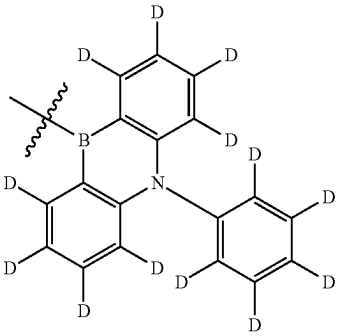
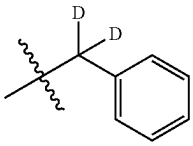
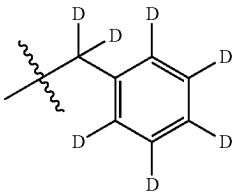
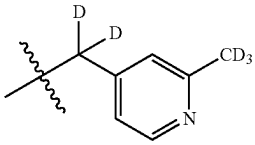
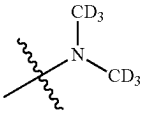
R396 
R397 
R398 
R399 
R400 
R401 

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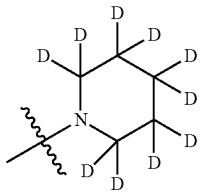
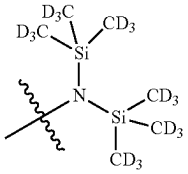
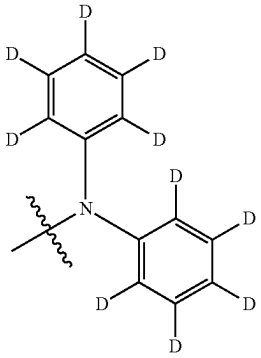
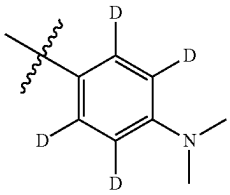
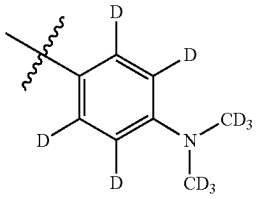
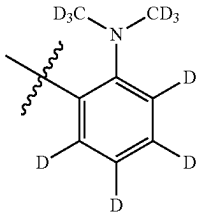
R402	
R403	
R404	
R405	
R406	
R407	

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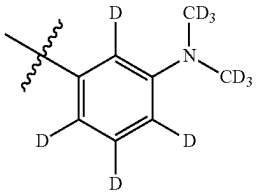
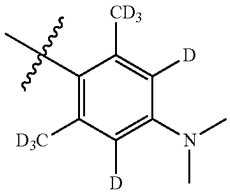
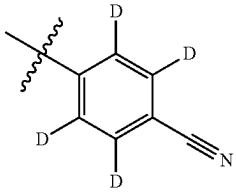
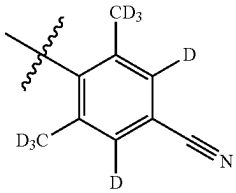
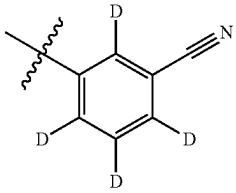
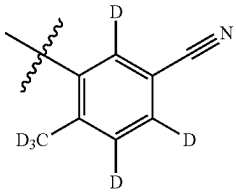
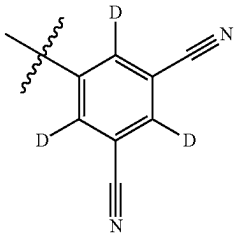
R408	
R409	
R410	
R411	
R412	
R413	
R414	

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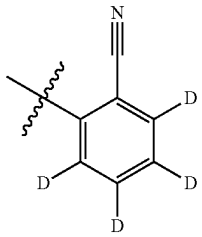
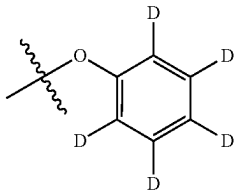
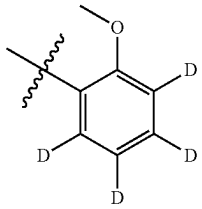
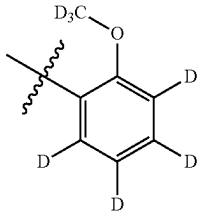
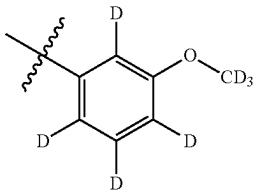
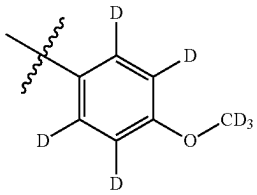
R415	
R416	
R417	
R418	
R419	
R420	

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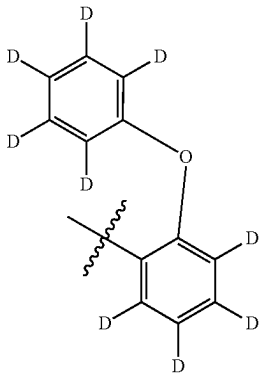
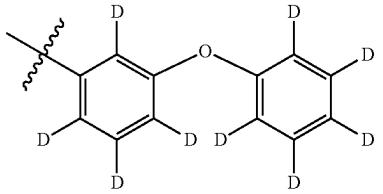
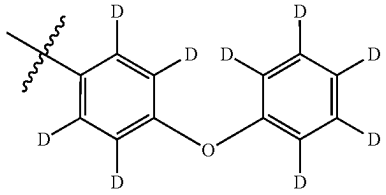
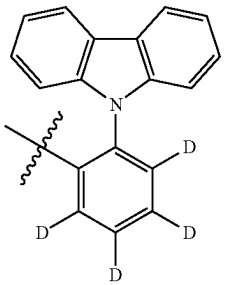
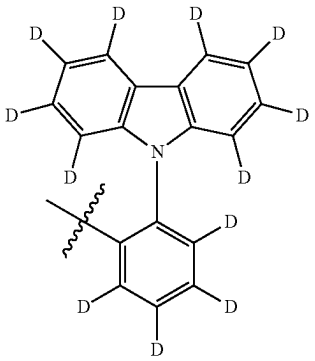
R421	
R422	
R423	
R424	
R425	

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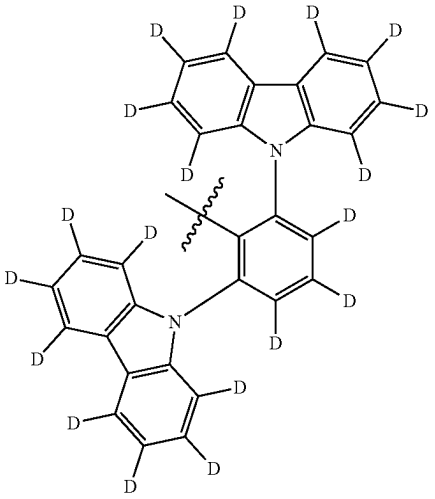
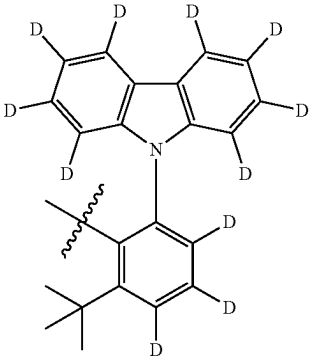
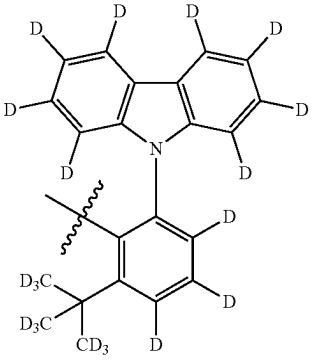
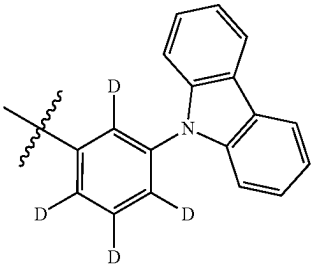
R426	
R427	
R428	
R429	

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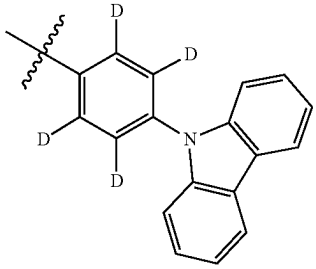
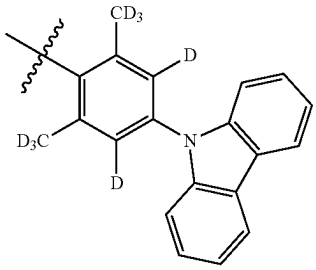
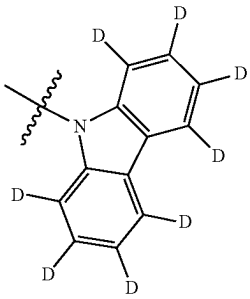
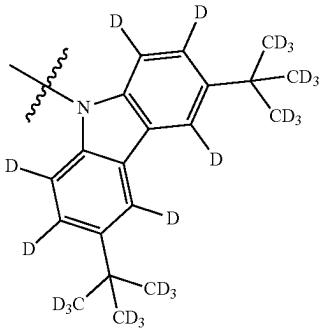
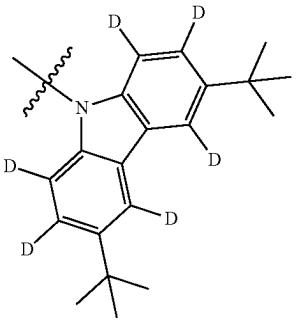
R430	
R431	
R432	
R433	
R434	

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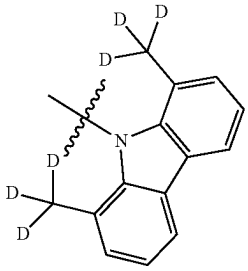
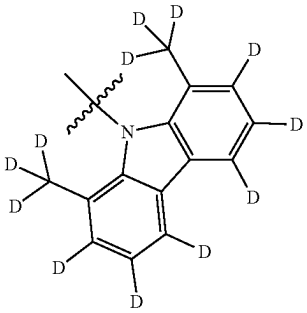
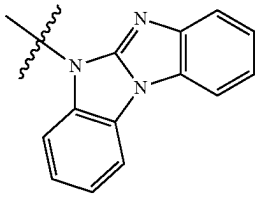
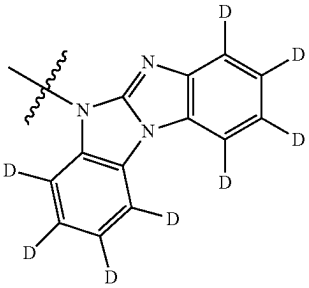
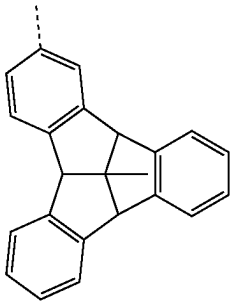
R435 
R436 
R437 
R438 
R439 

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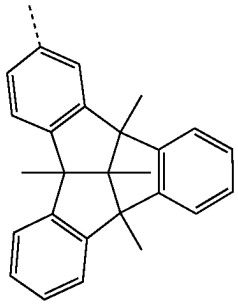
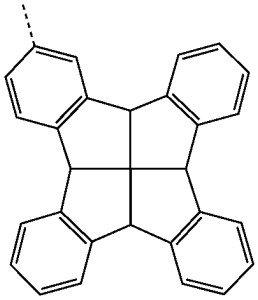
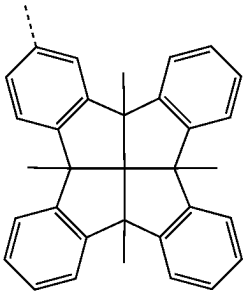
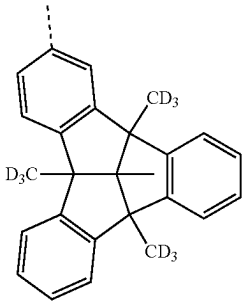
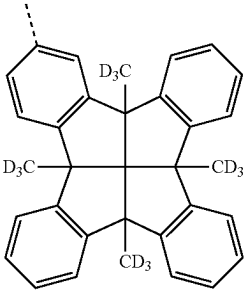
Structure
R440 
R441 
R442 
R443 
R444 

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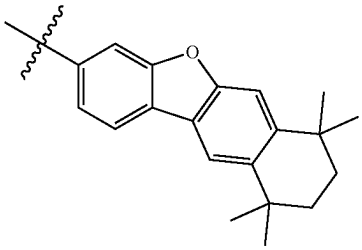
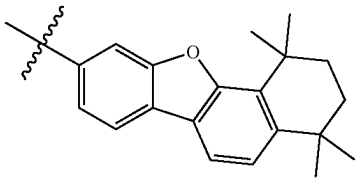
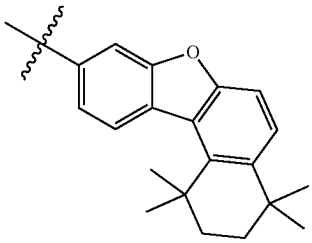
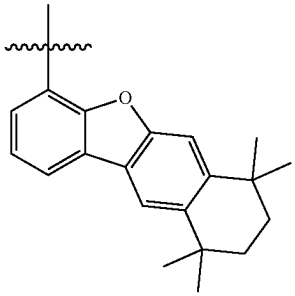
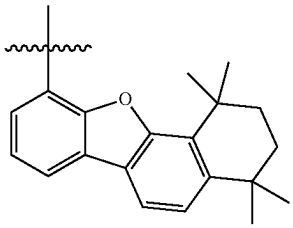
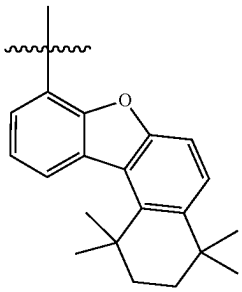
R445	
R446	
R447	
R448	
R449	
R450	

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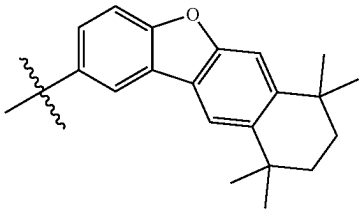
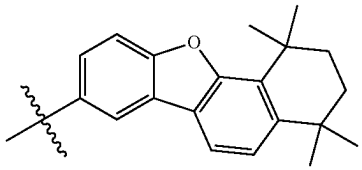
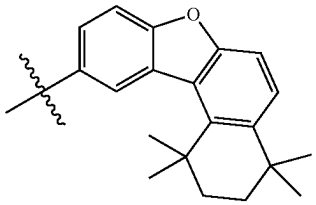
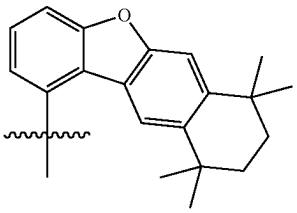
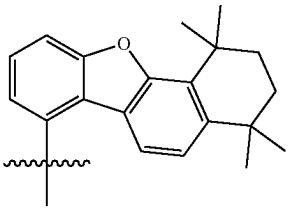
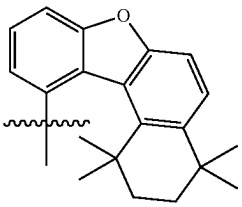
R451	
R452	
R453	
R454	
R455	
R456	

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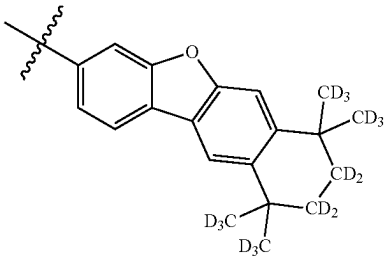
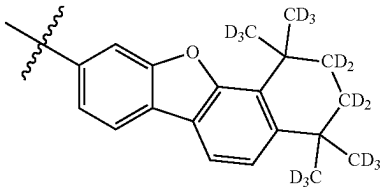
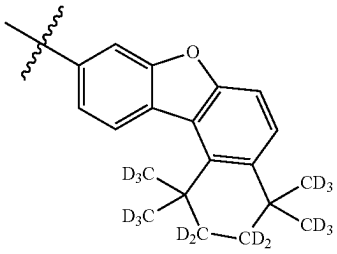
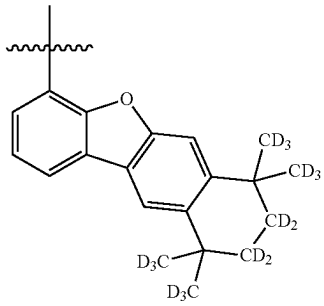
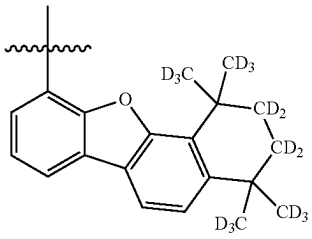
R457	
R458	
R459	
R460	
R461	

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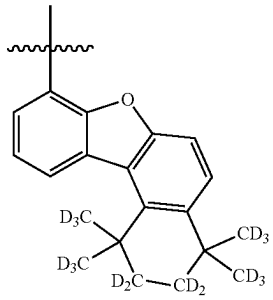
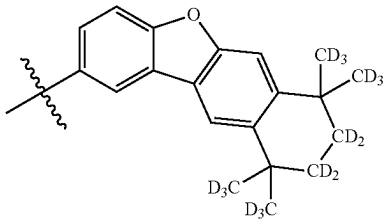
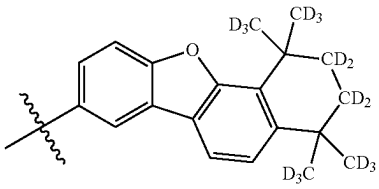
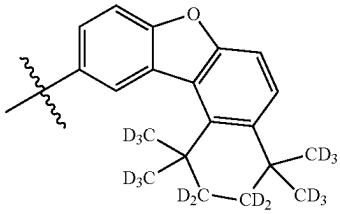
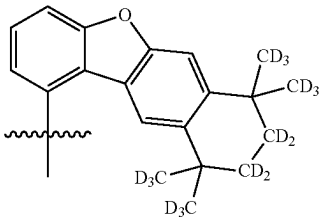
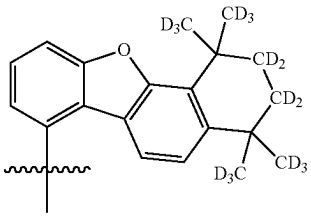
R462	
R463	
R464	
R465	
R466	
R467	

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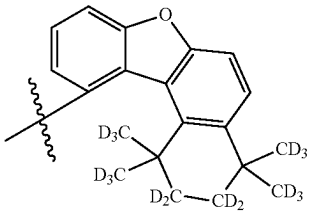
Structure	
R468	

[0204] In some embodiments, the compound has a formula of $M(L_A)_p(L_B)_q(L_C)_r$ wherein L_B and L_C are each a bidentate ligand; and wherein p is 1, 2, or 3; q is 0, 1, or 2; r is 0, 1, or 2; and p+q+r is the oxidation state of the metal M.

[0205] In some embodiments, the compound has a formula selected from the group consisting of $Ir(L_A)_3$, $Ir(L_A)(L_B)_2$, $Ir(L_A)_2(L_B)$, $Ir(L_A)_2(L_C)$, and $Ir(L_A)(L_B)(L_C)$; and wherein L_A, L_B, and L_C are different from each other.

[0206] In some embodiments, L_B comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, L_B comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, L_B comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, L_B comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, L_B comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0207] In some embodiments, L_C comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, L_C comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, L_C comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, L_C comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, L_C comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0208] In some embodiments, L_B is a substituted or unsubstituted phenylpyridine, and L_C is a substituted or unsubstituted acetylacetonate.

[0209] In some embodiments, the compound has a formula of $Pt(L_A)(L_B)$; and wherein L_A and L_B can be same or different. In some embodiments, L_A and L_B are connected to form a tetradentate ligand.

[0210] In some embodiments, L_B and L_C are each independently selected from the group consisting of the structures of the following LIST 6:

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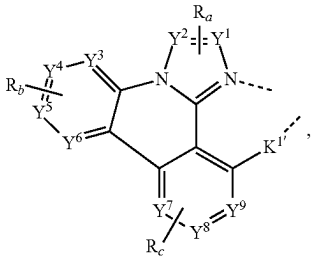

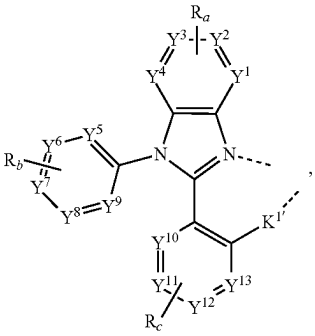

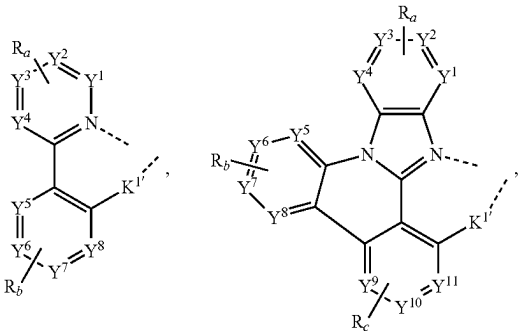

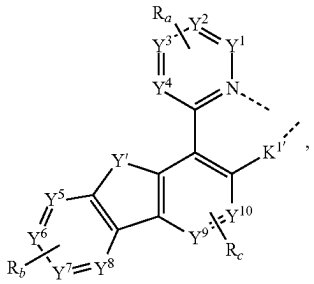

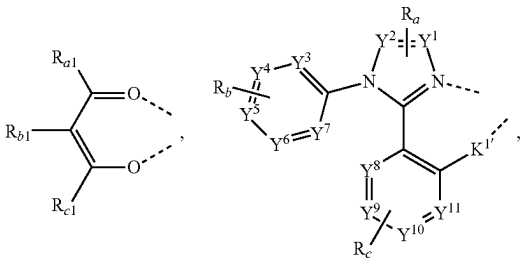

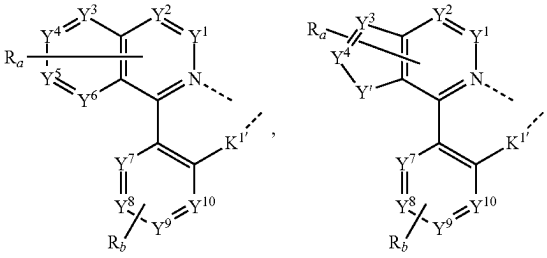

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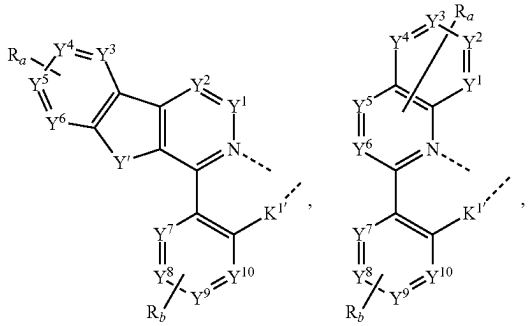

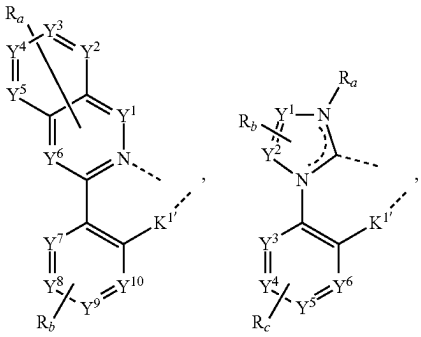

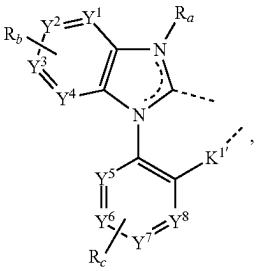

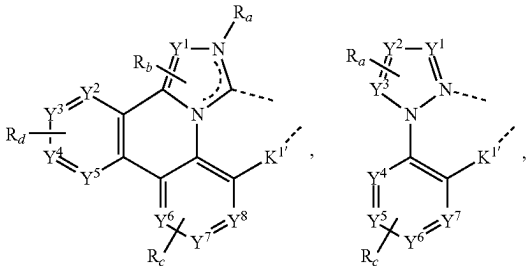

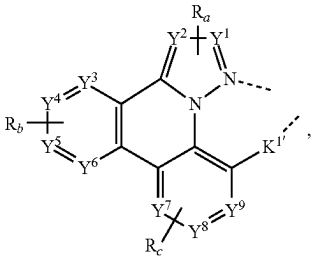

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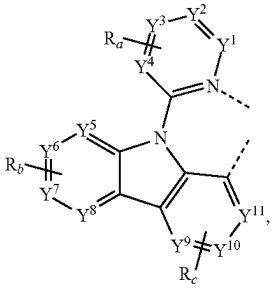

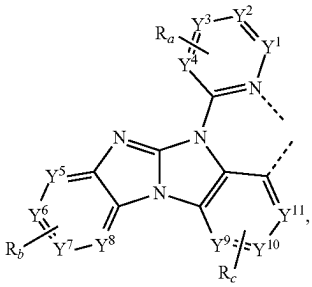

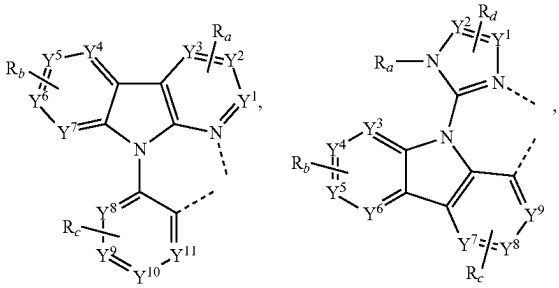

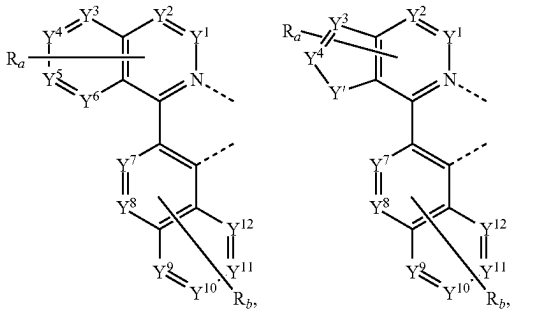

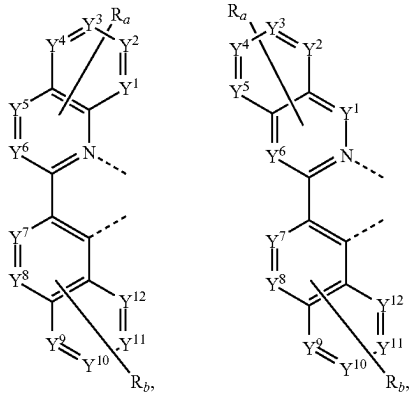

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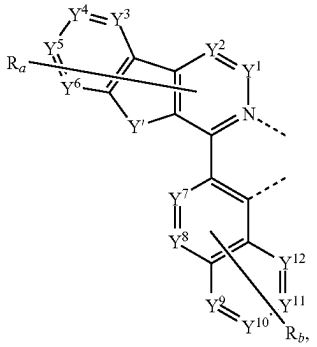

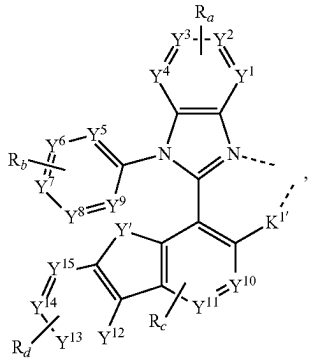

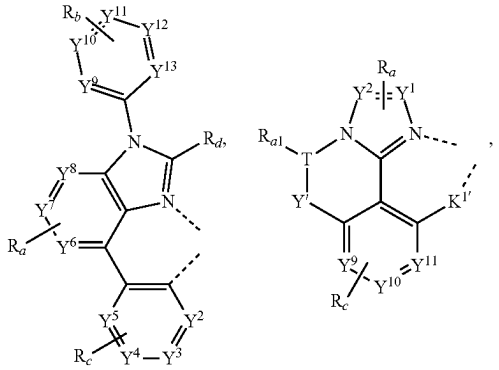

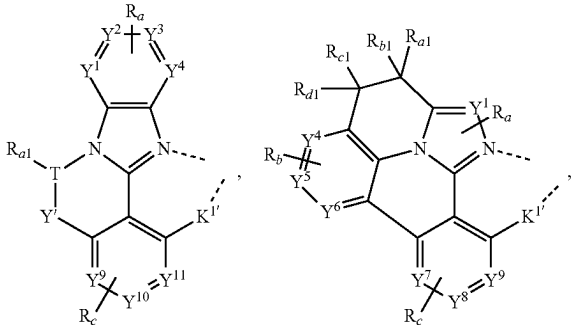

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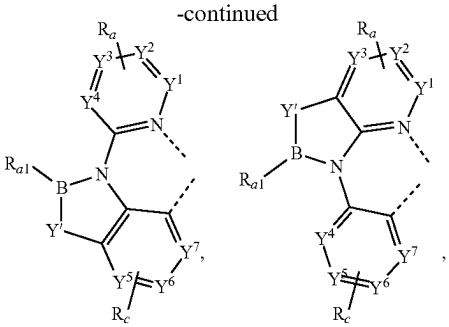
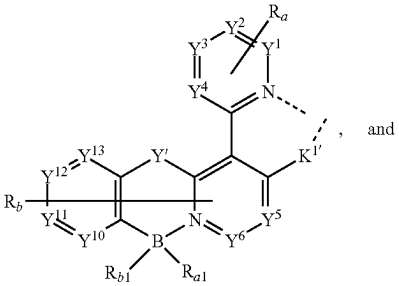
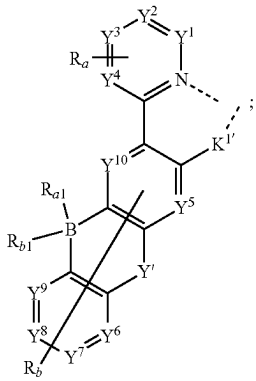






wherein:

[0211] T is selected from the group consisting of B, Al, Ga, and In;

[0212] $K^{1'}$ is selected from the group consisting of a single bond, O, S, NR_e, PR_e, BR_e, CR_eR_f, and SiR_eR_f; each of Y^1 to Y^{13} is independently selected from the group consisting of C and N;

[0213] Y' is selected from the group consisting of BR_e, BR_eR_f, NR_e, PR_e, $P(O)R_e$, O, S, Se, C═O, C═S, C═Se, C═NR_e, C═CR_eR_f, S═O, SO_2, CR_eR_f, SiR_eR_f, and GeR_eR_f;

[0214] R_e and R_f can be fused or joined to form a ring;

[0215] each R_a, R_b, R_c, and R_d independently represents from mono to the maximum allowed number of substitutions, or no substitution;

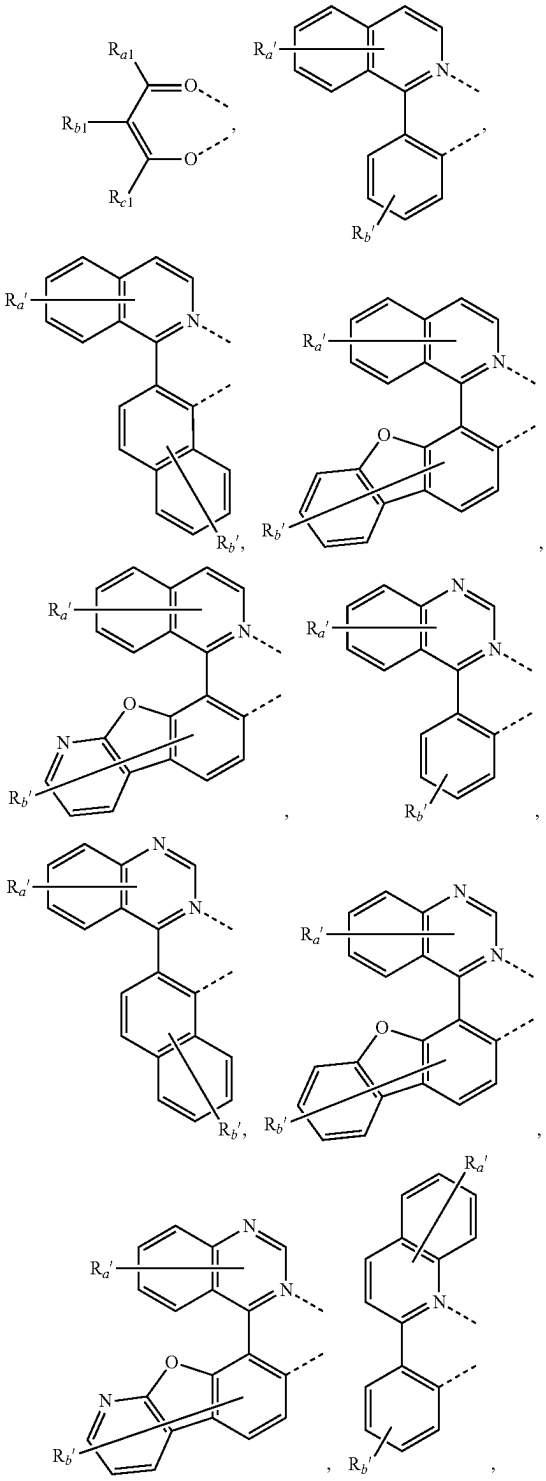
[0216] each of R_{a1}, R_{b1}, R_{c1}, R_{d1}, R_a, R_b, R_c, R_d, R_e, and R_f is independently a hydrogen or a subsituent selected from the group consisting of the General Substituetns defined herein; and

[0217] any two substituents of R_{a1}, R_{b1}, R_{c1}, R_{d1}, R_a, R_b, R_c, and R_d can be fused or joined to form a ring or form a multidentate ligand.

[0218] In some embodiments, at least one of R_{a1}, R_{b1}, R_{c1}, R_{d1}, R_a, R_b, R_c, and R_d comprises an aromatic group with a structure of Formula II fused thereto. In some embodiments,

at leaset one of R_a, R_b, R_c, and R_d comprises an aromatic group with a structure of Formula II fused thereto.

[0219] In some embodiments, L_B and L_C are each independently selected from the group consisting of the structures of the following LIST 7:



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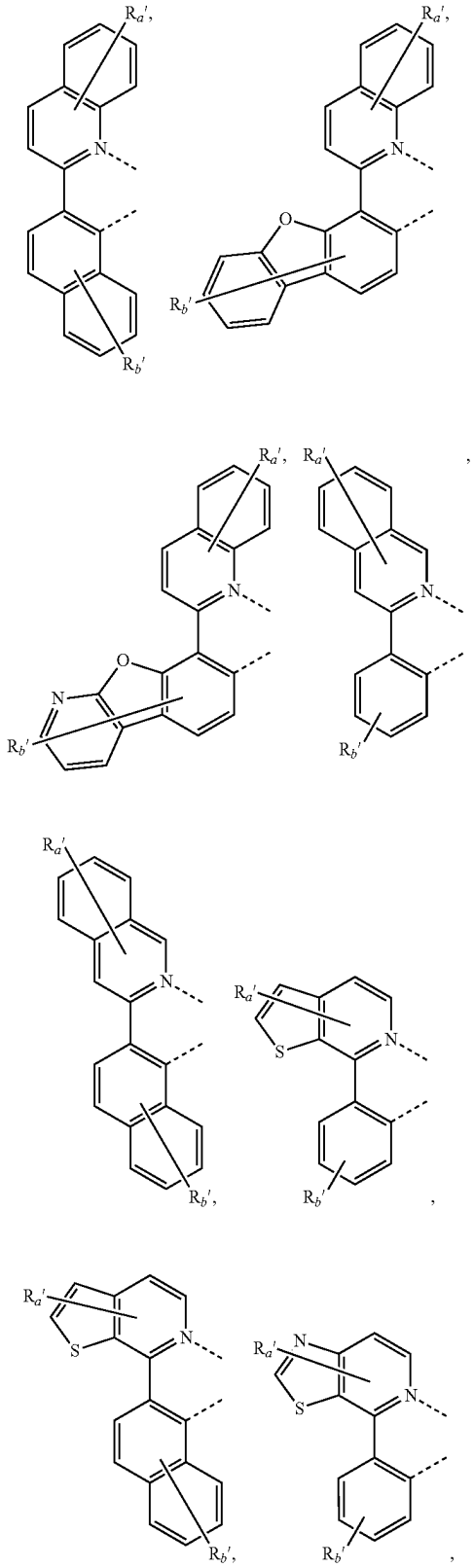

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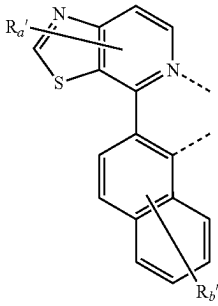
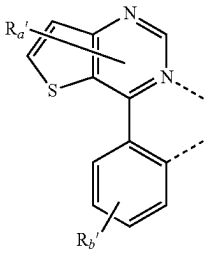
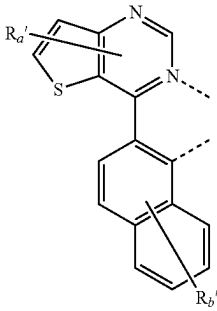
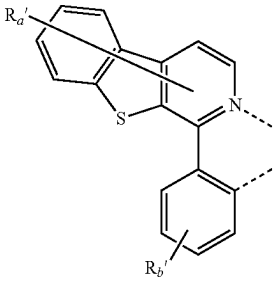
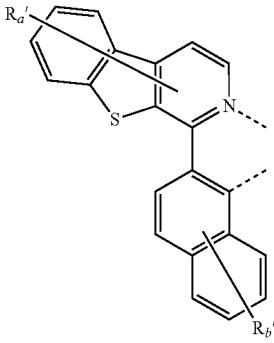
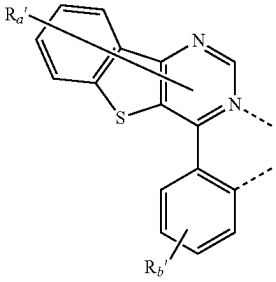
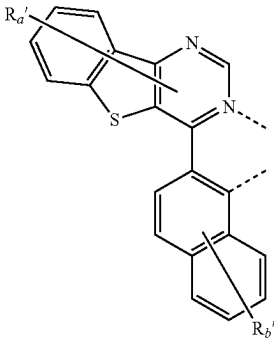
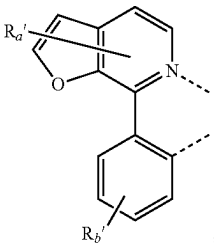
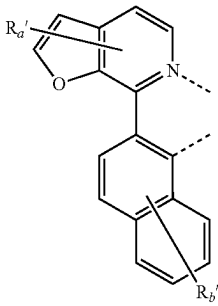
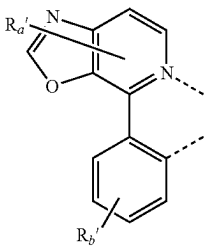

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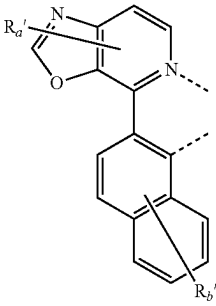
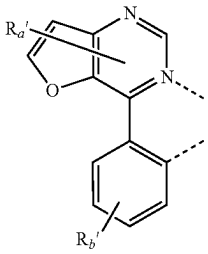
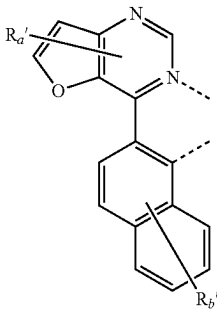
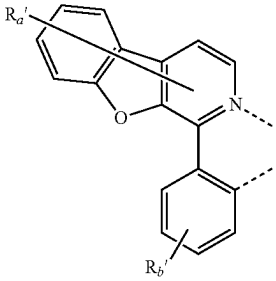
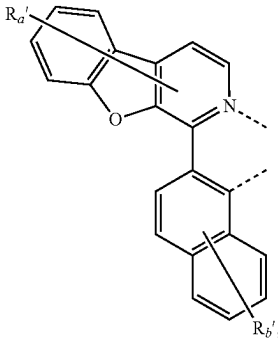
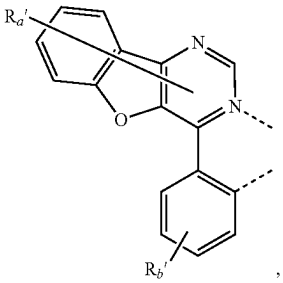
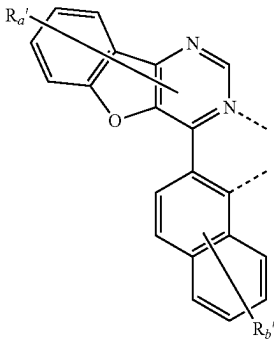
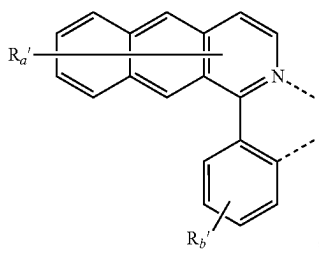

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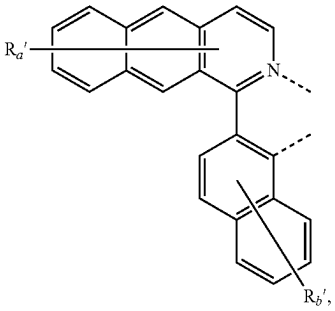

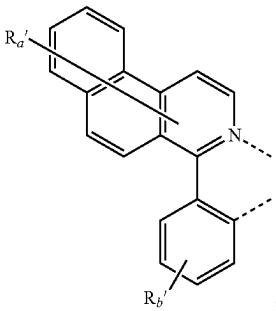

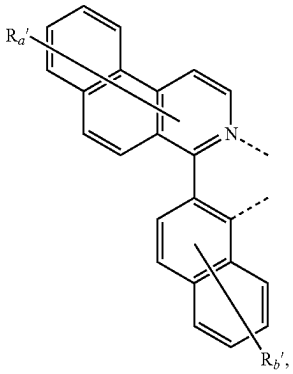

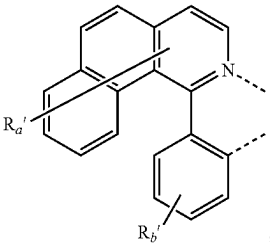

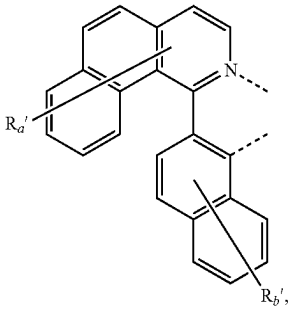

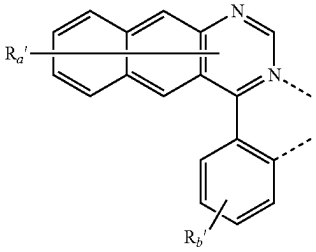

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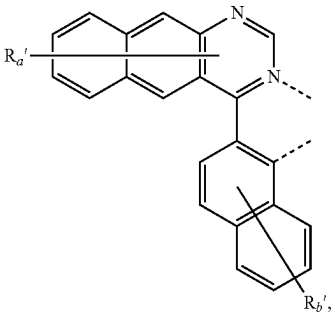

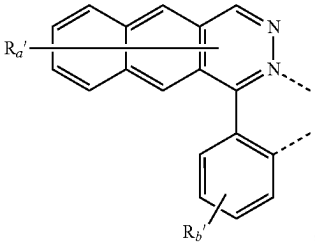

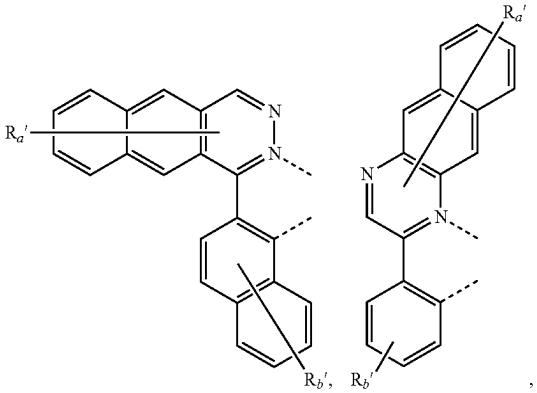

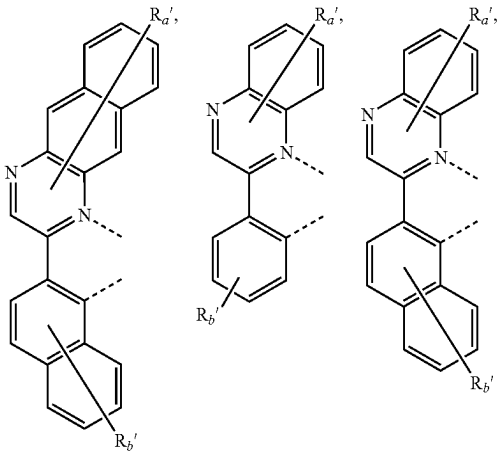

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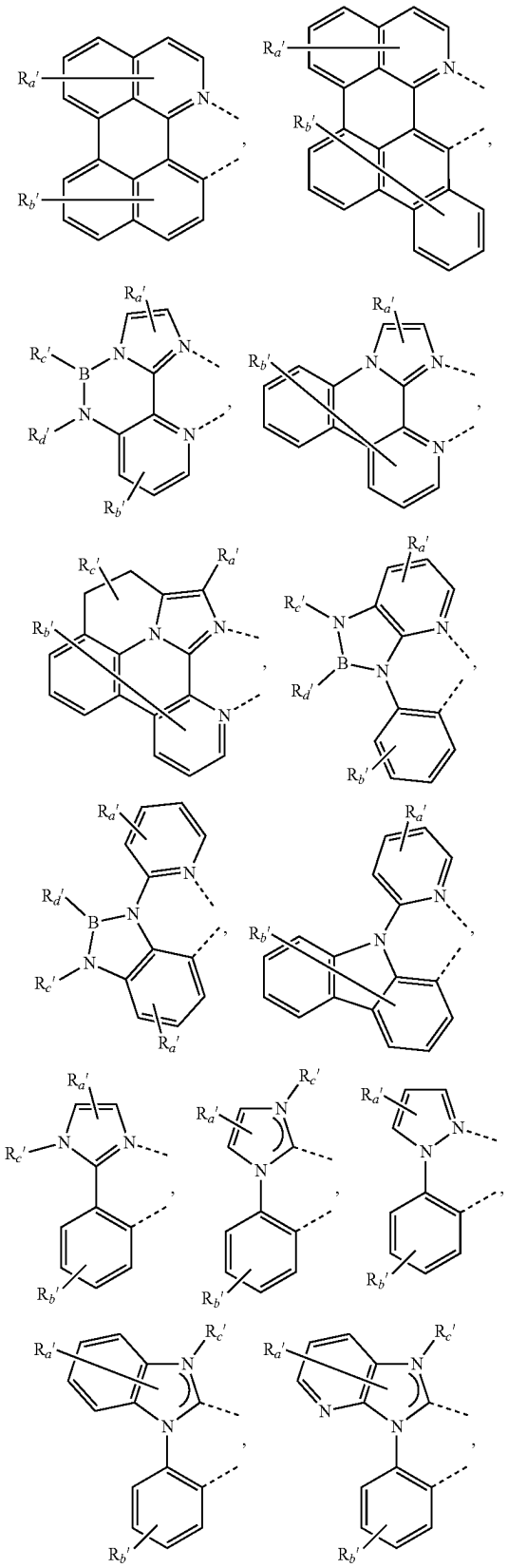

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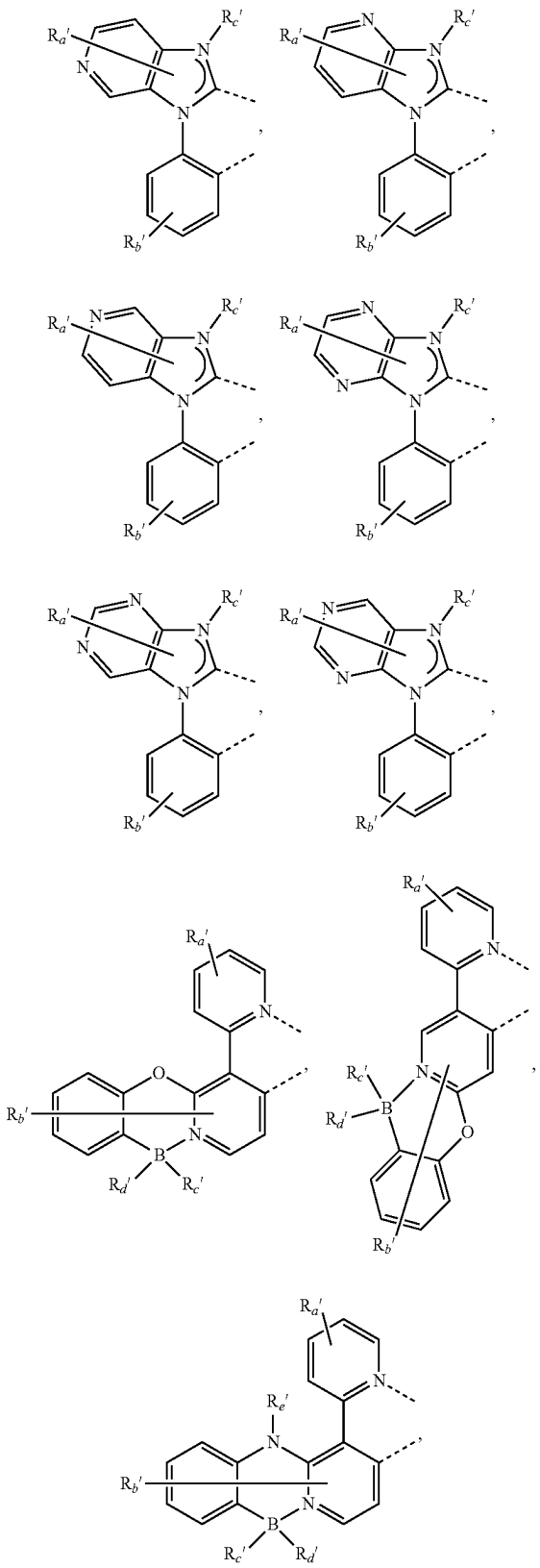

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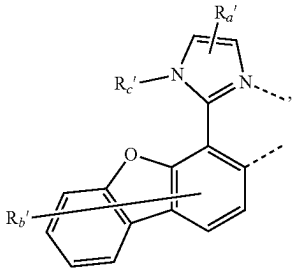

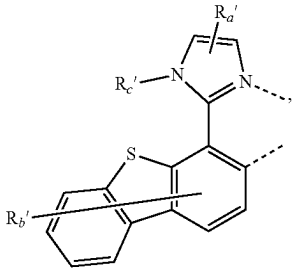

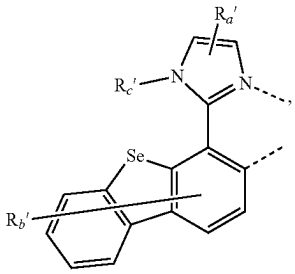

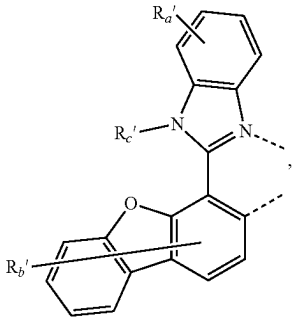

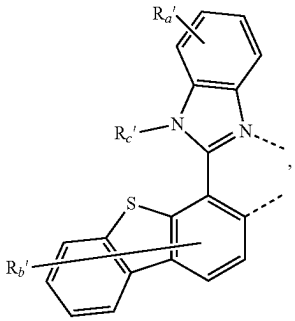

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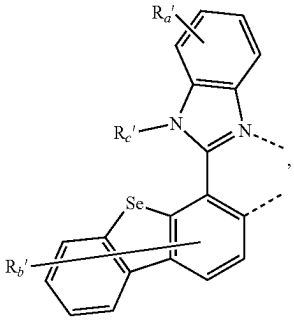

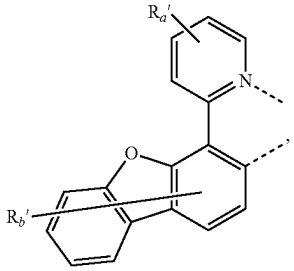

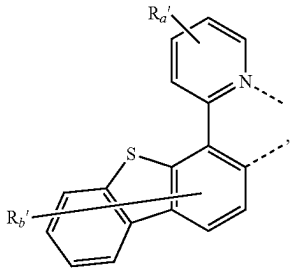

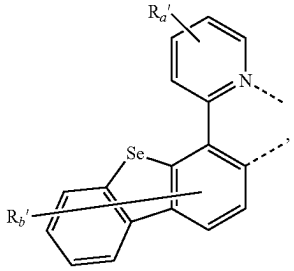

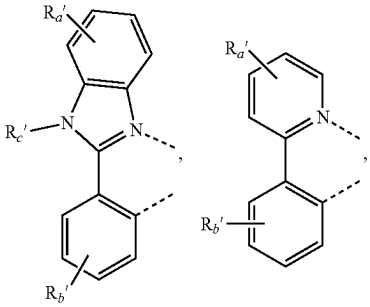

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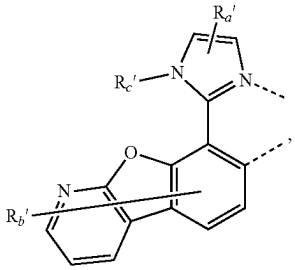

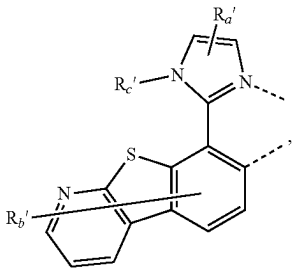

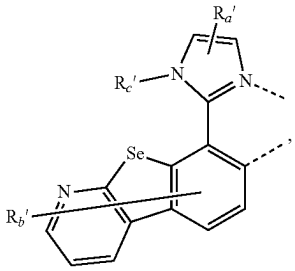

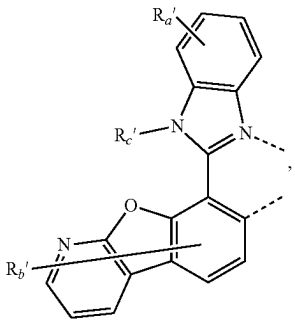

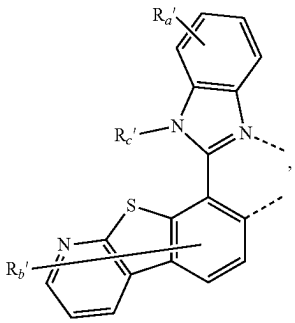

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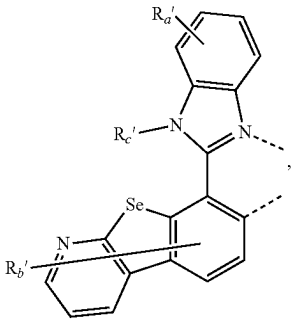

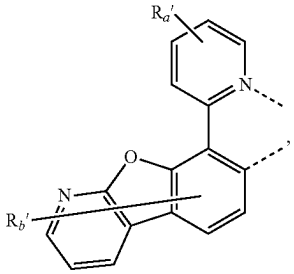

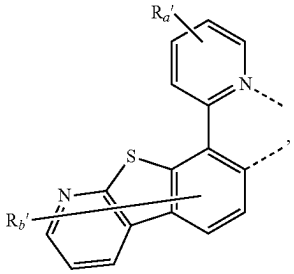

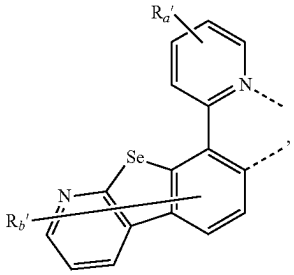

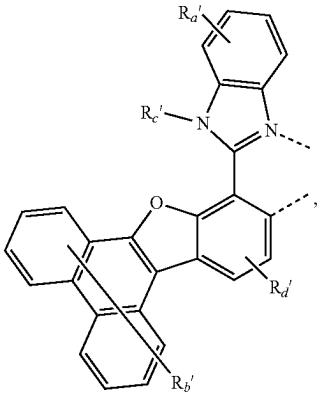

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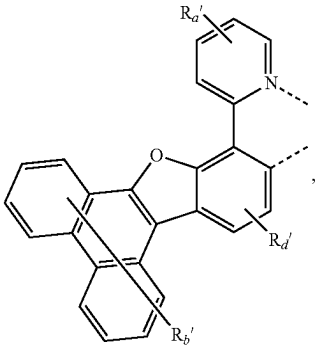

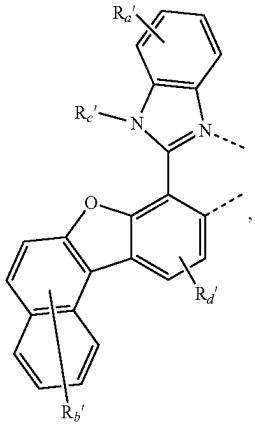

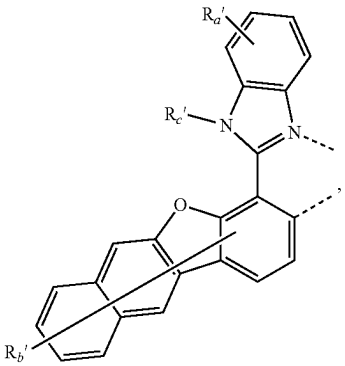

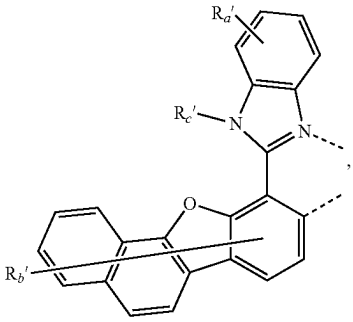

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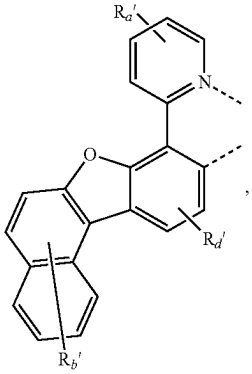

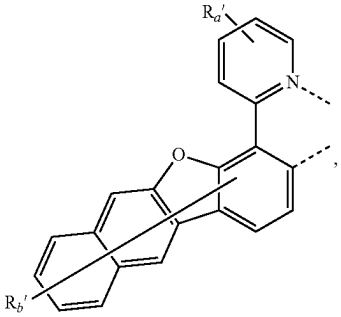

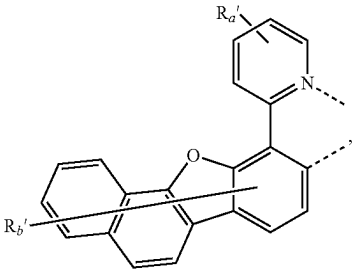

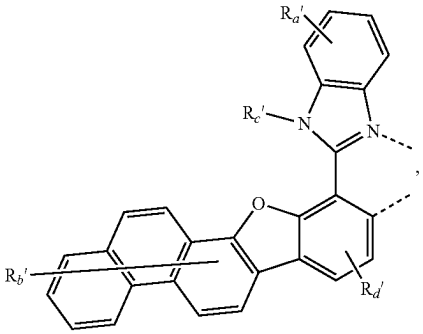

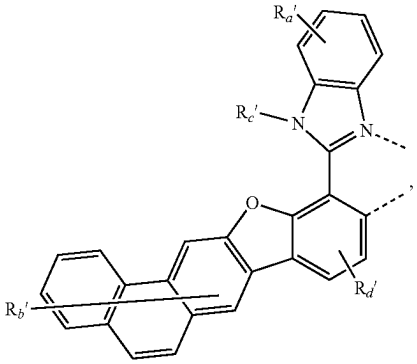

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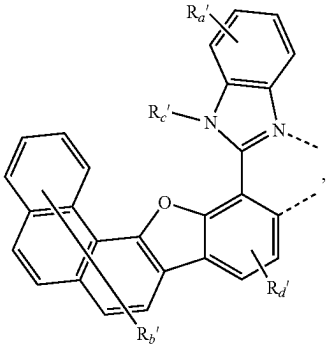

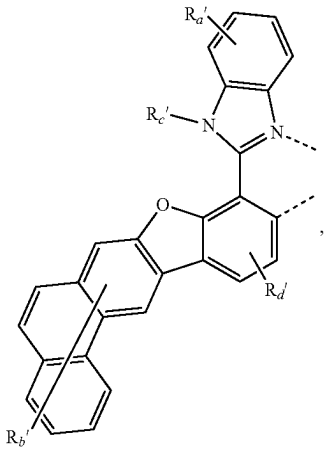

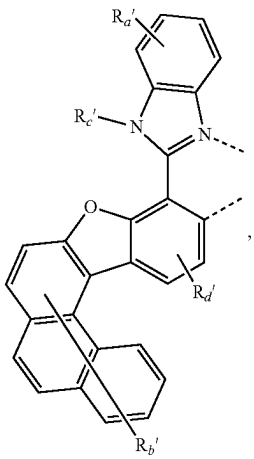

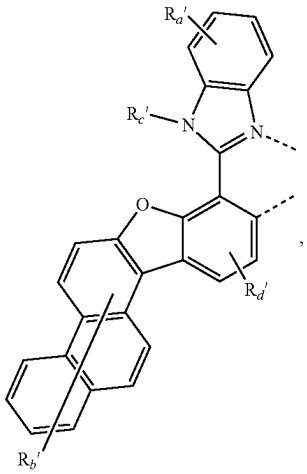

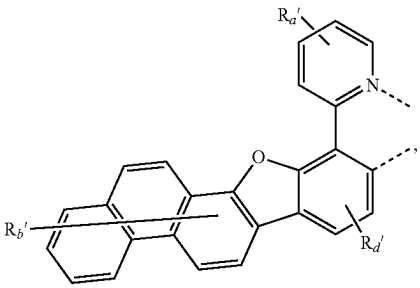

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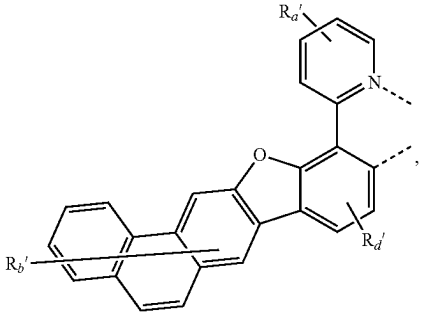

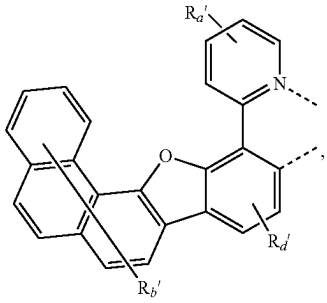

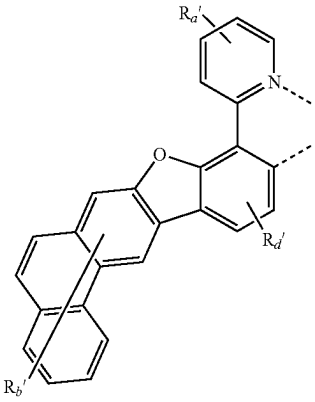

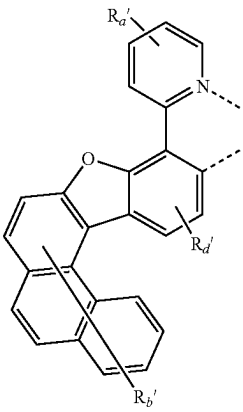

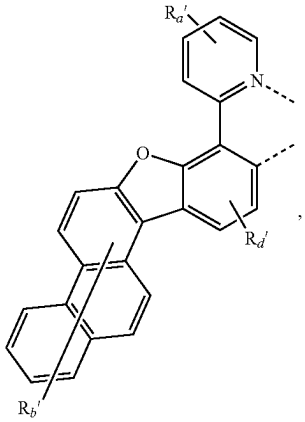

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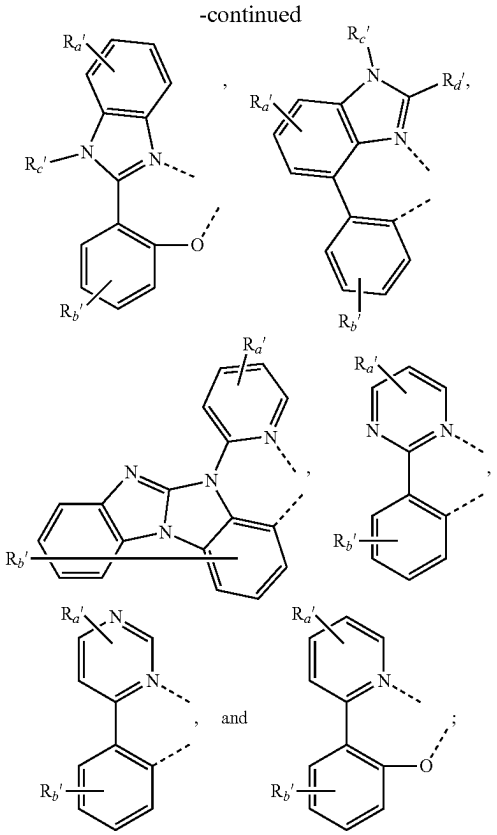


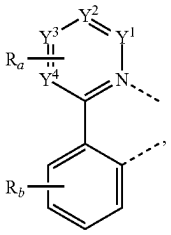
wherein:

[0220] R_a', R_b', R_c', R_d', and R_e' each independently represents zero, mono, or up to a maximum allowed number of substitution to its associated ring;

[0221] R_{a1}, R_{b1}, R_{c1}, R_a', R_b', R_c', R_d', and R_e' each independently hydrogen or a substituent selected from the group consisting of

[0222] the General Substituents defined herein; and two substituents of R_{a1}, R_{b1}, R_{c1}, R_a', R_b', R_c', R_d', and R_e' can be fused or joined to form a ring or form a multidentate ligand.

[0223] In some embodiments, L_B comprises a structure of



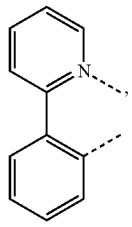
wherein the variables are the same as previously defined. In some embodiments, each of Y^1 to Y^4 is independently carbon. In some embodiments, at least one of Y^1 to Y^4 is N. In some embodiments, exactly one of Y^1 to Y^4 is N. In some embodiments, Y^1 is N. In some embodiments, Y^2 is N. In some embodiments, Y^3 is N. In some embodiments, Y^4 is N. In some embodiments, at least one of R_a is a tertiary alkyl, silyl or germyl. In some embodiments, at least one of R_a is a tertiary alkyl. In some embodiments, Y^3 is C and the R_a attached thereto is a tertiary alkyl, silyl or germyl. In some embodiments, Y^1 to Y^3 is C, Y^4 is N, and the R_a attached to Y^3 is a tertiary alkyl, silyl or germyl. In some embodiments, Y^1 to Y^3 is C, Y^4 is N, and the R_a attached to Y^2 is a tertiary alkyl, silyl or germyl. In some embodiments, at least one of R_b is a tertiary alkyl, silyl, or germyl. In some embodiments, the tertiary alkyl is tert-butyl. In some embodiments, at least one pair of R_a, one pair of R_b, or one pair of R_a and R_b are joined or fused into a ring.

[0224] In some embodiments, the compound has formula $Ir(L_A)_3$, formula $Ir(L_A)(L_{Bk})_2$, formula $Ir(L_A)_2(L_{Bk})$, formula $Ir(L_A)_2(L_{Cj\text{-}I})$, or formula $Ir(L_A)_2(L_{Cj\text{-}II})$,

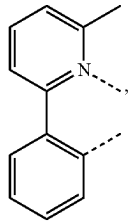
[0225] wherein L_A is according to any one embodiment described herein, including L_A1-(T1)(R1)(R1)(R1) to L_A20-(T76)(R468)(R468)(R468);

[0226] wherein k is an integer from 1 to 530, and each L_{Bk} has the structure defined in the following LIST 8:

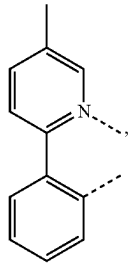
L_{B1}



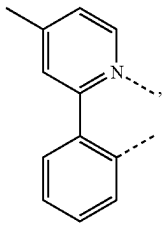
L_{B2}



L_{B3}



L_{B4}



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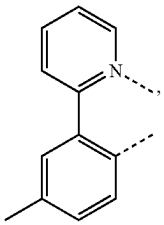
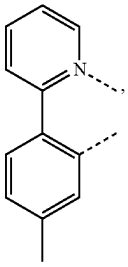
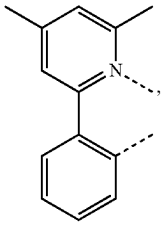
L_{B5}



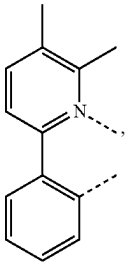
L_{B6}



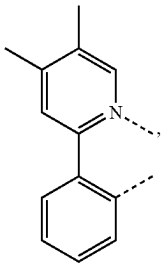
L_{B7}



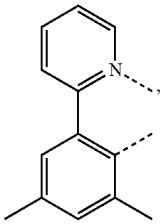
L_{B8}



L_{B9}



L_{B10}



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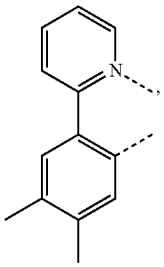
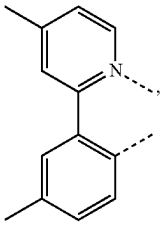
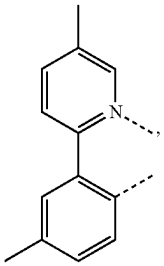
L_{B11}



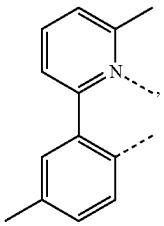
L_{B12}



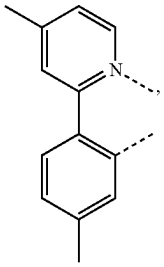
L_{B13}



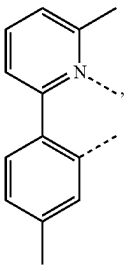
L_{B14}



L_{B15}



L_{B16}



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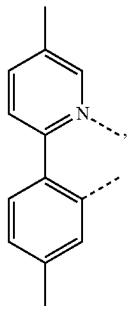
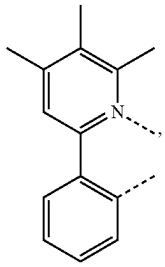


L_{B18}



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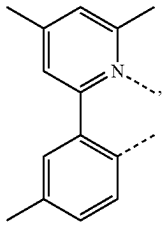
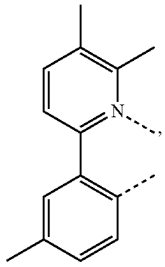
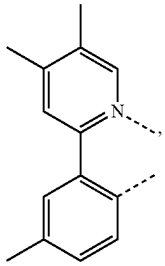


L_{B20}



L_{B21}



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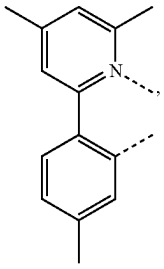
L_{B22}



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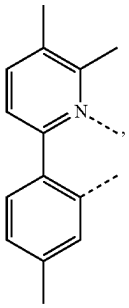

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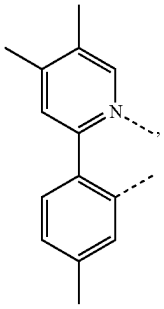
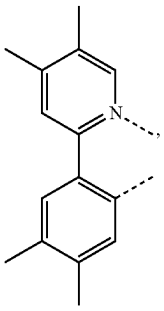
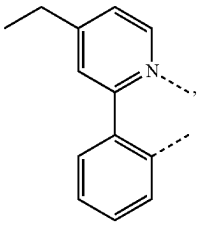


L_{B25}



L_{B26}



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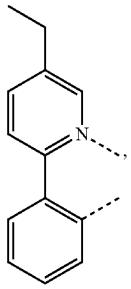
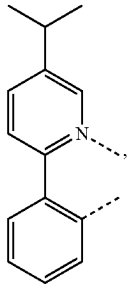
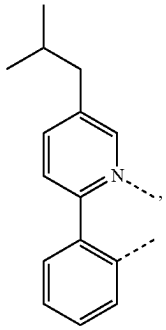
L_{B27}



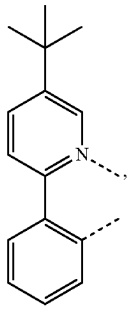
L_{B28}



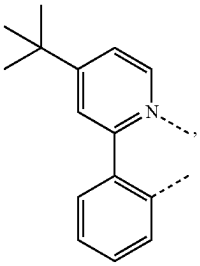
L_{B29}



L_{B30}



L_{B31}



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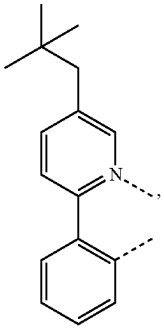

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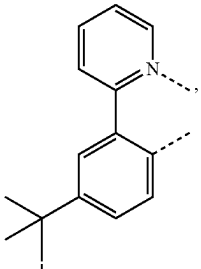

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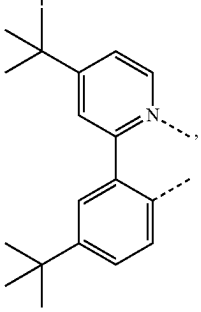

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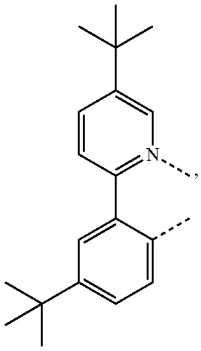

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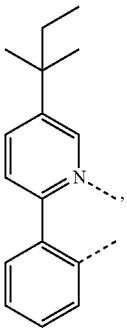

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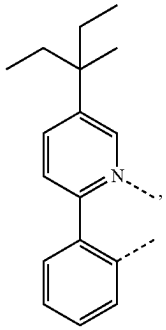

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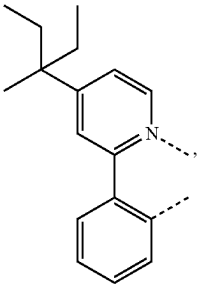

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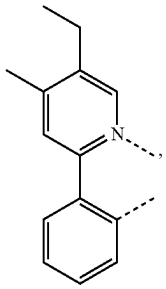

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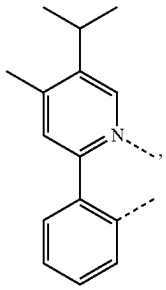

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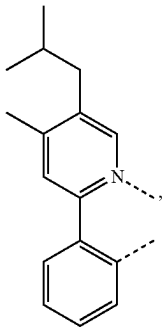

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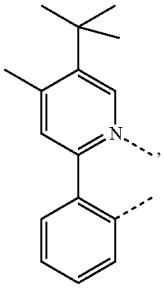

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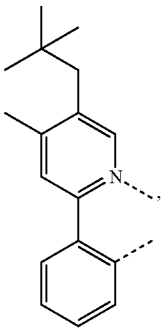

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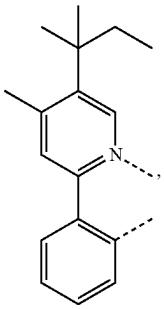

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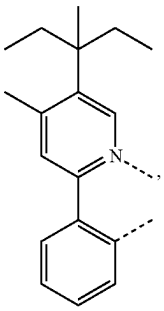

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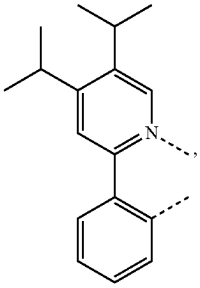

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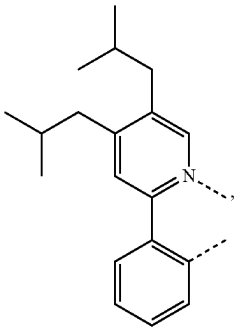

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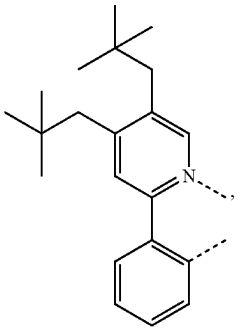

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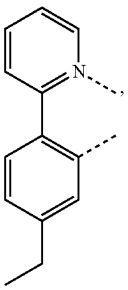

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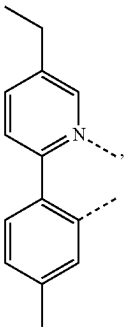

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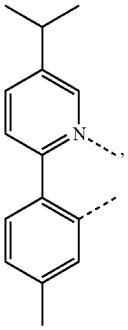

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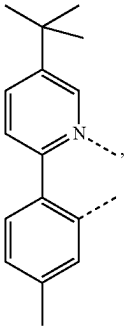

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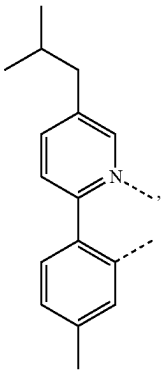

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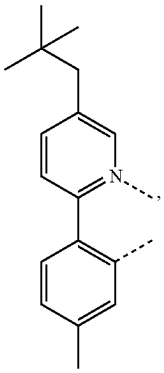

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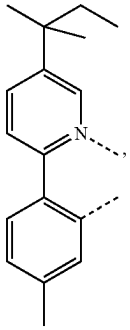

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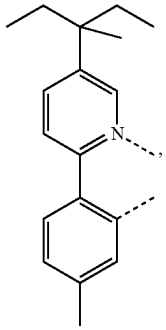

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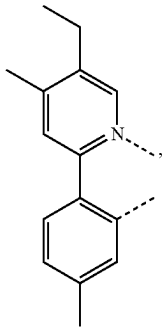

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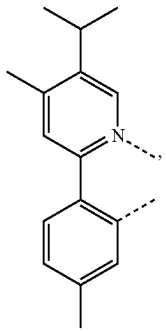

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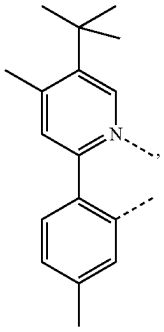

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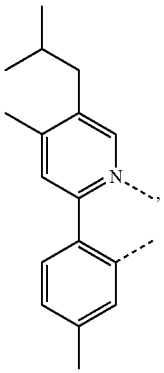

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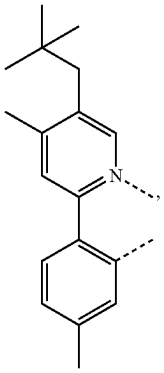

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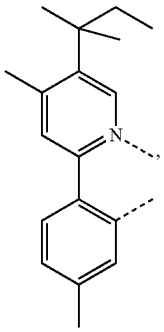

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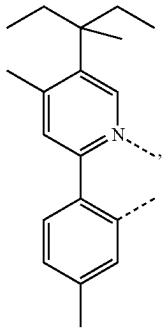

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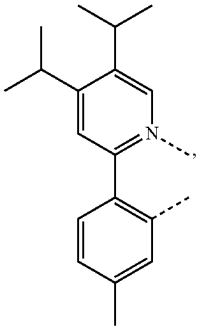

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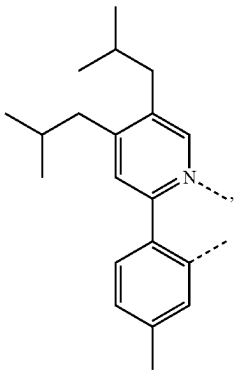

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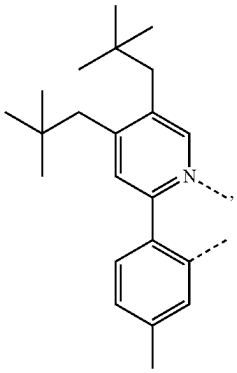

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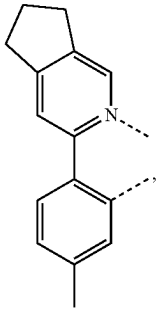

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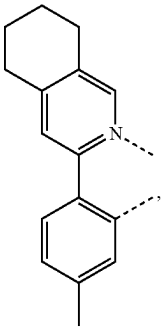

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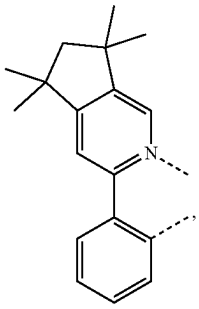

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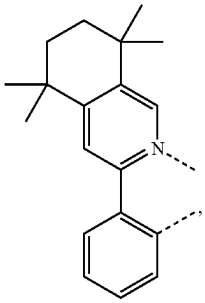

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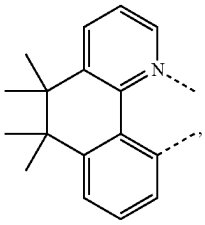

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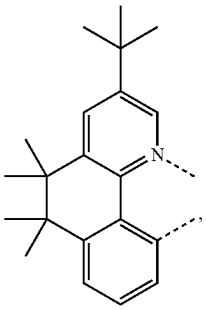

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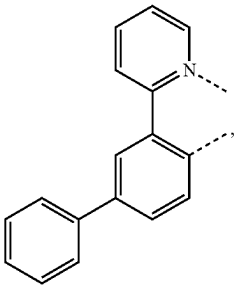

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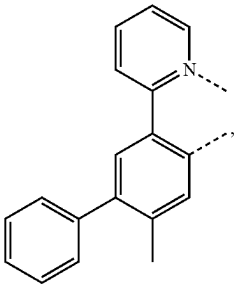

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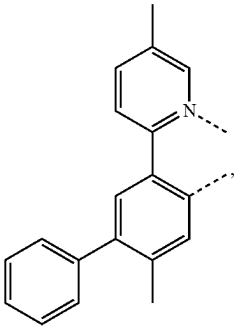

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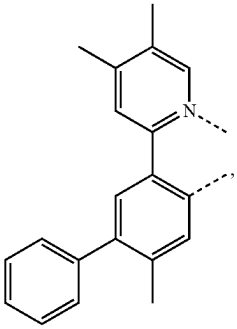

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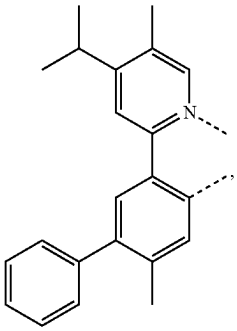

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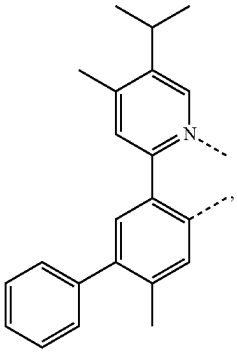

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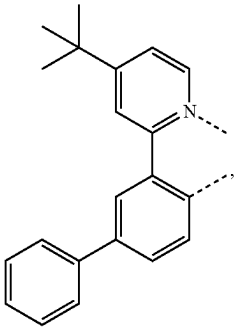

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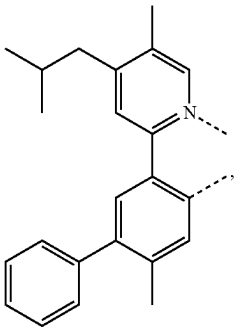

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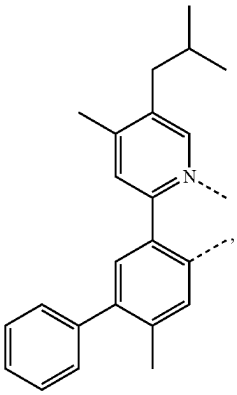

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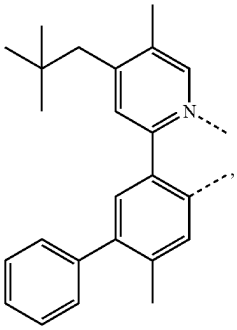

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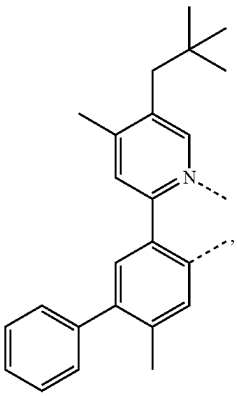

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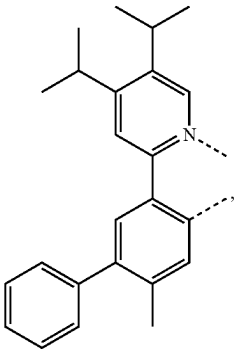

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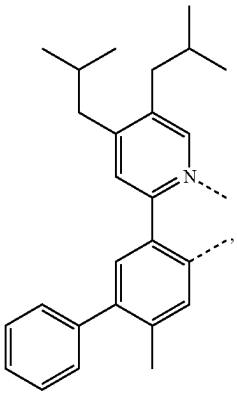

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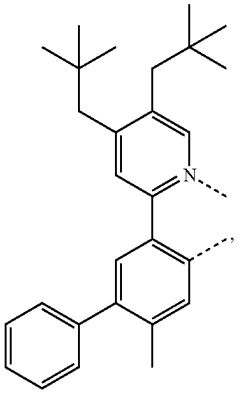

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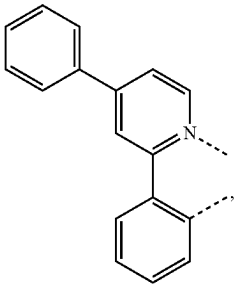

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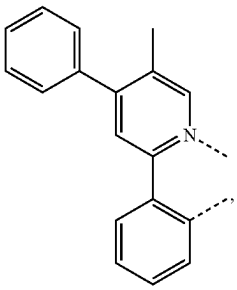

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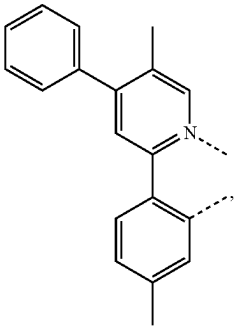

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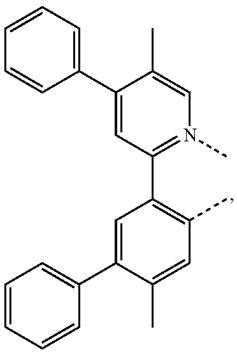

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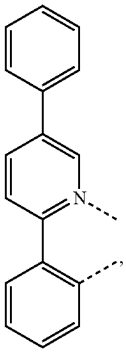

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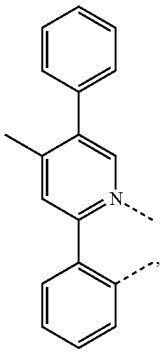

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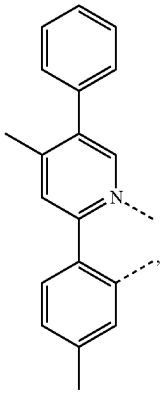

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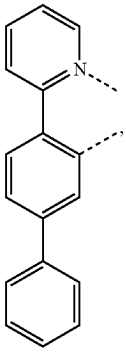

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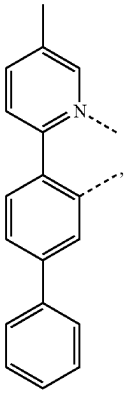

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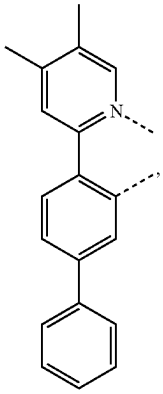

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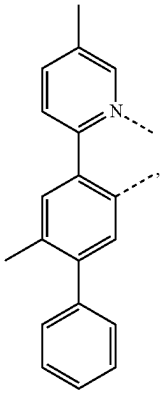

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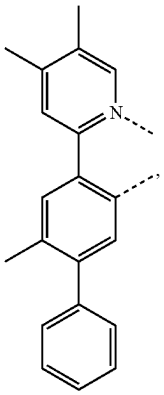

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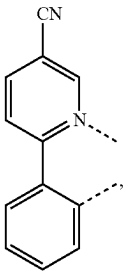

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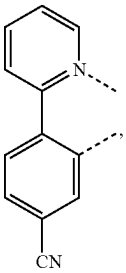

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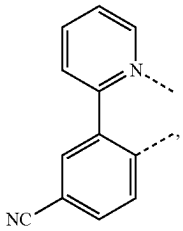

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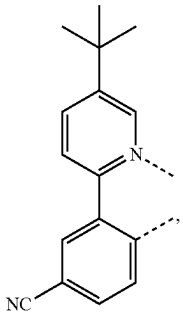

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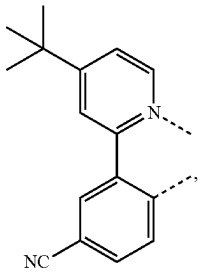

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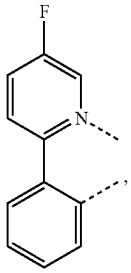

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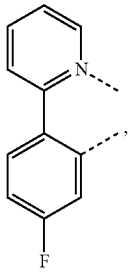

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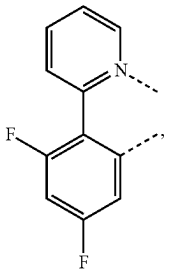

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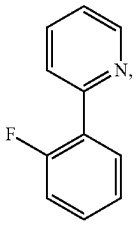

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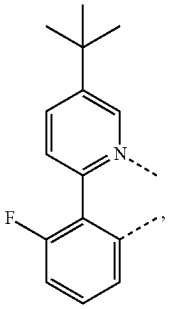

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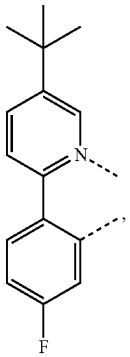

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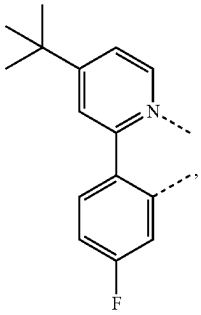

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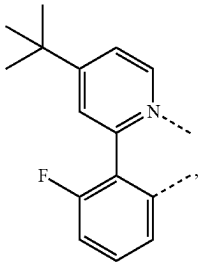

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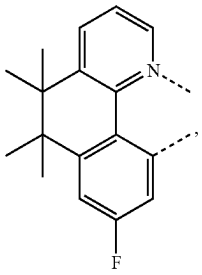

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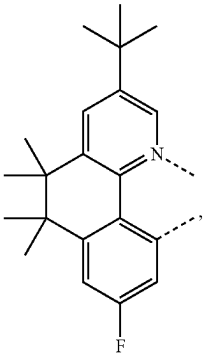

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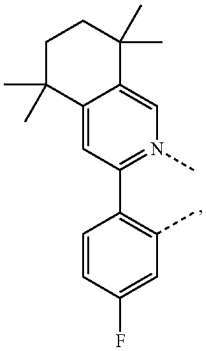

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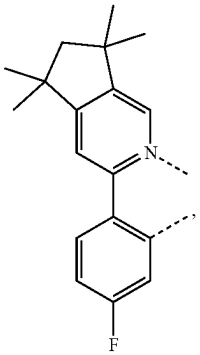

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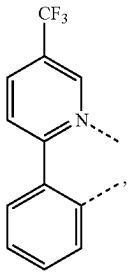

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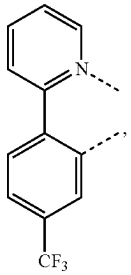

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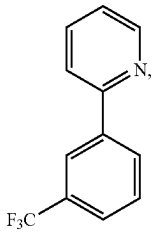

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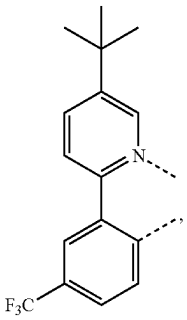

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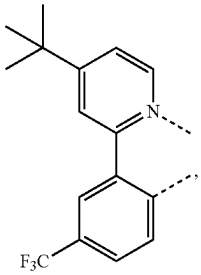

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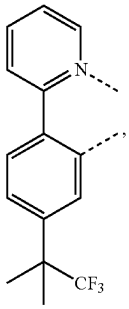

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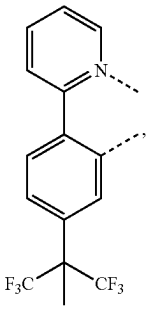

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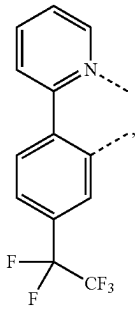

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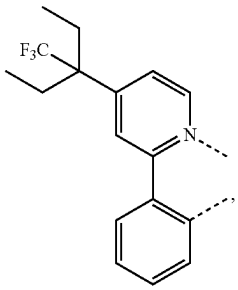

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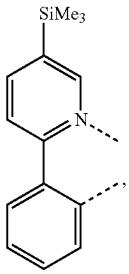

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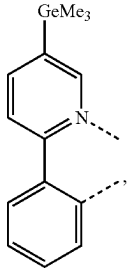

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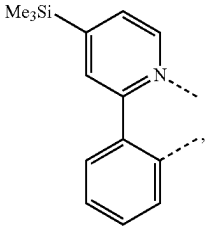

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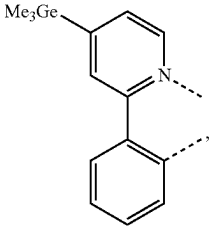

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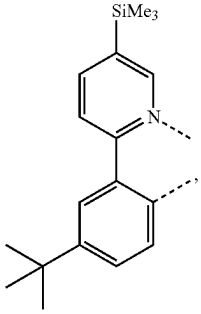

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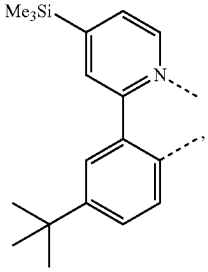

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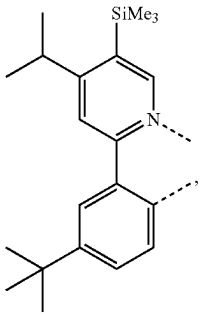

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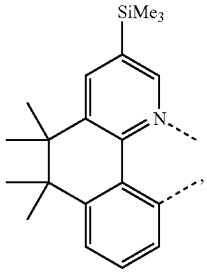

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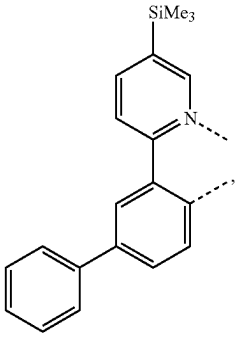

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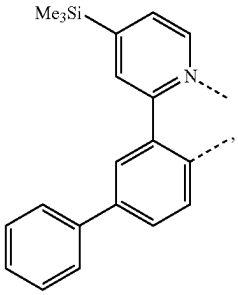

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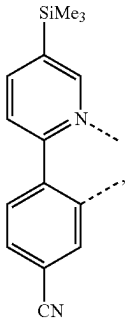

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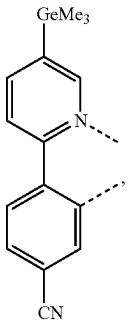

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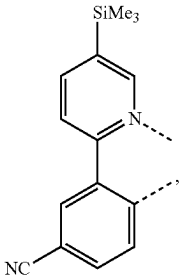

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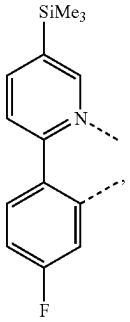

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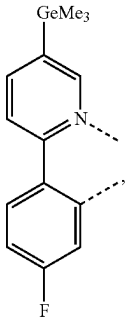

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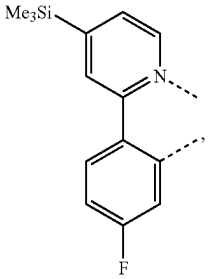

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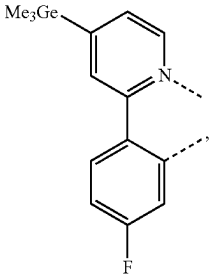

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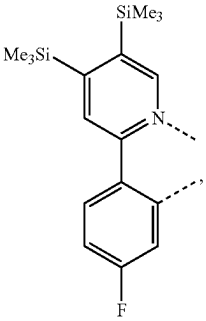

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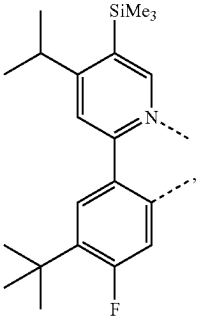

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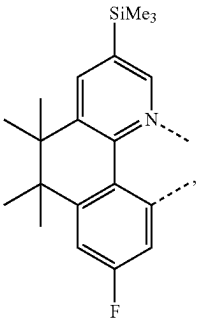

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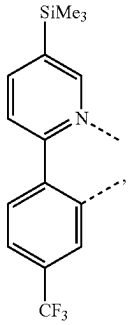

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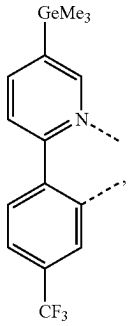

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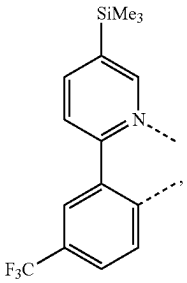

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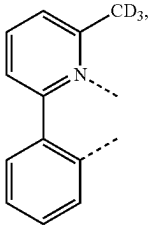

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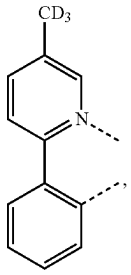

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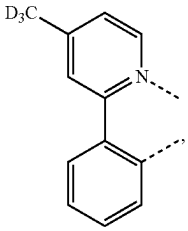

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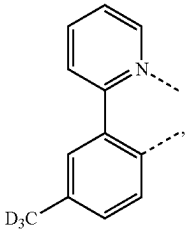

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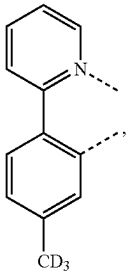

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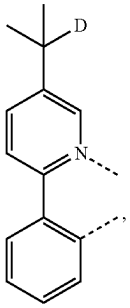

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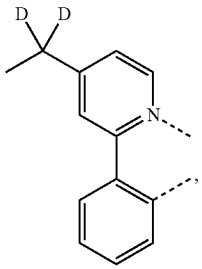

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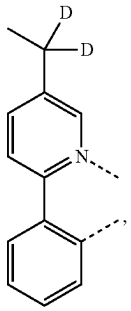

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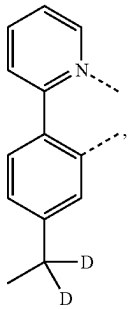

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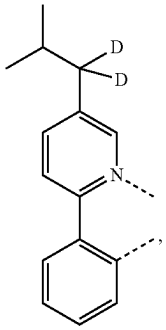

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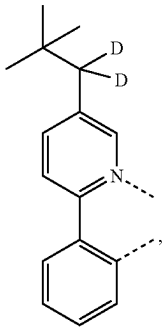

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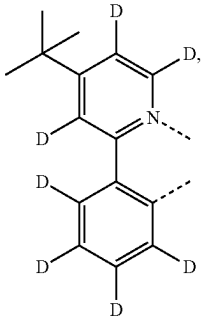

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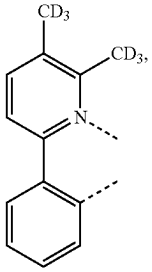

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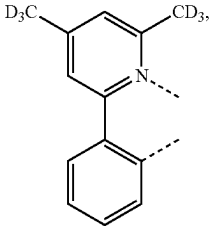

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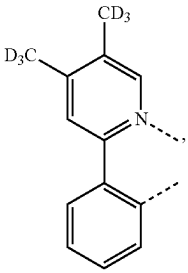

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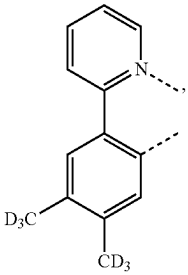

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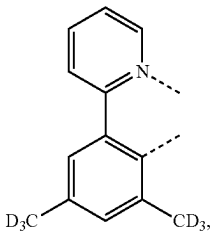

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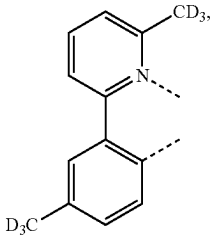

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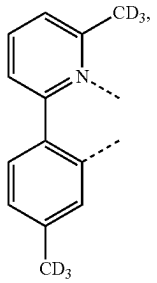

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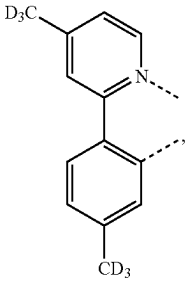

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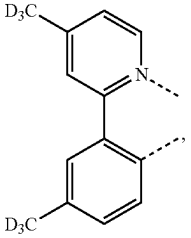

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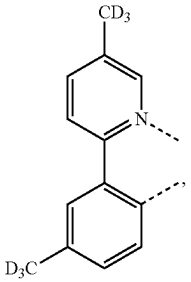

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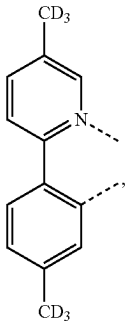

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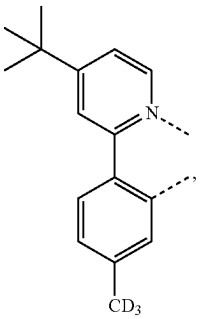

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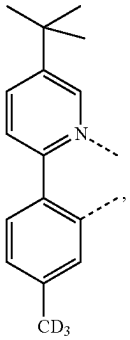

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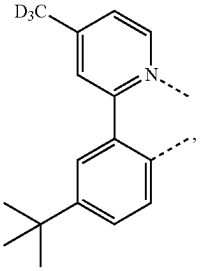

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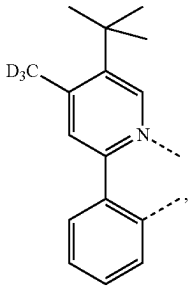

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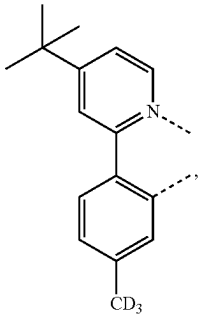

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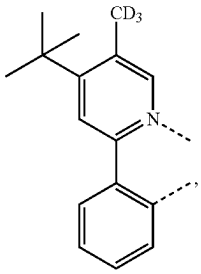

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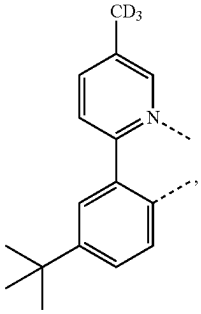

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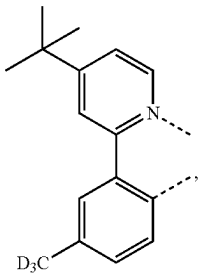

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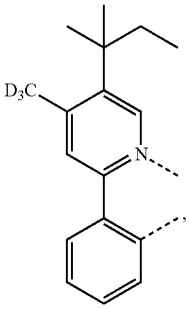

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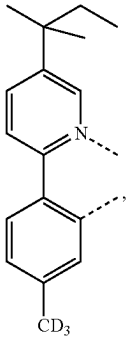

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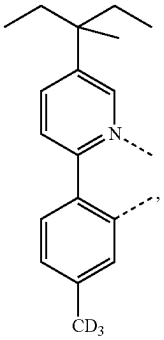

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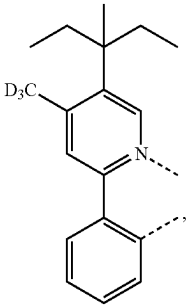

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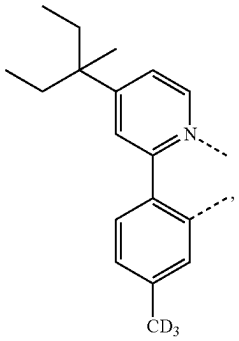

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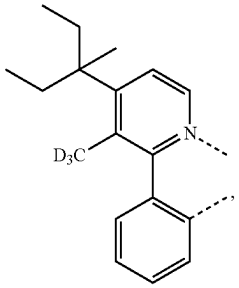

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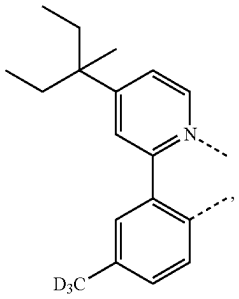

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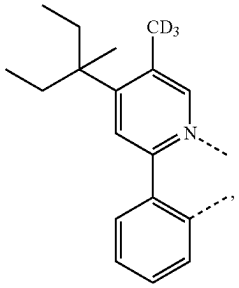

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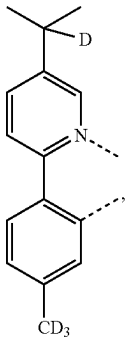

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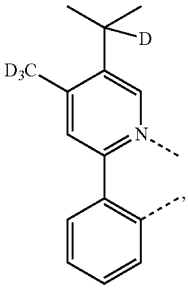

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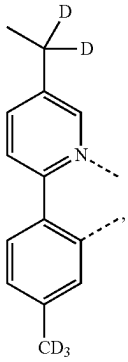

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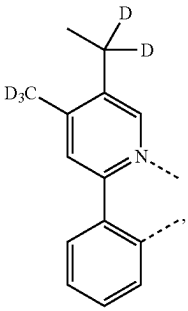

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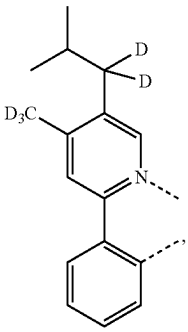

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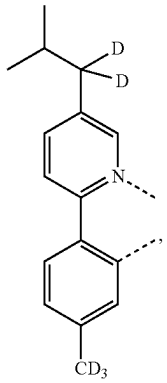

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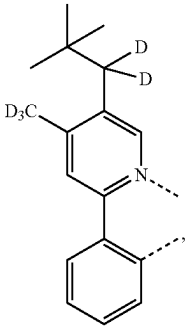

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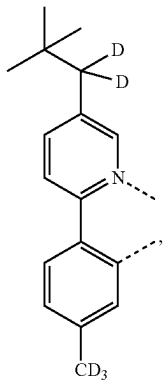

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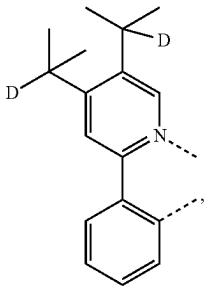

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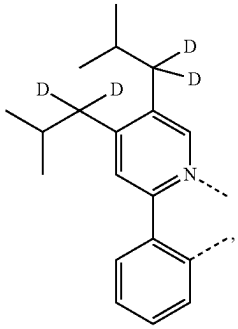

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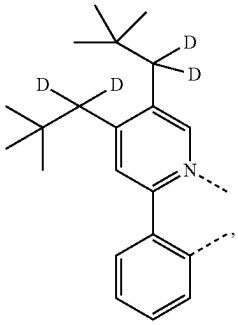

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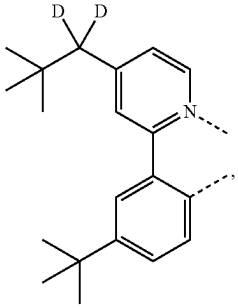

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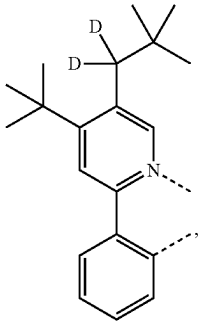

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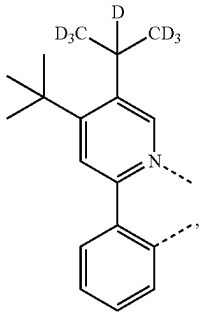

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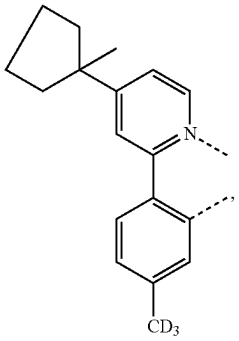

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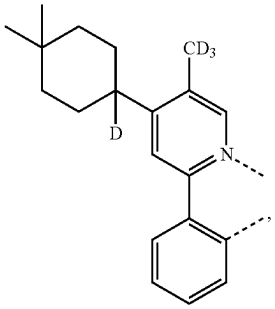

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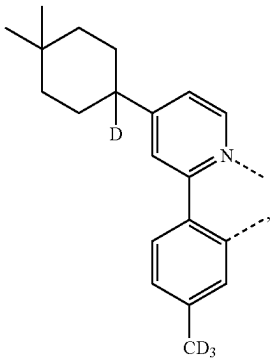

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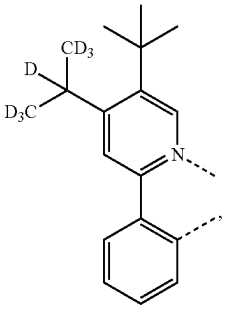

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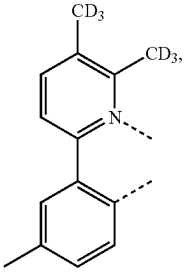

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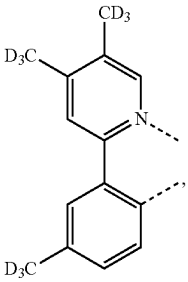

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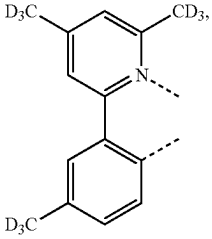

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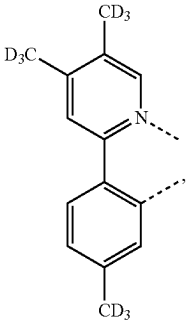

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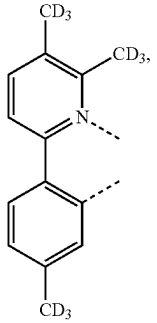

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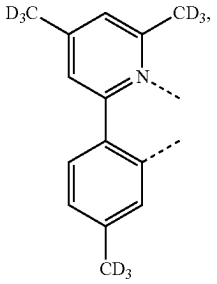

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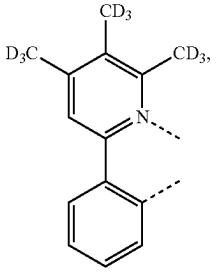

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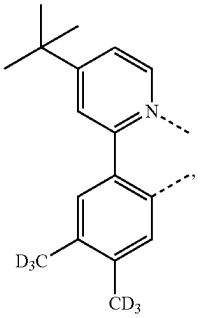

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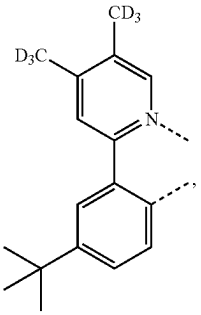

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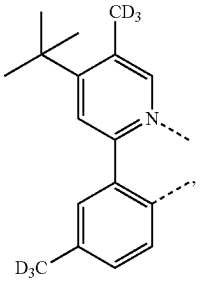

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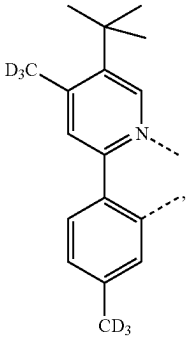

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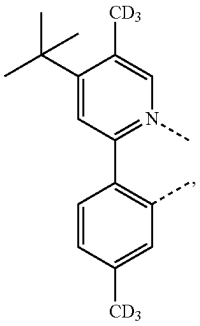

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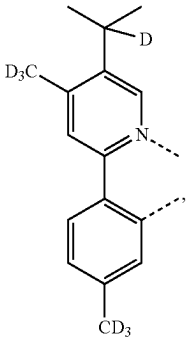

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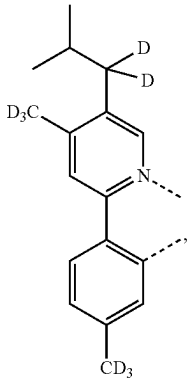

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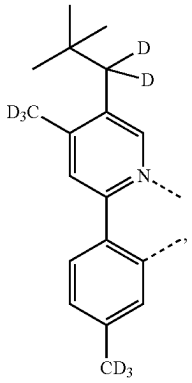

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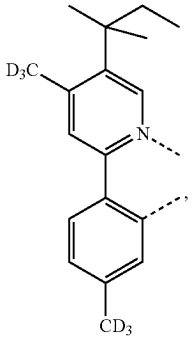

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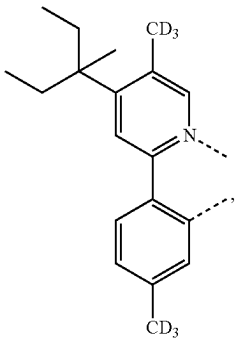

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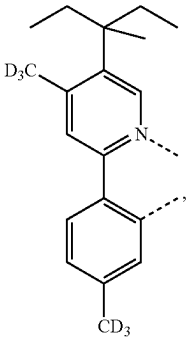

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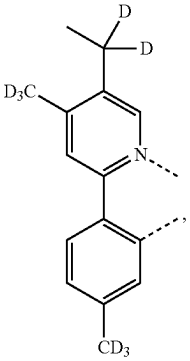

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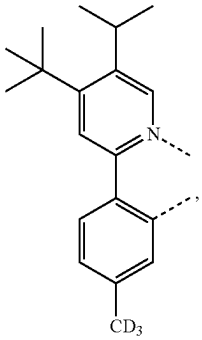

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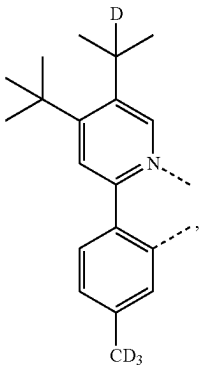

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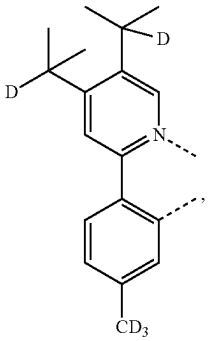

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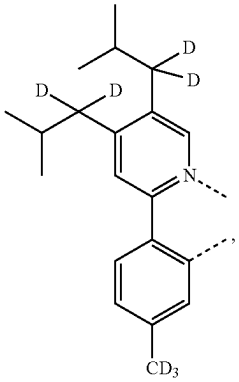

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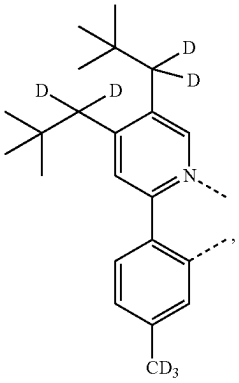

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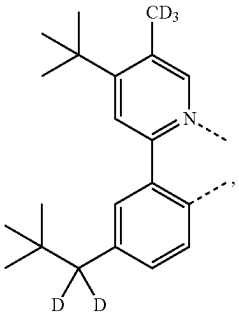

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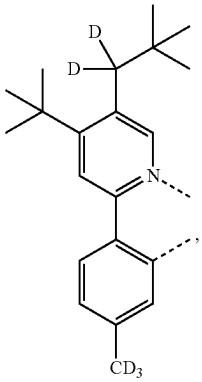

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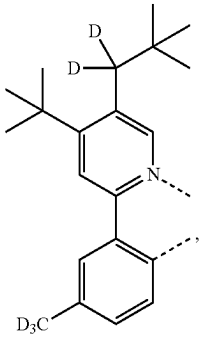

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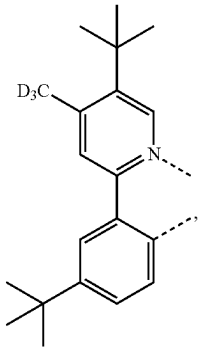

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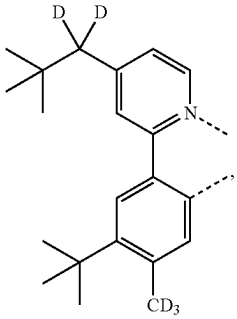

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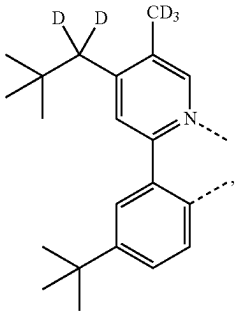

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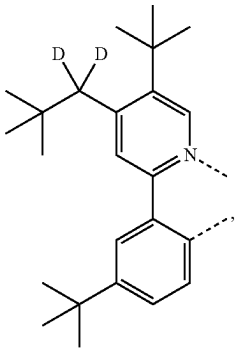

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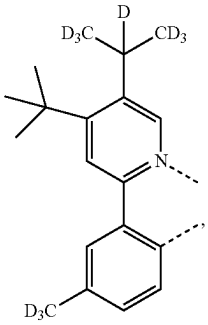

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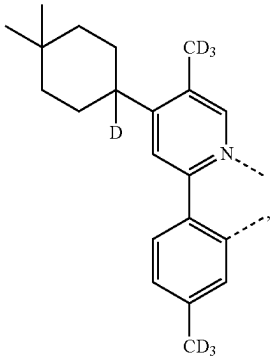

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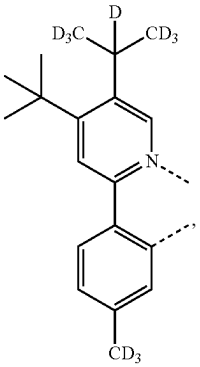

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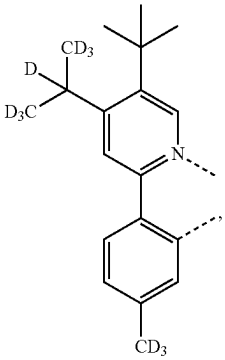

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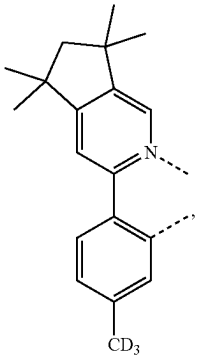

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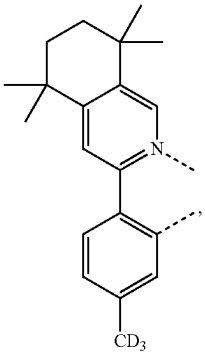

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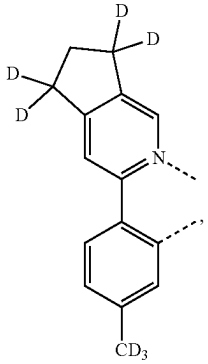

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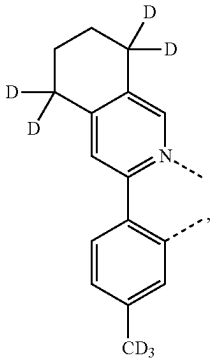

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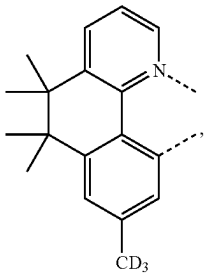

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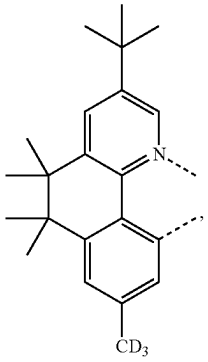

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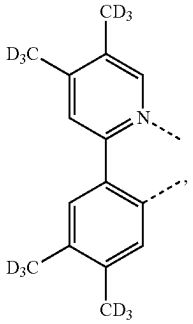

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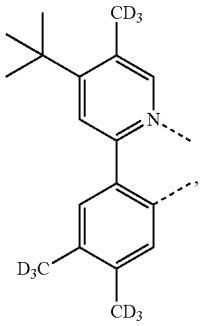

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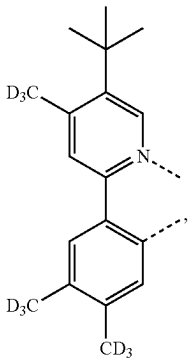

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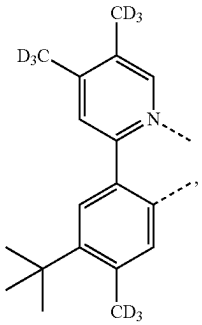

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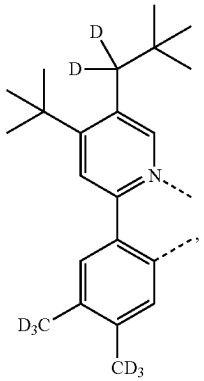

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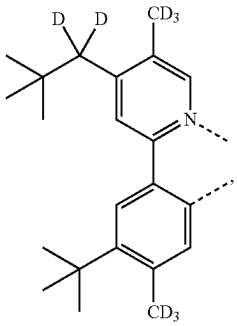

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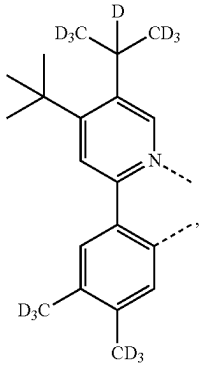

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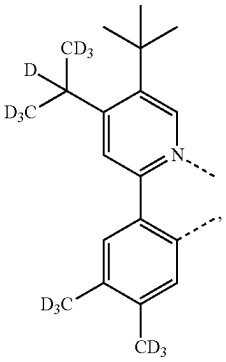

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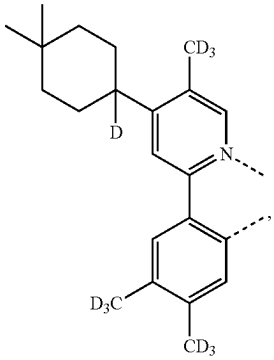

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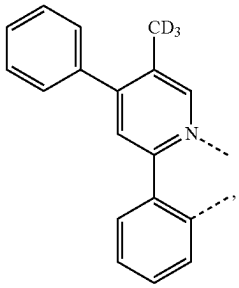

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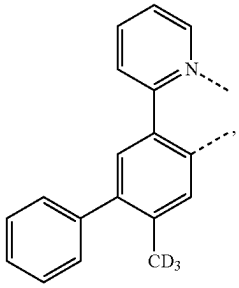

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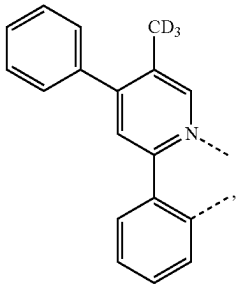

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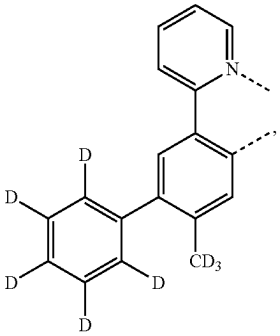

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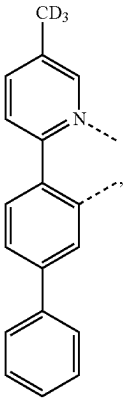

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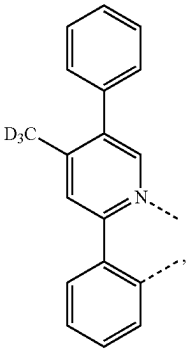

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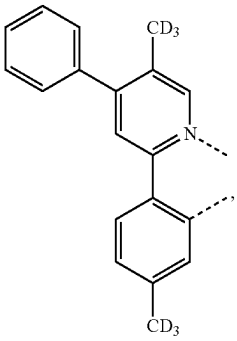

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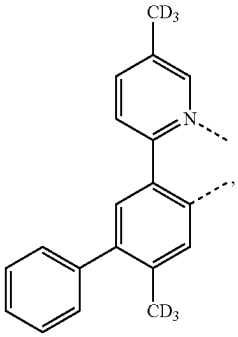

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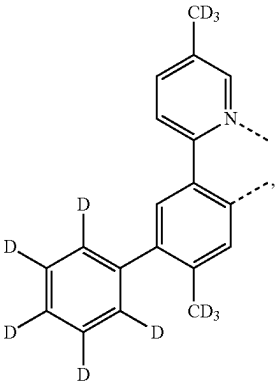

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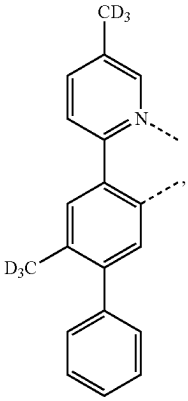

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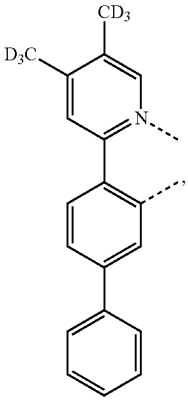

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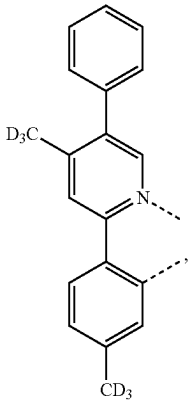

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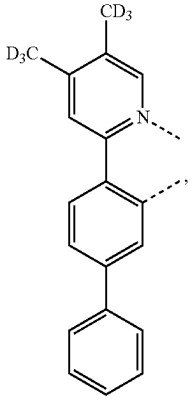

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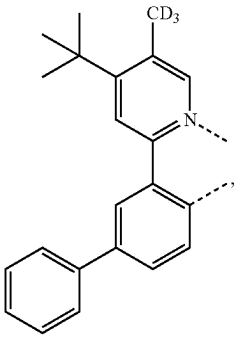

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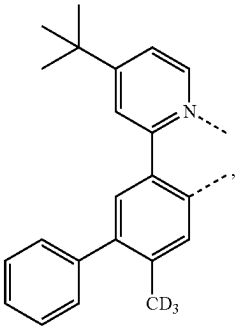

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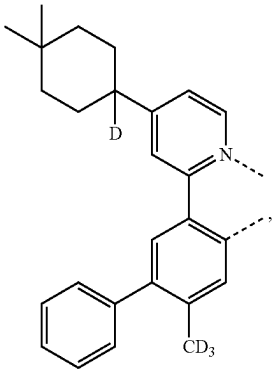

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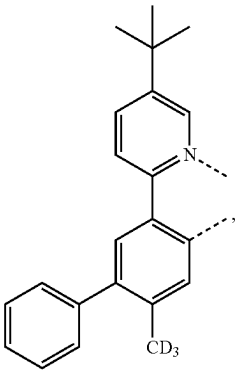

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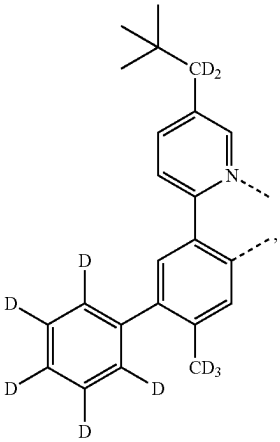

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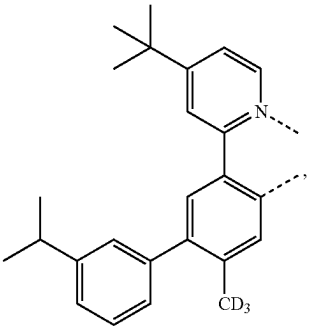

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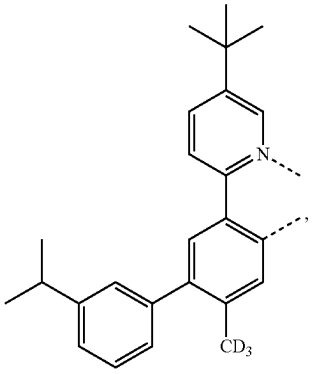

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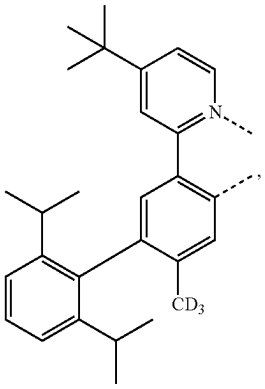

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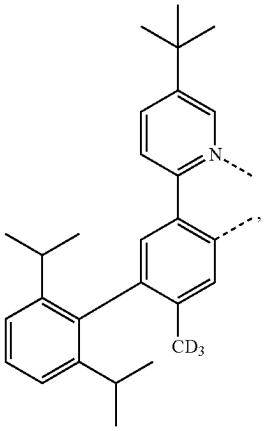

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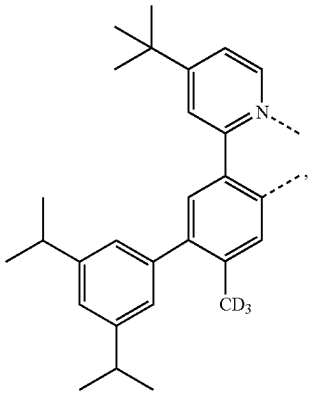

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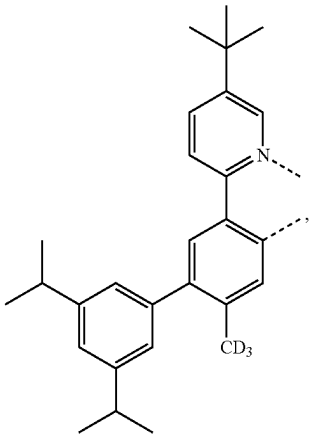

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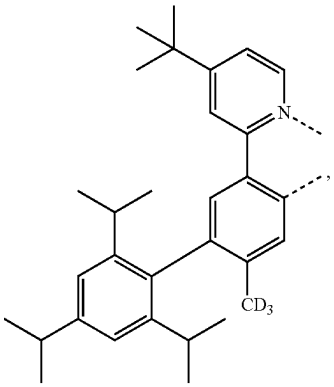

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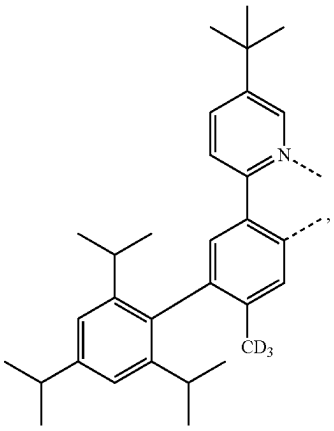

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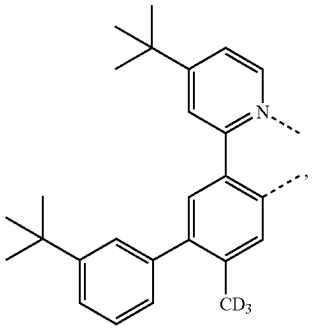

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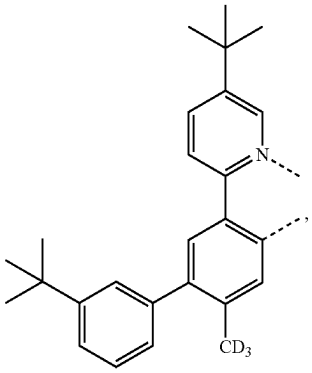

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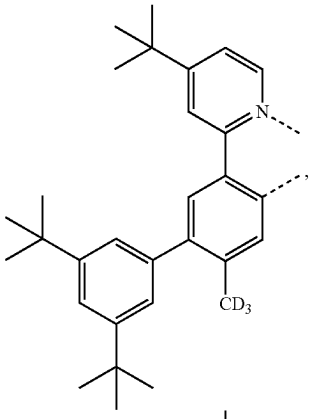

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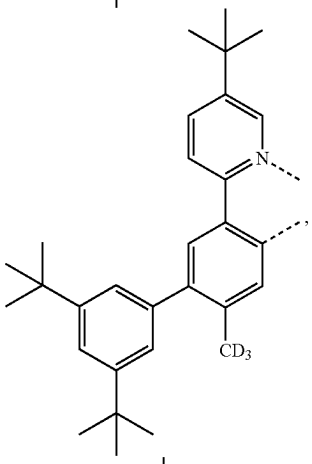

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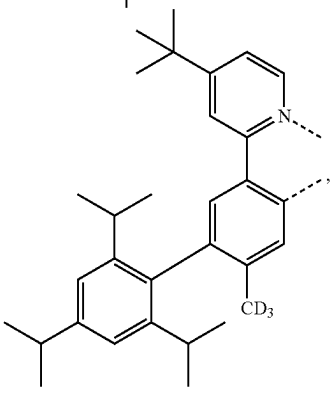

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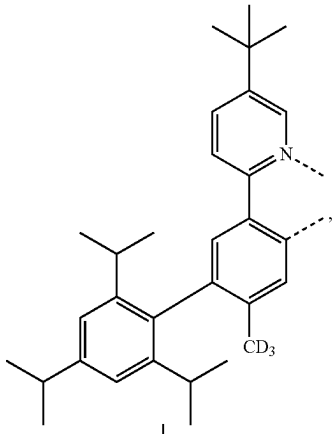

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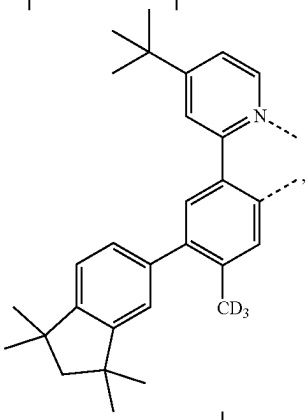

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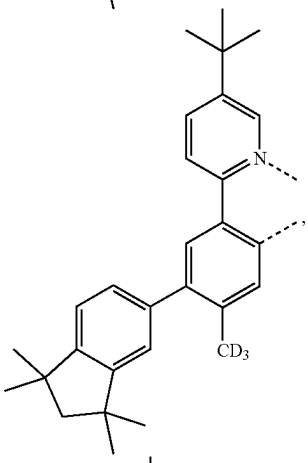

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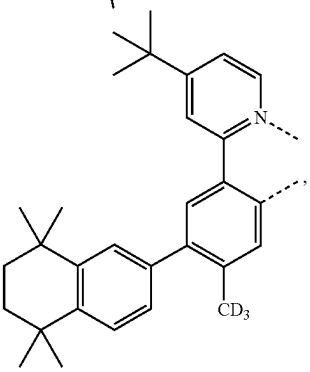

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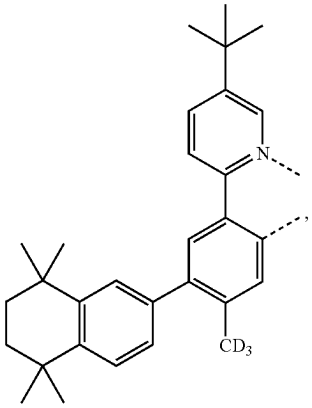

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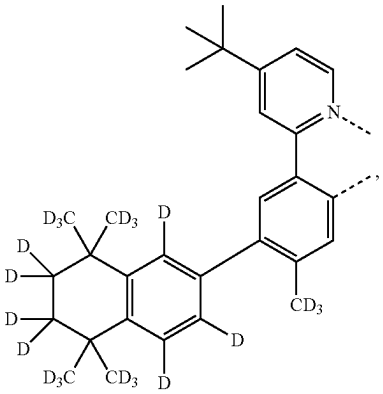

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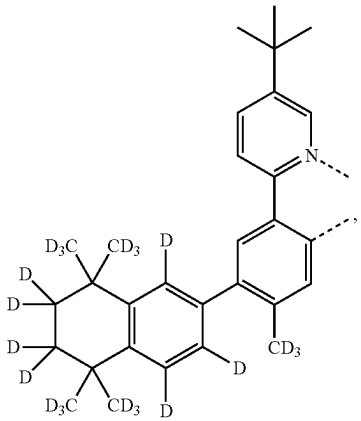

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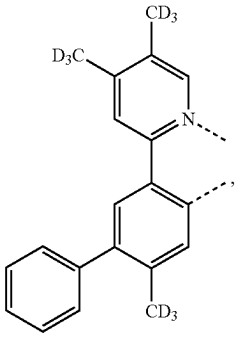

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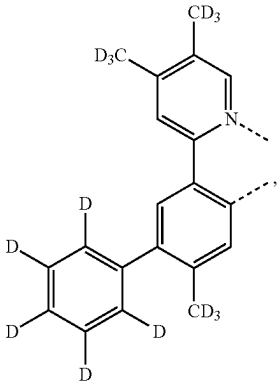

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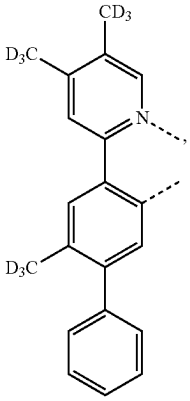

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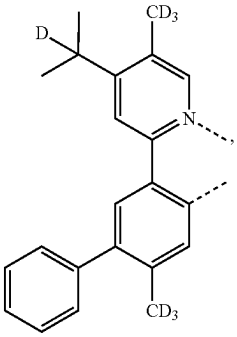

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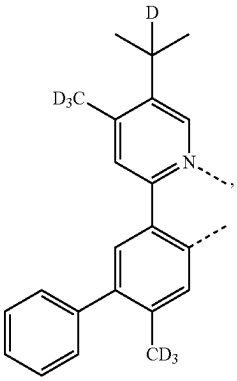

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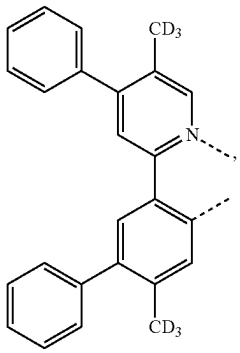

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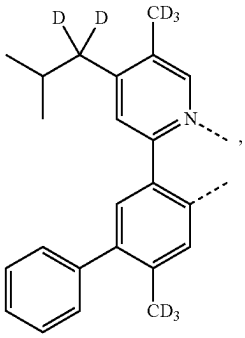

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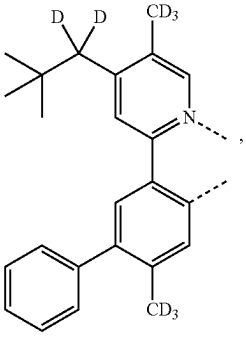

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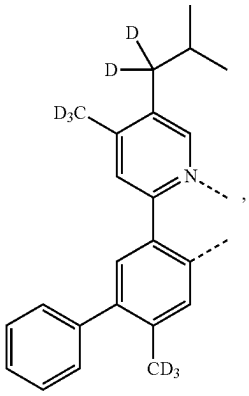

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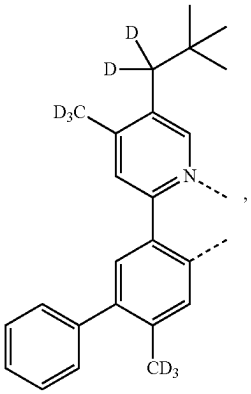

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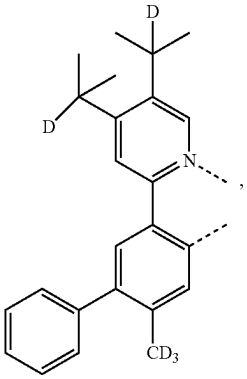

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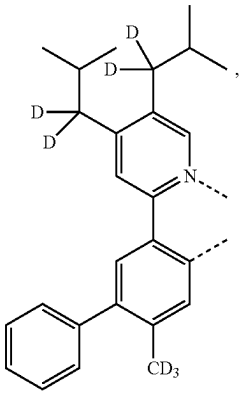

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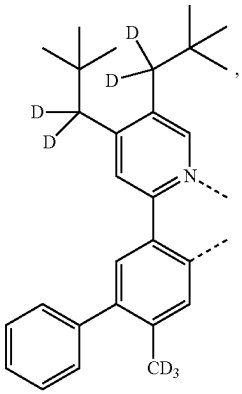

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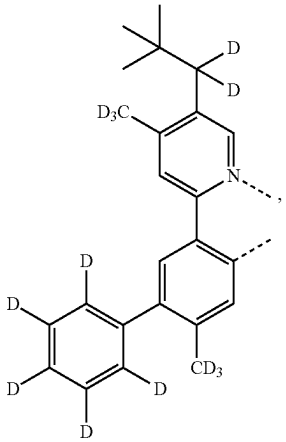

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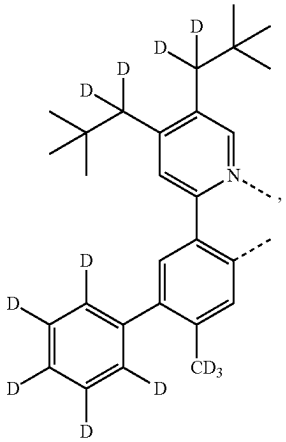

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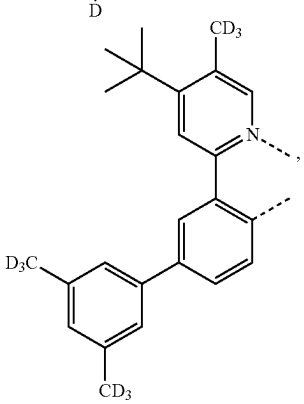

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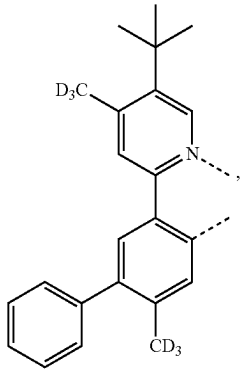

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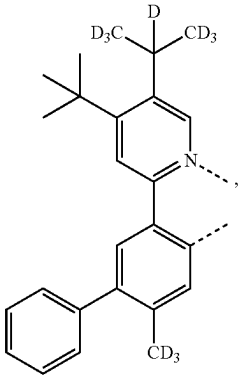

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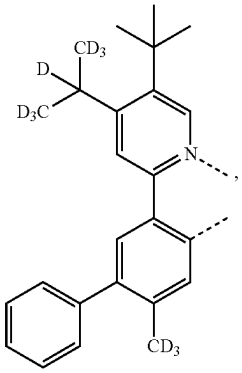

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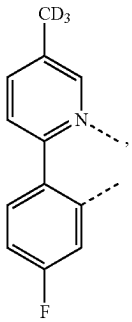

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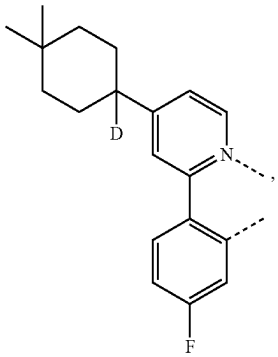

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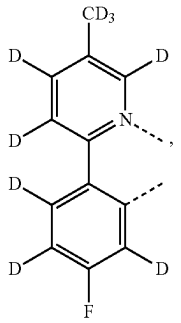

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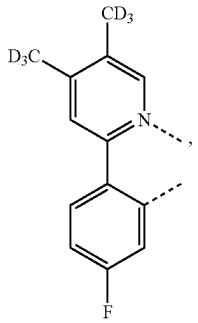

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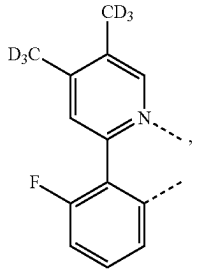

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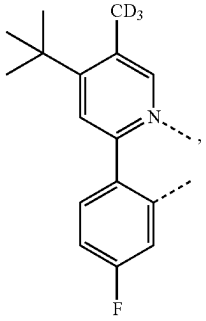

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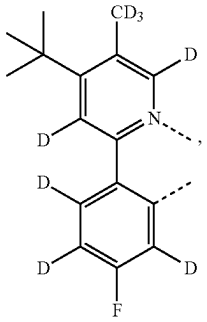

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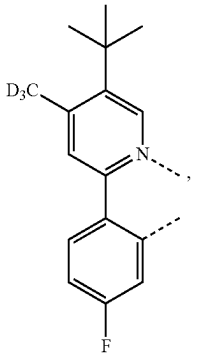

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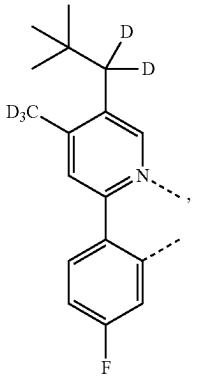

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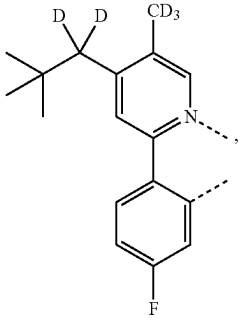

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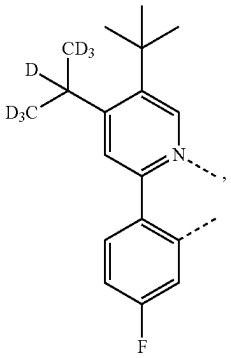

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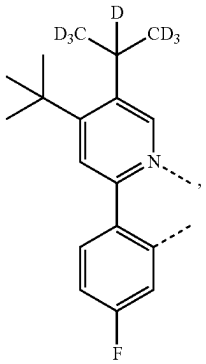

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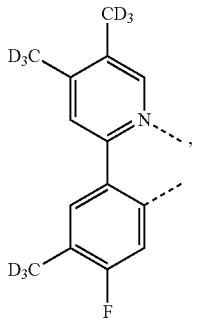

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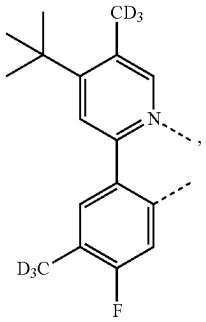

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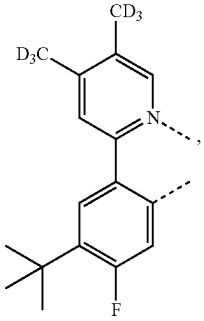

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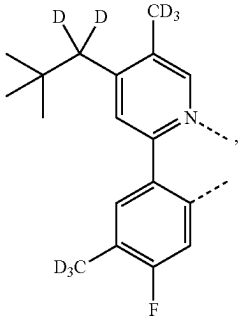

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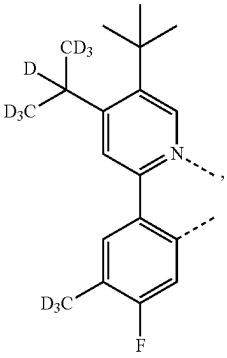

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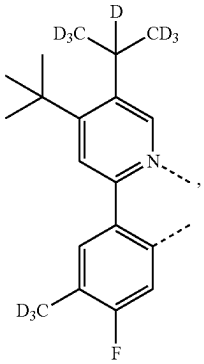

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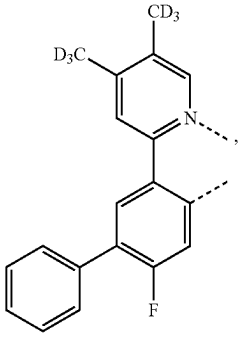

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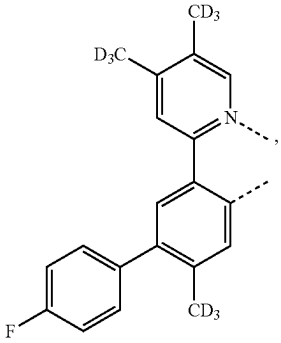

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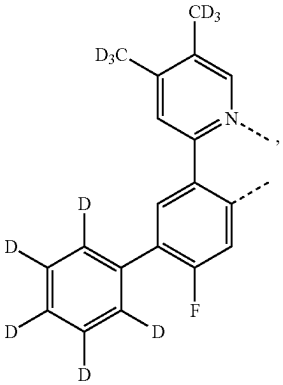

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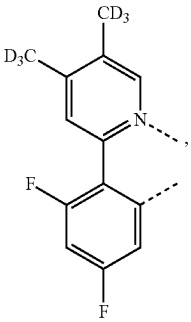

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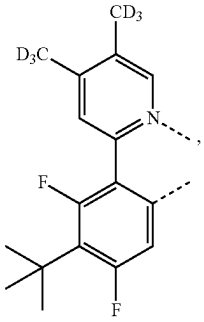

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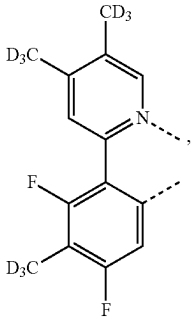

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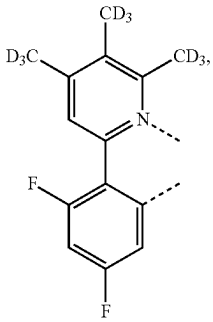

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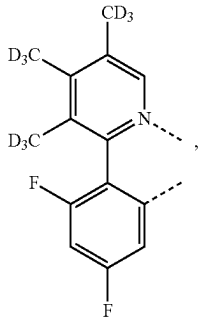

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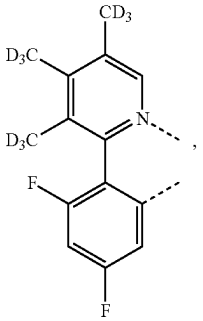

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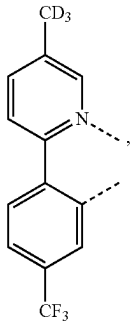

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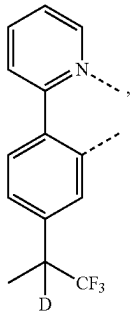

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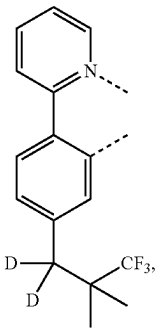

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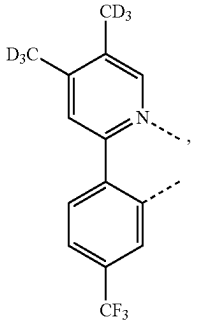

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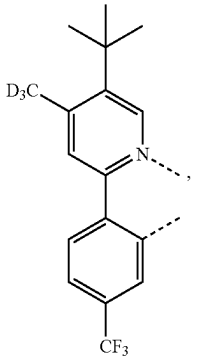

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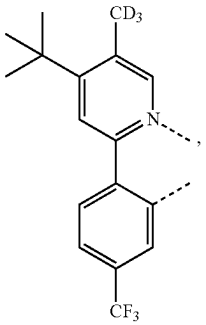

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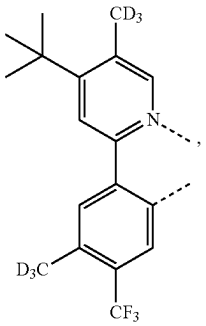

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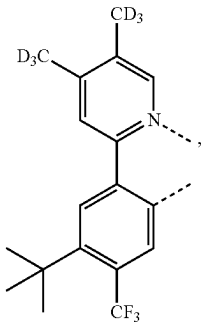

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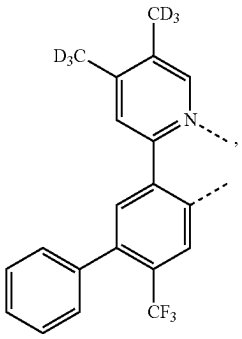

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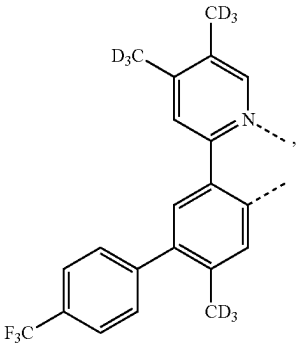

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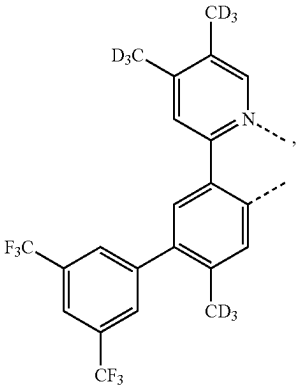

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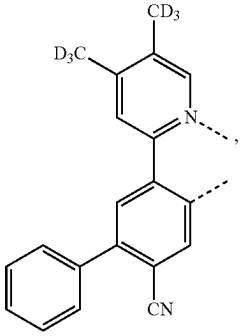

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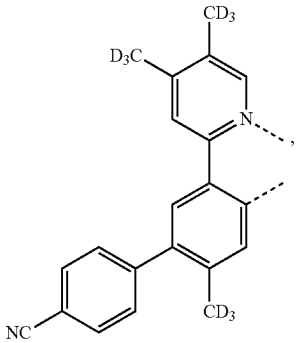

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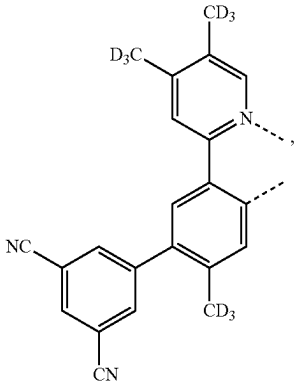

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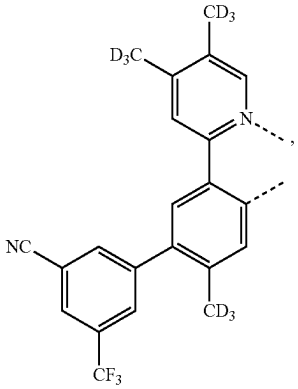

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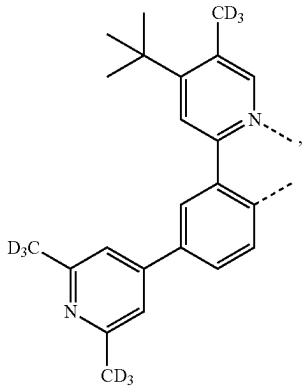

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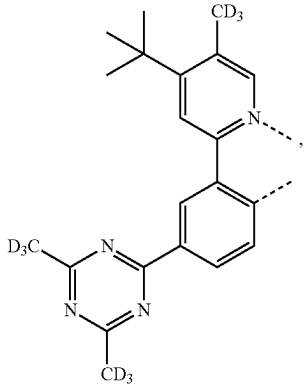

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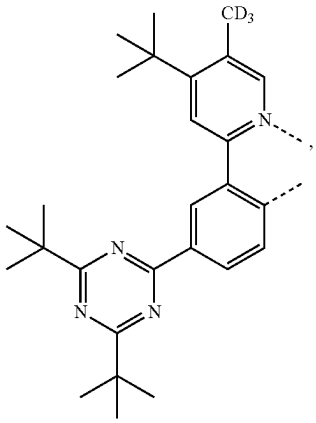

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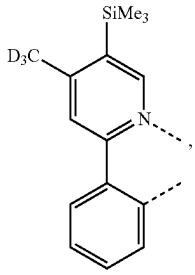

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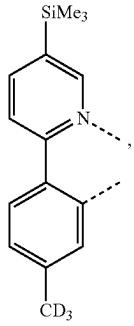

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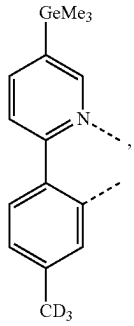

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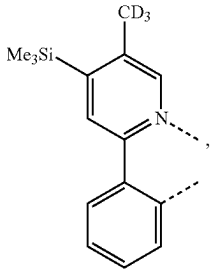

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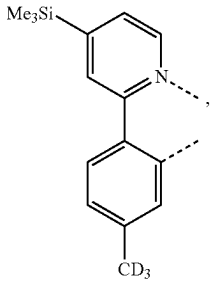

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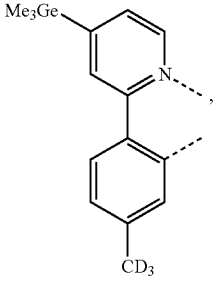

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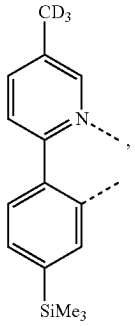

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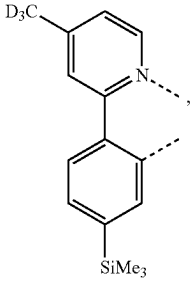

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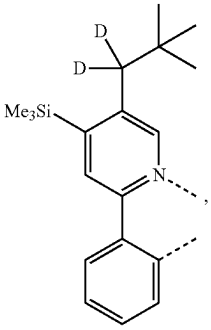

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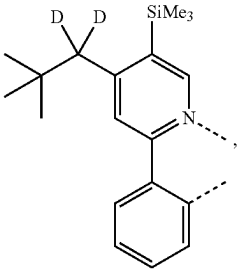

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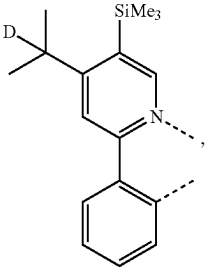

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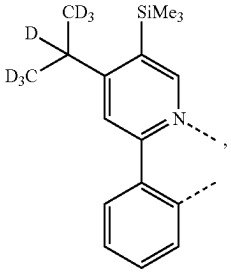

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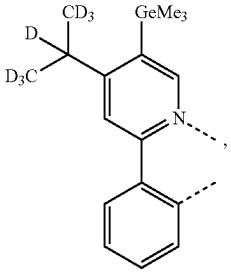

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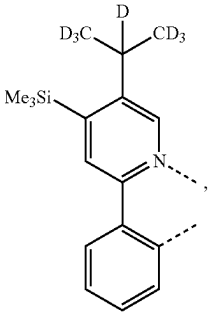

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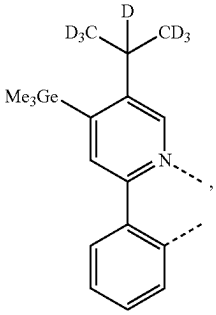

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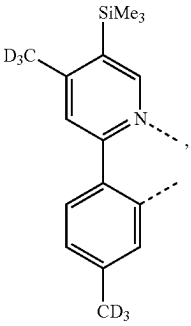

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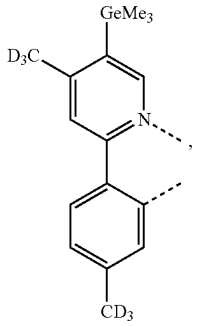

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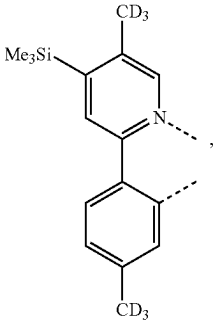

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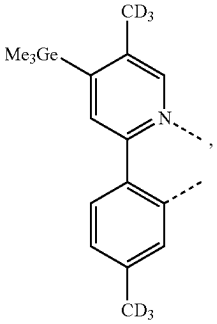

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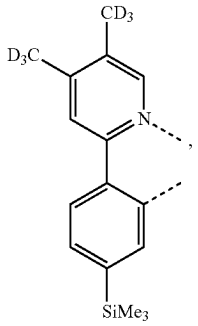

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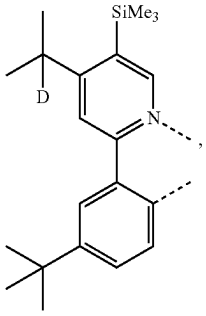

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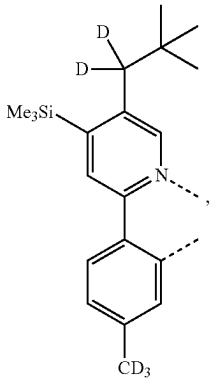

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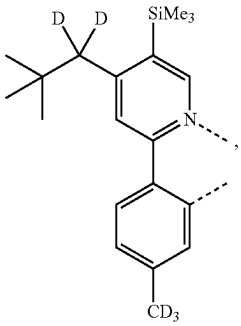

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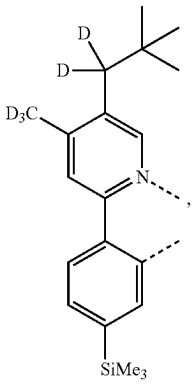

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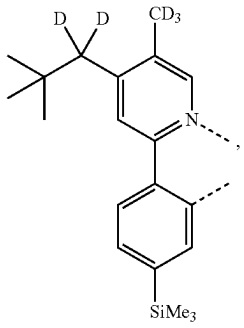

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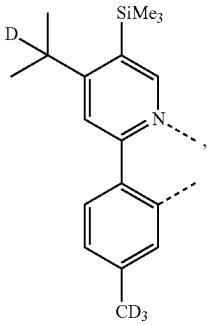

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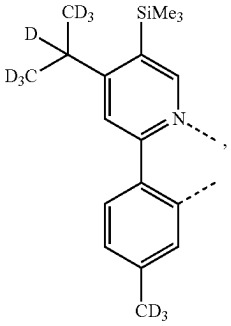

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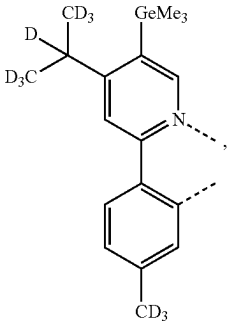

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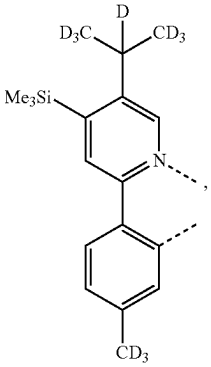

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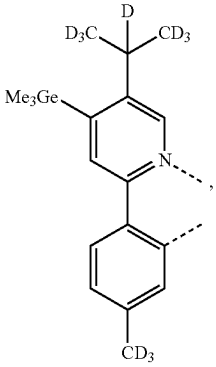

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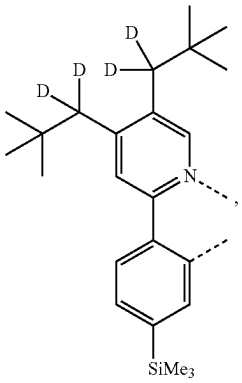

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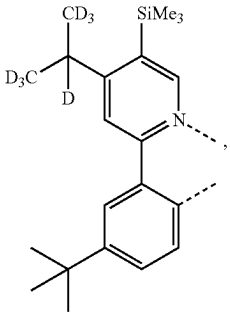

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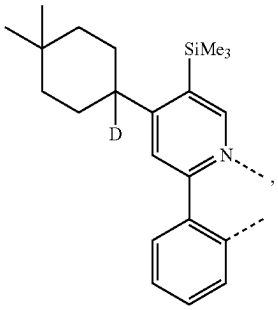

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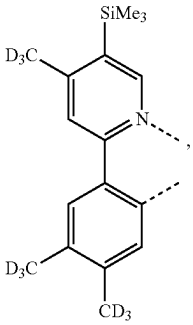

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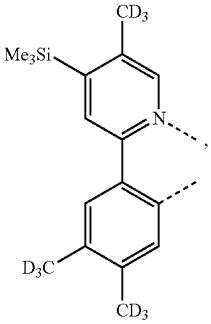

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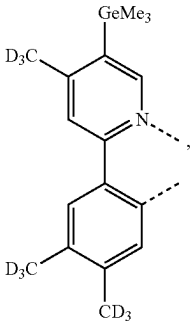

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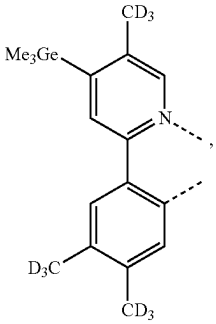

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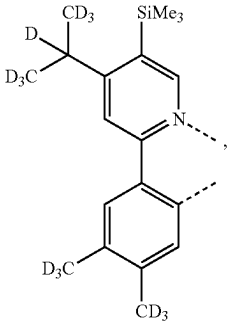

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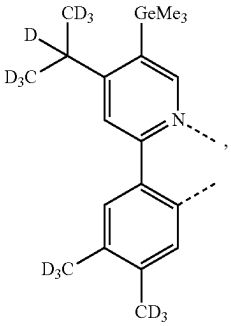

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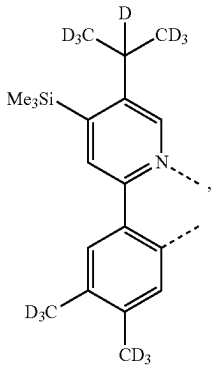

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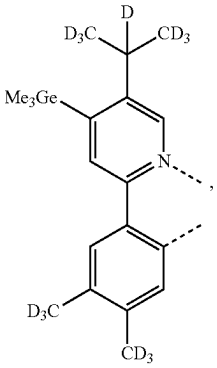

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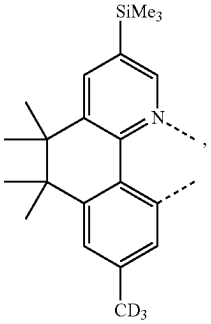

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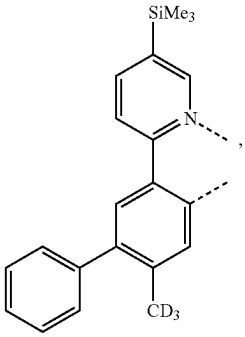

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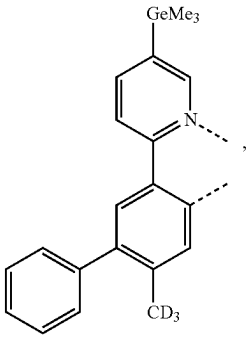

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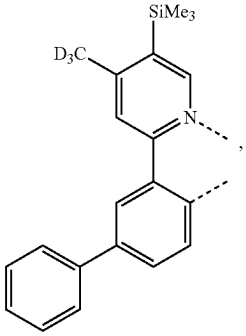

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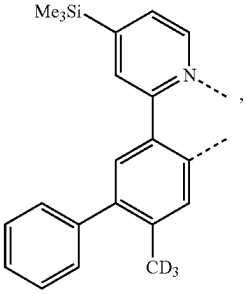

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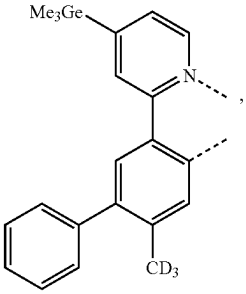

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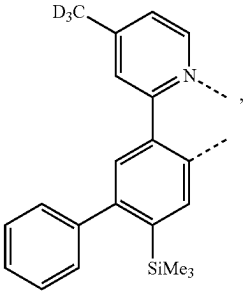

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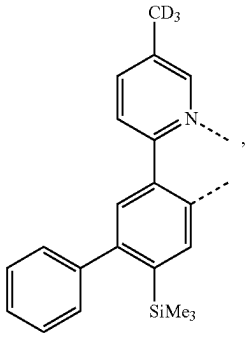

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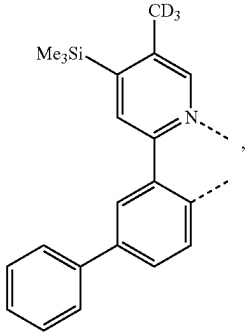

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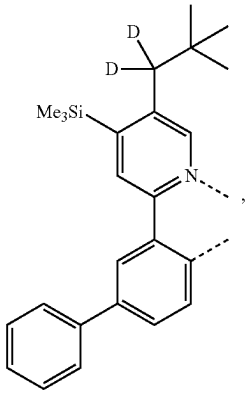

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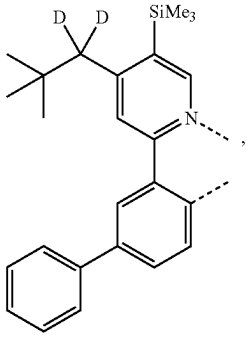

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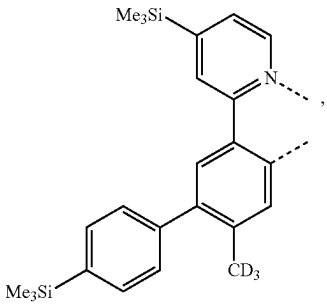

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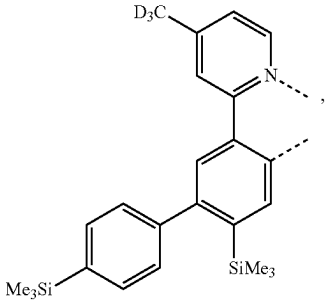

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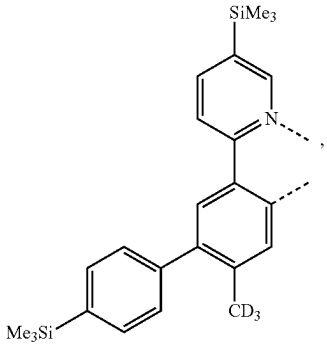

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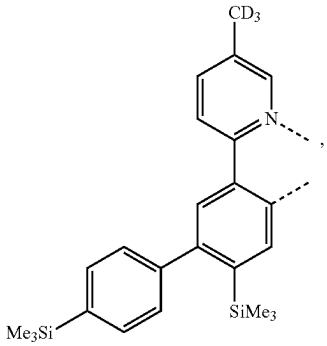

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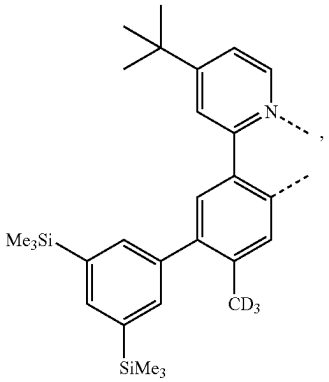

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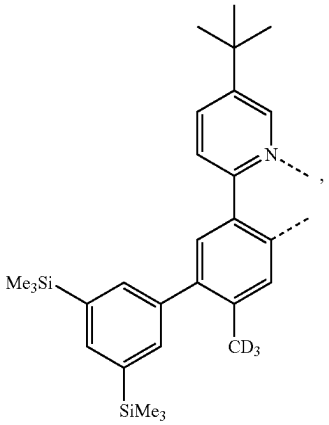

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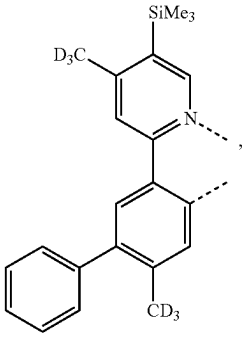

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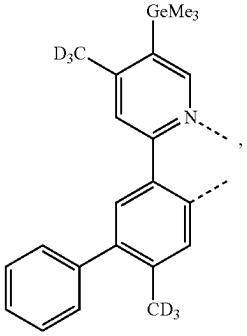

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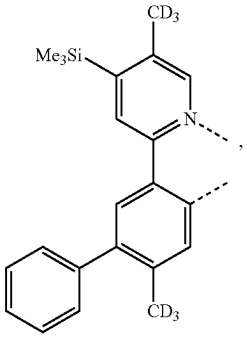

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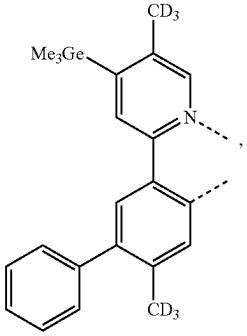

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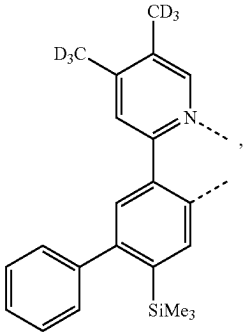

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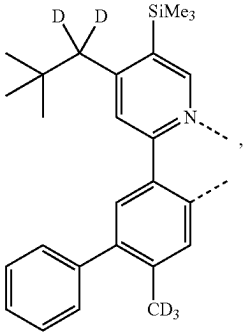

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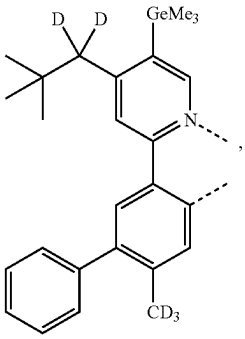

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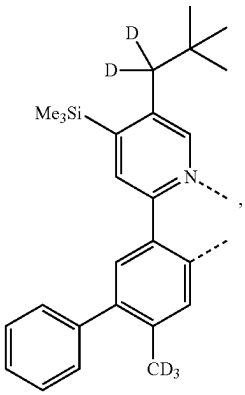

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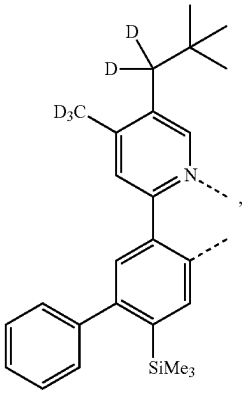

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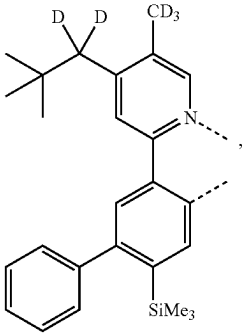

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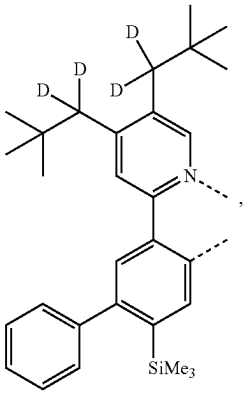

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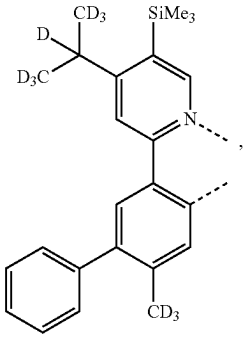

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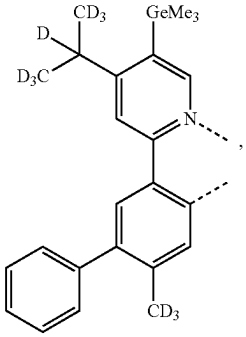

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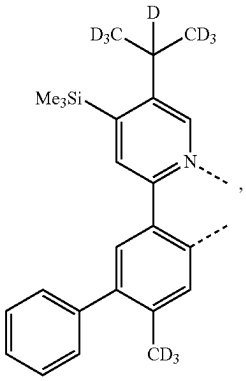

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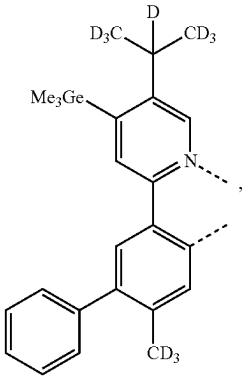

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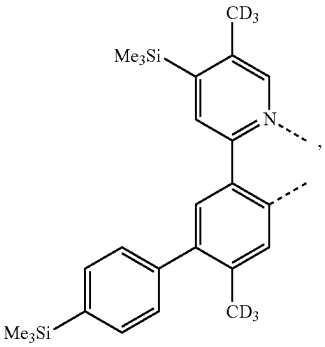

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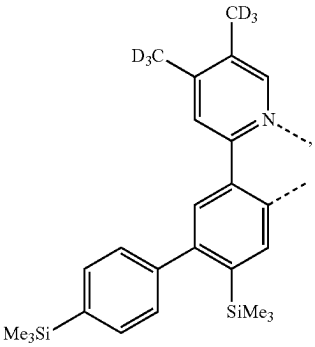

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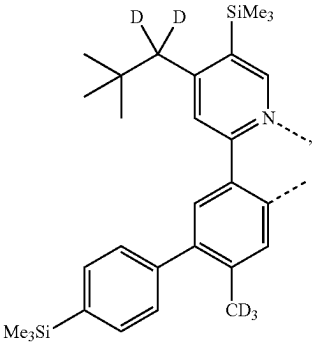

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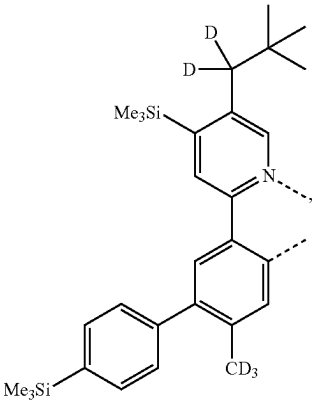

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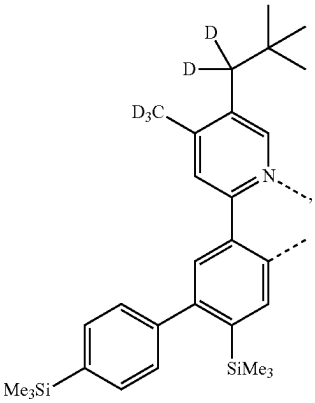

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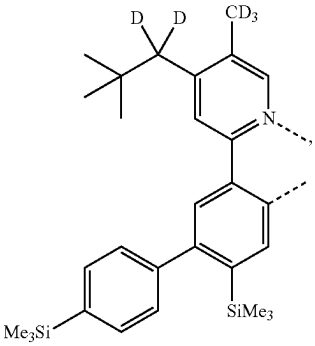

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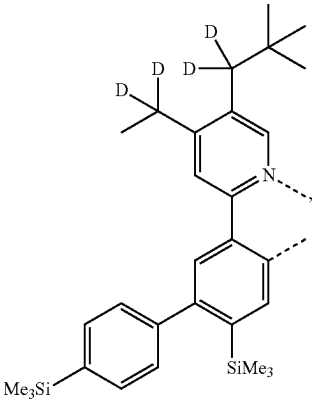

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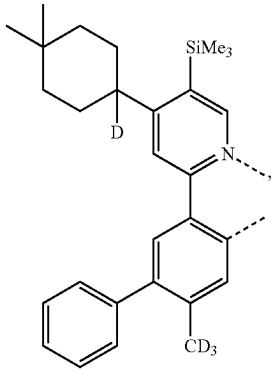

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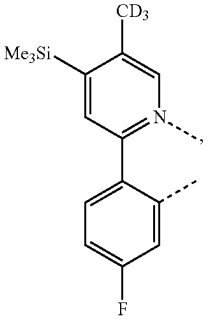

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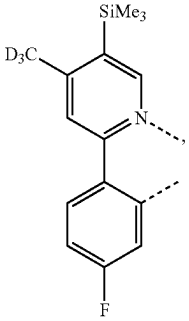

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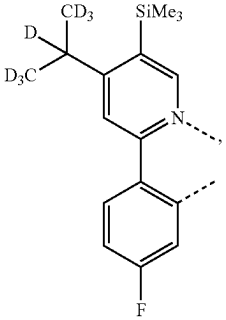

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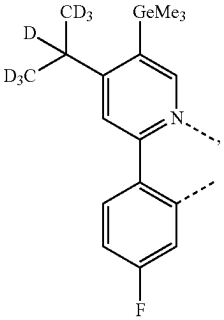

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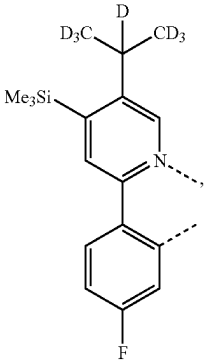

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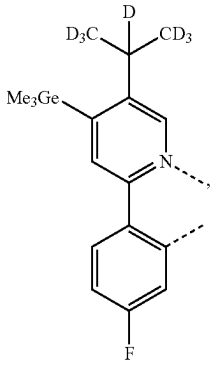

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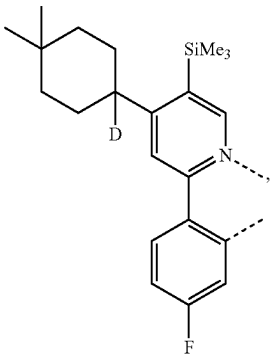

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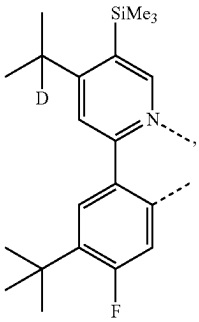

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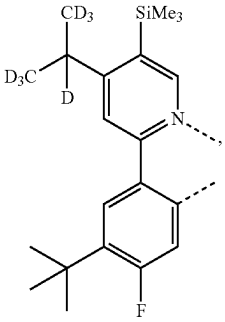

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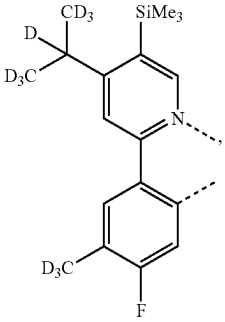

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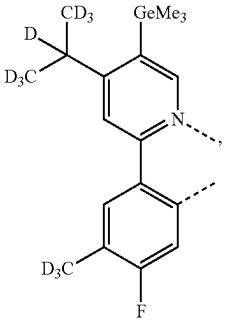

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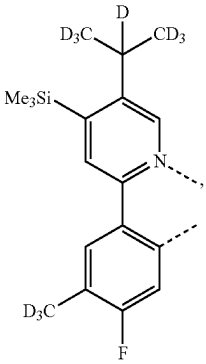

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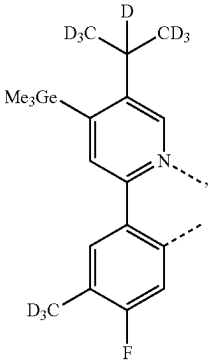

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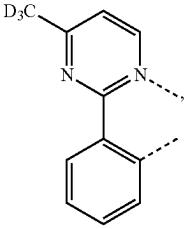

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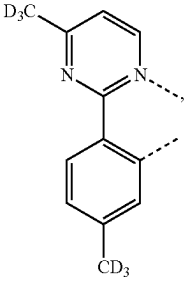

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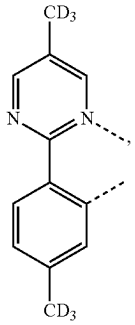

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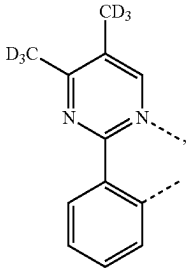

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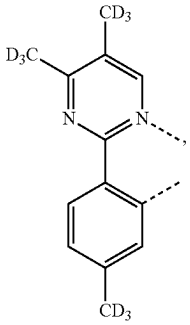

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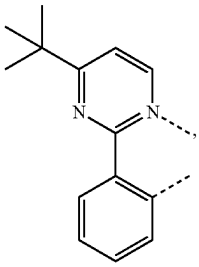

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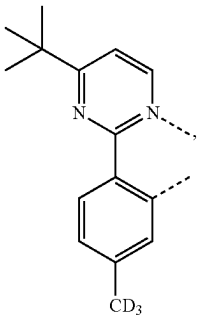

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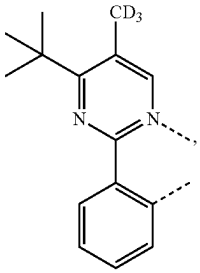

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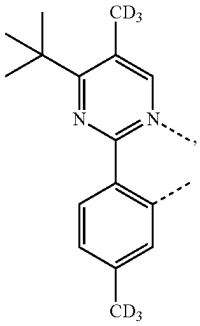

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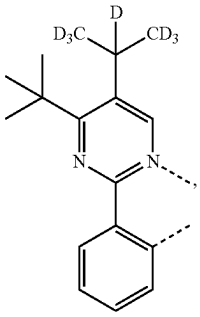

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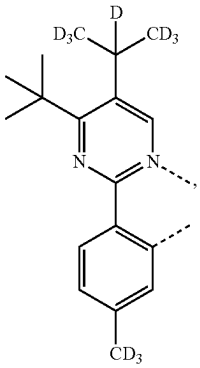

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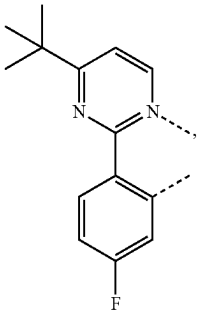

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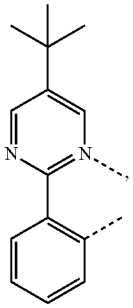

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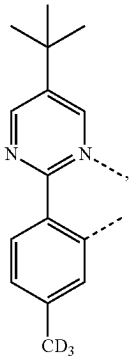

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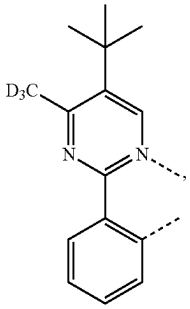

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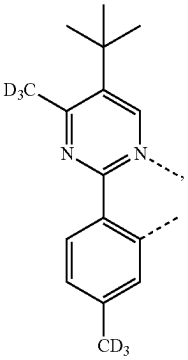

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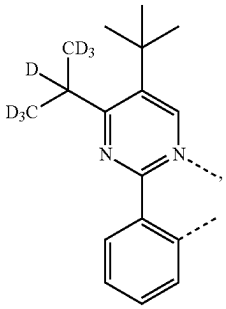

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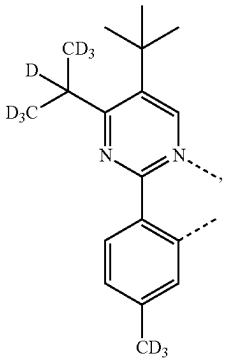

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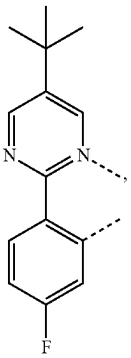

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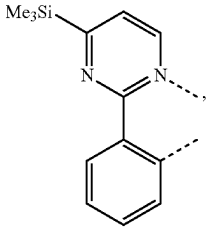

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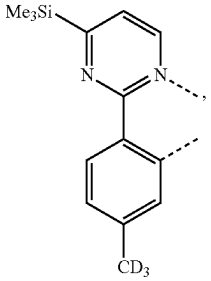

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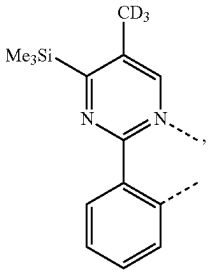

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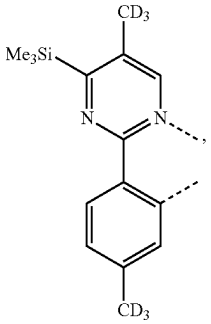

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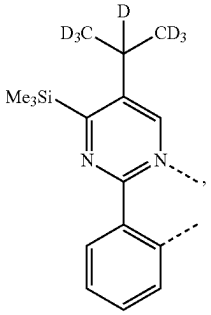

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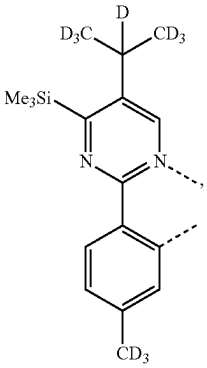

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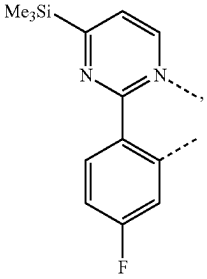

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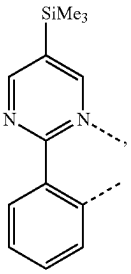

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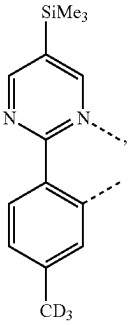

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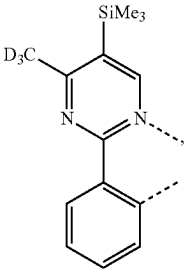

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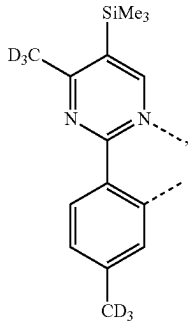

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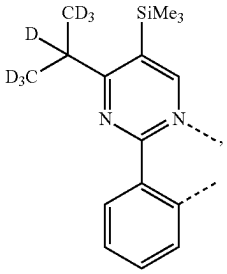

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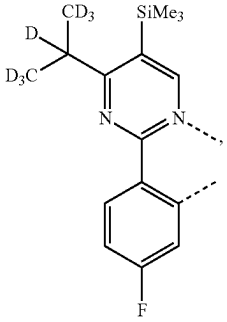

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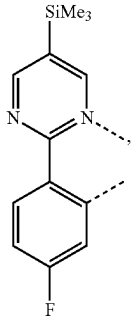

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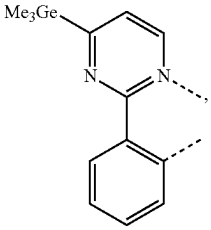

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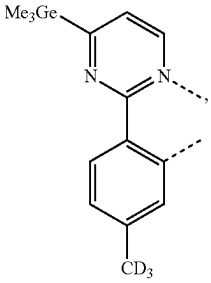

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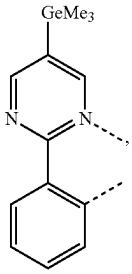

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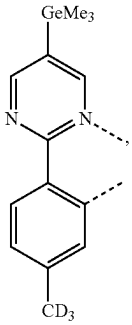

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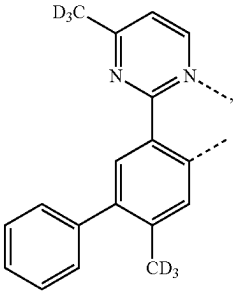

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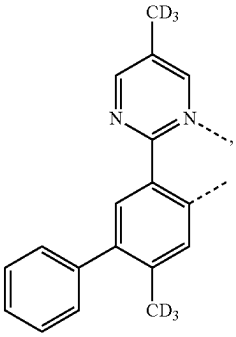

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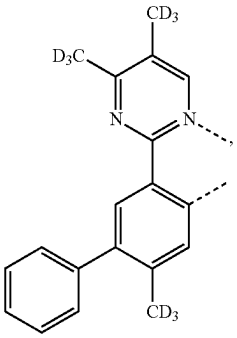

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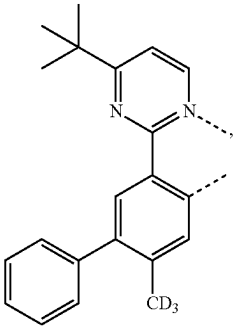

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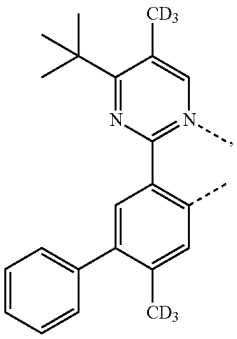

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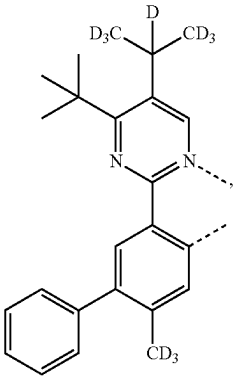

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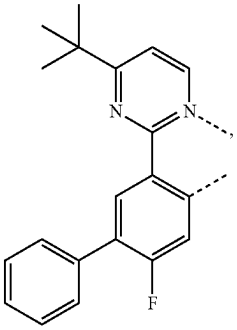

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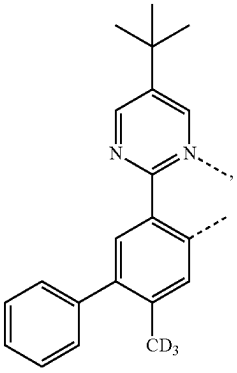

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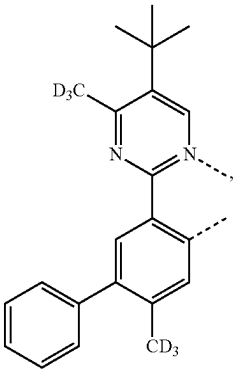

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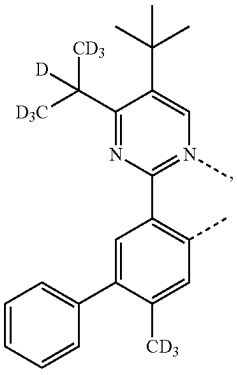

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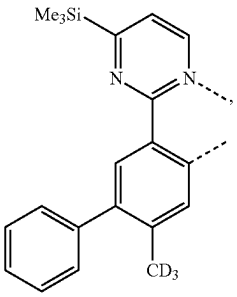

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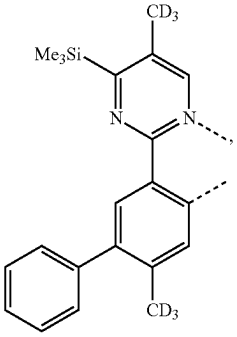

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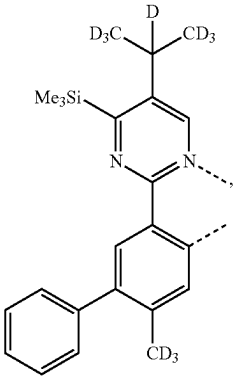

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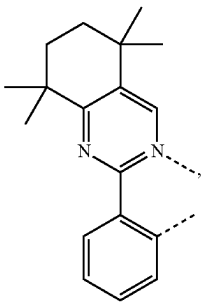

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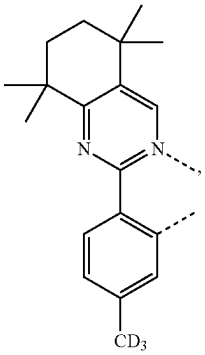

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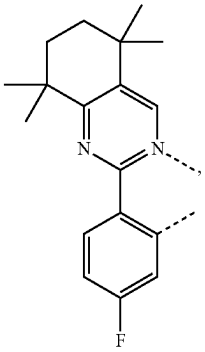

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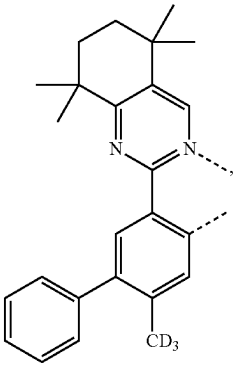

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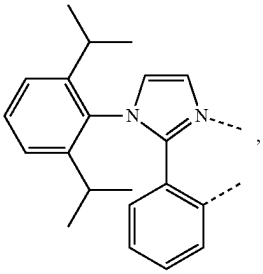

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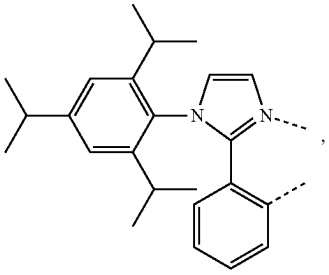

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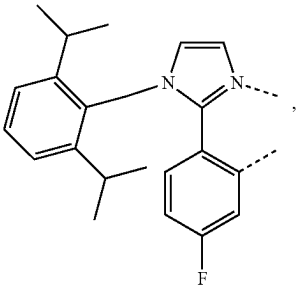

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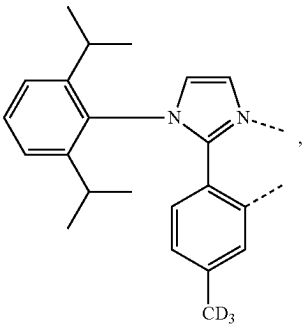

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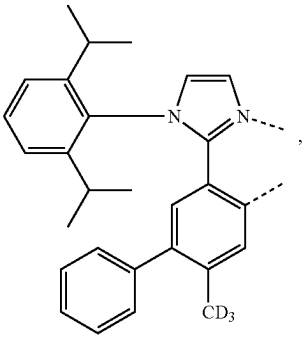

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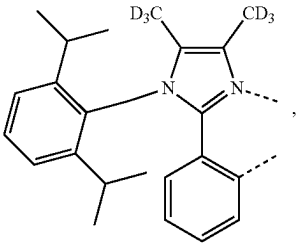

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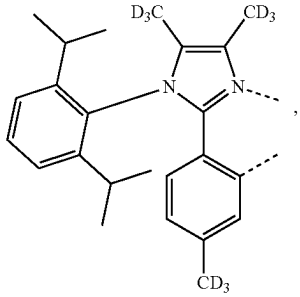

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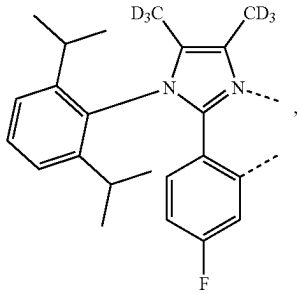

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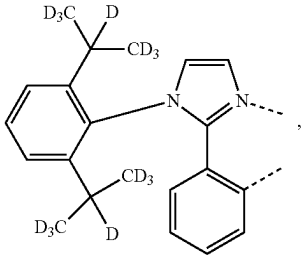

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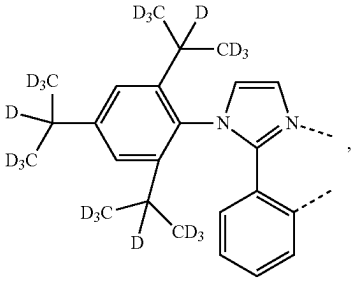

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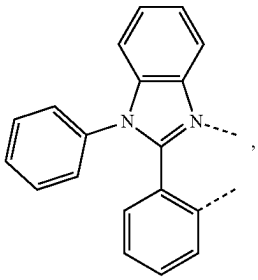

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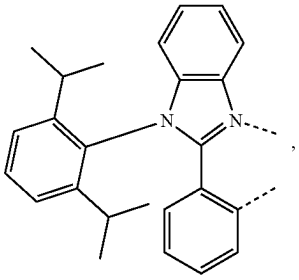

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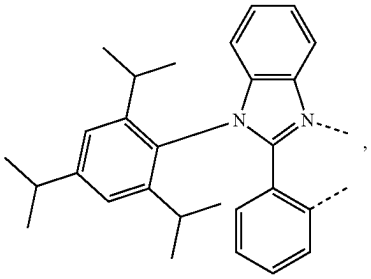
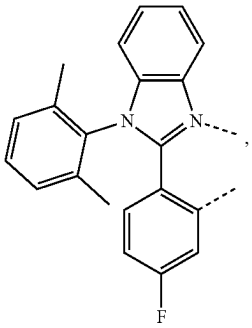


L_{B517}



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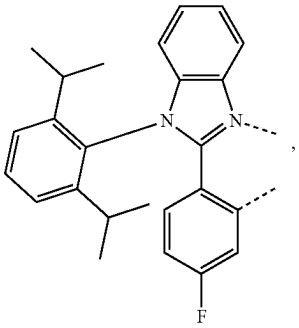

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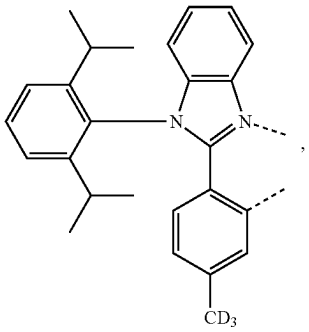

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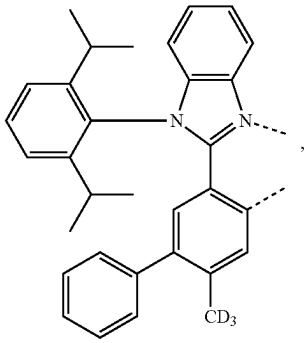

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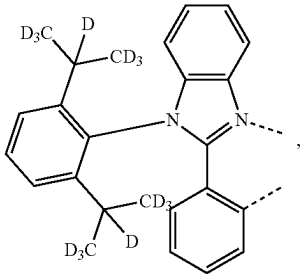

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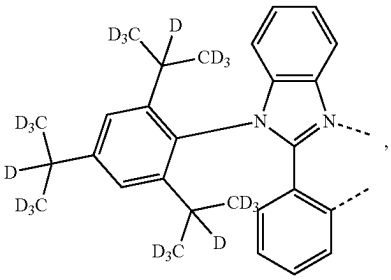

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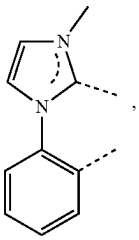

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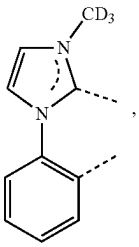

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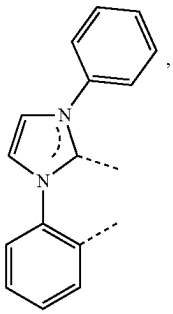
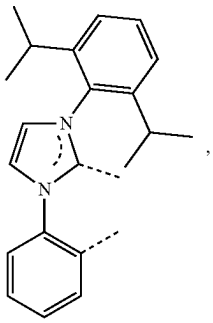


L_{B526}



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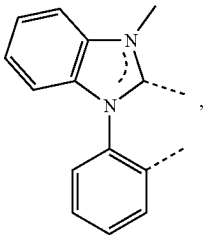

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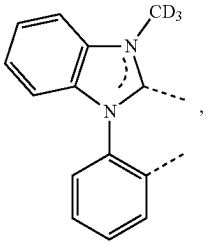

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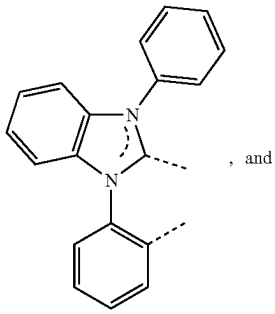
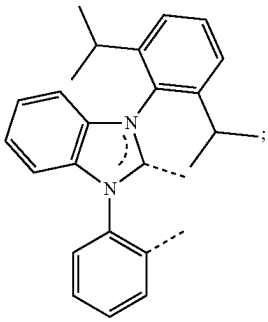
L_{B529}



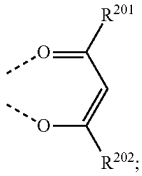
, and

L_{B530}



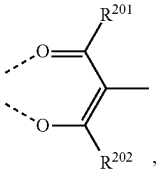
;

[0227] wherein each $L_{Cj\text{-}I}$ has a structure based on formula



and

[0228] each $L_{Cj\text{-}II}$ has a structure based on formula



wherein for each L_{Cj} in $L_{Cj\text{-}I}$ and $L_{Cj\text{-}II}$, R^{201} and R^{202} are defined in the following LIST 9:

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C1}	R^{D1}	R^{D1}	L_{C193}	R^{D1}	R^{D3}	L_{C385}	R^{D17}	R^{D40}	L_{C577}	R^{D143}	R^{D120}
L_{C2}	R^{D2}	R^{D2}	L_{C194}	R^{D1}	R^{D4}	L_{C386}	R^{D17}	R^{D41}	L_{C578}	R^{D143}	R^{D133}
L_{C3}	R^{D3}	R^{D3}	L_{C195}	R^{D1}	R^{D5}	L_{C387}	R^{D17}	R^{D42}	L_{C579}	R^{D143}	R^{D134}
L_{C4}	R^{D4}	R^{D4}	L_{C196}	R^{D1}	R^{D9}	L_{C388}	R^{D17}	R^{D43}	L_{C580}	R^{D143}	R^{D135}
L_{C5}	R^{D5}	R^{D5}	L_{C197}	R^{D1}	R^{D10}	L_{C389}	R^{D17}	R^{D48}	L_{C581}	R^{D143}	R^{D136}
L_{C6}	R^{D6}	R^{D6}	L_{C198}	R^{D1}	R^{D17}	L_{C390}	R^{D17}	R^{D49}	L_{C582}	R^{D143}	R^{D144}
L_{C7}	R^{D7}	R^{D7}	L_{C199}	R^{D1}	R^{D18}	L_{C391}	R^{D17}	R^{D50}	L_{C583}	R^{D143}	R^{D145}
L_{C8}	R^{D8}	R^{D8}	L_{C200}	R^{D1}	R^{D20}	L_{C392}	R^{D17}	R^{D54}	L_{C584}	R^{D143}	R^{D146}
L_{C9}	R^{D9}	R^{D9}	L_{C201}	R^{D1}	R^{D22}	L_{C393}	R^{D17}	R^{D55}	L_{C585}	R^{D143}	R^{D147}
L_{C10}	R^{D10}	R^{D10}	L_{C202}	R^{D1}	R^{D37}	L_{C394}	R^{D17}	R^{D58}	L_{C586}	R^{D143}	R^{D149}
L_{C11}	R^{D11}	R^{D11}	L_{C203}	R^{D1}	R^{D40}	L_{C395}	R^{D17}	R^{D59}	L_{C587}	R^{D143}	R^{D151}
L_{C12}	R^{D12}	R^{D12}	L_{C204}	R^{D1}	R^{D41}	L_{C396}	R^{D17}	R^{D78}	L_{C588}	R^{D143}	R^{D154}
L_{C13}	R^{D13}	R^{D13}	L_{C205}	R^{D1}	R^{D42}	L_{C397}	R^{D17}	R^{D79}	L_{C589}	R^{D143}	R^{D155}
L_{C14}	R^{D14}	R^{D14}	L_{C206}	R^{D1}	R^{D43}	L_{C398}	R^{D17}	R^{D81}	L_{C590}	R^{D143}	R^{D161}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C15}	R^{D15}	R^{D15}	L_{C207}	R^{D1}	R^{D48}	L_{C399}	R^{D17}	R^{D87}	L_{C591}	R^{D143}	R^{D175}
L_{C16}	R^{D16}	R^{D16}	L_{C208}	R^{D1}	R^{D49}	L_{C400}	R^{D17}	R^{D88}	L_{C592}	R^{D144}	R^{D3}
L_{C17}	R^{D17}	R^{D17}	L_{C209}	R^{D1}	R^{D50}	L_{C401}	R^{D17}	R^{D89}	L_{C593}	R^{D144}	R^{D5}
L_{C18}	R^{D18}	R^{D18}	L_{C210}	R^{D1}	R^{D54}	L_{C402}	R^{D17}	R^{D93}	L_{C594}	R^{D144}	R^{D17}
L_{C19}	R^{D19}	R^{D19}	L_{C211}	R^{D1}	R^{D55}	L_{C403}	R^{D17}	R^{D116}	L_{C595}	R^{D144}	R^{D18}
L_{C20}	R^{D20}	R^{D20}	L_{C212}	R^{D1}	R^{D58}	L_{C404}	R^{D17}	R^{D117}	L_{C596}	R^{D144}	R^{D20}
L_{C21}	R^{D21}	R^{D21}	L_{C213}	R^{D1}	R^{D59}	L_{C405}	R^{D17}	R^{D118}	L_{C597}	R^{D144}	R^{D22}
L_{C22}	R^{D22}	R^{D22}	L_{C214}	R^{D1}	R^{D78}	L_{C406}	R^{D17}	R^{D119}	L_{C598}	R^{D144}	R^{D37}
L_{C23}	R^{D23}	R^{D23}	L_{C215}	R^{D1}	R^{D79}	L_{C407}	R^{D17}	R^{D120}	L_{C599}	R^{D144}	R^{D40}
L_{C24}	R^{D24}	R^{D24}	L_{C216}	R^{D1}	R^{D81}	L_{C408}	R^{D17}	R^{D133}	L_{C600}	R^{D144}	R^{D41}
L_{C25}	R^{D25}	R^{D25}	L_{C217}	R^{D1}	R^{D87}	L_{C409}	R^{D17}	R^{D134}	L_{C601}	R^{D144}	R^{D42}
L_{C26}	R^{D26}	R^{D26}	L_{C218}	R^{D1}	R^{D88}	L_{C410}	R^{D17}	R^{D135}	L_{C602}	R^{D144}	R^{D43}
L_{C27}	R^{D27}	R^{D27}	L_{C219}	R^{D1}	R^{D89}	L_{C411}	R^{D17}	R^{D136}	L_{C603}	R^{D144}	R^{D48}
L_{C28}	R^{D28}	R^{D28}	L_{C220}	R^{D1}	R^{D93}	L_{C412}	R^{D17}	R^{D143}	L_{C604}	R^{D144}	R^{D49}
L_{C29}	R^{D29}	R^{D29}	L_{C221}	R^{D1}	R^{D116}	L_{C413}	R^{D17}	R^{D144}	L_{C605}	R^{D144}	R^{D54}
L_{C30}	R^{D30}	R^{D30}	L_{C222}	R^{D1}	R^{D117}	L_{C414}	R^{D17}	R^{D145}	L_{C606}	R^{D144}	R^{D58}
L_{C31}	R^{D31}	R^{D31}	L_{C223}	R^{D1}	R^{D118}	L_{C415}	R^{D17}	R^{D146}	L_{C607}	R^{D144}	R^{D59}
L_{C32}	R^{D32}	R^{D32}	L_{C224}	R^{D1}	R^{D119}	L_{C416}	R^{D17}	R^{D147}	L_{C608}	R^{D144}	R^{D78}
L_{C33}	R^{D33}	R^{D33}	L_{C225}	R^{D1}	R^{D120}	L_{C417}	R^{D17}	R^{D149}	L_{C609}	R^{D144}	R^{D79}
L_{C34}	R^{D34}	R^{D34}	L_{C226}	R^{D1}	R^{D133}	L_{C418}	R^{D17}	R^{D151}	L_{C610}	R^{D144}	R^{D81}
L_{C35}	R^{D35}	R^{D35}	L_{C227}	R^{D1}	R^{D134}	L_{C419}	R^{D17}	R^{D154}	L_{C611}	R^{D144}	R^{D87}
L_{C36}	R^{D36}	R^{D36}	L_{C228}	R^{D1}	R^{D135}	L_{C420}	R^{D17}	R^{D155}	L_{C612}	R^{D144}	R^{D88}
L_{C37}	R^{D37}	R^{D37}	L_{C229}	R^{D1}	R^{D136}	L_{C421}	R^{D17}	R^{D161}	L_{C613}	R^{D144}	R^{D89}
L_{C38}	R^{D38}	R^{D38}	L_{C230}	R^{D1}	R^{D143}	L_{C422}	R^{D17}	R^{D175}	L_{C614}	R^{D144}	R^{D93}
L_{C39}	R^{D39}	R^{D39}	L_{C231}	R^{D1}	R^{D144}	L_{C423}	R^{D50}	R^{D3}	L_{C615}	R^{D144}	R^{D116}
L_{C40}	R^{D40}	R^{D40}	L_{C232}	R^{D1}	R^{D145}	L_{C424}	R^{D50}	R^{D5}	L_{C616}	R^{D144}	R^{D117}
L_{C41}	R^{D41}	R^{D41}	L_{C233}	R^{D1}	R^{D146}	L_{C425}	R^{D50}	R^{D18}	L_{C617}	R^{D144}	R^{D118}
L_{C42}	R^{D42}	R^{D42}	L_{C234}	R^{D1}	R^{D147}	L_{C426}	R^{D50}	R^{D20}	L_{C618}	R^{D144}	R^{D119}
L_{C43}	R^{D43}	R^{D43}	L_{C235}	R^{D1}	R^{D149}	L_{C427}	R^{D50}	R^{D22}	L_{C619}	R^{D144}	R^{D120}
L_{C44}	R^{D44}	R^{D44}	L_{C236}	R^{D1}	R^{D151}	L_{C428}	R^{D50}	R^{D37}	L_{C620}	R^{D144}	R^{D133}
L_{C45}	R^{D45}	R^{D45}	L_{C237}	R^{D1}	R^{D154}	L_{C429}	R^{D50}	R^{D40}	L_{C621}	R^{D144}	R^{D134}
L_{C46}	R^{D46}	R^{D46}	L_{C238}	R^{D1}	R^{D155}	L_{C430}	R^{D50}	R^{D41}	L_{C622}	R^{D144}	R^{D135}
L_{C47}	R^{D47}	R^{D47}	L_{C239}	R^{D1}	R^{D161}	L_{C431}	R^{D50}	R^{D42}	L_{C623}	R^{D144}	R^{D136}
L_{C48}	R^{D48}	R^{D48}	L_{C240}	R^{D1}	R^{D175}	L_{C432}	R^{D50}	R^{D43}	L_{C624}	R^{D144}	R^{D145}
L_{C49}	R^{D49}	R^{D49}	L_{C241}	R^{D4}	R^{D3}	L_{C433}	R^{D50}	R^{D48}	L_{C625}	R^{D144}	R^{D146}
L_{C50}	R^{D50}	R^{D50}	L_{C242}	R^{D4}	R^{D5}	L_{C434}	R^{D50}	R^{D49}	L_{C626}	R^{D144}	R^{D147}
L_{C51}	R^{D51}	R^{D51}	L_{C243}	R^{D4}	R^{D9}	L_{C435}	R^{D50}	R^{D54}	L_{C627}	R^{D144}	R^{D149}
L_{C52}	R^{D52}	R^{D52}	L_{C244}	R^{D4}	R^{D10}	L_{C436}	R^{D50}	R^{D55}	L_{C628}	R^{D144}	R^{D151}
L_{C53}	R^{D53}	R^{D53}	L_{C245}	R^{D4}	R^{D17}	L_{C437}	R^{D50}	R^{D58}	L_{C629}	R^{D144}	R^{D154}
L_{C54}	R^{D54}	R^{D54}	L_{C246}	R^{D4}	R^{D18}	L_{C438}	R^{D50}	R^{D59}	L_{C630}	R^{D144}	R^{D155}
L_{C55}	R^{D55}	R^{D55}	L_{C247}	R^{D4}	R^{D20}	L_{C439}	R^{D50}	R^{D78}	L_{C631}	R^{D144}	R^{D161}
L_{C56}	R^{D56}	R^{D56}	L_{C248}	R^{D4}	R^{D22}	L_{C440}	R^{D50}	R^{D79}	L_{C632}	R^{D144}	R^{D175}
L_{C57}	R^{D57}	R^{D57}	L_{C249}	R^{D4}	R^{D37}	L_{C441}	R^{D50}	R^{D81}	L_{C633}	R^{D145}	R^{D3}
L_{C58}	R^{D58}	R^{D58}	L_{C250}	R^{D4}	R^{D40}	L_{C442}	R^{D50}	R^{D87}	L_{C634}	R^{D145}	R^{D5}
L_{C59}	R^{D59}	R^{D59}	L_{C251}	R^{D4}	R^{D41}	L_{C443}	R^{D50}	R^{D88}	L_{C635}	R^{D145}	R^{D17}
L_{C60}	R^{D60}	R^{D60}	L_{C252}	R^{D4}	R^{D42}	L_{C444}	R^{D50}	R^{D89}	L_{C636}	R^{D145}	R^{D18}
L_{C61}	R^{D61}	R^{D61}	L_{C253}	R^{D4}	R^{D43}	L_{C445}	R^{D50}	R^{D93}	L_{C637}	R^{D145}	R^{D20}
L_{C62}	R^{D62}	R^{D62}	L_{C254}	R^{D4}	R^{D48}	L_{C446}	R^{D50}	R^{D116}	L_{C638}	R^{D145}	R^{D22}
L_{C63}	R^{D63}	R^{D63}	L_{C255}	R^{D4}	R^{D49}	L_{C447}	R^{D50}	R^{D117}	L_{C639}	R^{D145}	R^{D37}
L_{C64}	R^{D64}	R^{D64}	L_{C256}	R^{D4}	R^{D50}	L_{C448}	R^{D50}	R^{D118}	L_{C640}	R^{D145}	R^{D40}
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L_{C67}	R^{D67}	R^{D67}	L_{C259}	R^{D4}	R^{D58}	L_{C451}	R^{D50}	R^{D133}	L_{C643}	R^{D145}	R^{D43}
L_{C68}	R^{D68}	R^{D68}	L_{C260}	R^{D4}	R^{D59}	L_{C452}	R^{D50}	R^{D134}	L_{C644}	R^{D145}	R^{D48}
L_{C69}	R^{D69}	R^{D69}	L_{C261}	R^{D4}	R^{D78}	L_{C453}	R^{D50}	R^{D135}	L_{C645}	R^{D145}	R^{D49}
L_{C70}	R^{D70}	R^{D70}	L_{C262}	R^{D4}	R^{D79}	L_{C454}	R^{D50}	R^{D136}	L_{C646}	R^{D145}	R^{D54}
L_{C71}	R^{D71}	R^{D71}	L_{C263}	R^{D4}	R^{D81}	L_{C455}	R^{D50}	R^{D143}	L_{C647}	R^{D145}	R^{D58}
L_{C72}	R^{D72}	R^{D72}	L_{C264}	R^{D4}	R^{D87}	L_{C456}	R^{D50}	R^{D144}	L_{C648}	R^{D145}	R^{D59}
L_{C73}	R^{D73}	R^{D73}	L_{C265}	R^{D4}	R^{D88}	L_{C457}	R^{D50}	R^{D145}	L_{C649}	R^{D145}	R^{D78}
L_{C74}	R^{D74}	R^{D74}	L_{C266}	R^{D4}	R^{D89}	L_{C458}	R^{D50}	R^{D146}	L_{C650}	R^{D145}	R^{D79}
L_{C75}	R^{D75}	R^{D75}	L_{C267}	R^{D4}	R^{D93}	L_{C459}	R^{D50}	R^{D147}	L_{C651}	R^{D145}	R^{D81}
L_{C76}	R^{D76}	R^{D76}	L_{C268}	R^{D4}	R^{D116}	L_{C460}	R^{D50}	R^{D149}	L_{C652}	R^{D145}	R^{D87}
L_{C77}	R^{D77}	R^{D77}	L_{C269}	R^{D4}	R^{D117}	L_{C461}	R^{D50}	R^{D151}	L_{C653}	R^{D145}	R^{D88}
L_{C78}	R^{D78}	R^{D78}	L_{C270}	R^{D4}	R^{D118}	L_{C462}	R^{D50}	R^{D154}	L_{C654}	R^{D145}	R^{D89}
L_{C79}	R^{D79}	R^{D79}	L_{C271}	R^{D4}	R^{D119}	L_{C463}	R^{D50}	R^{D155}	L_{C655}	R^{D145}	R^{D93}
L_{C80}	R^{D80}	R^{D80}	L_{C272}	R^{D4}	R^{D120}	L_{C464}	R^{D50}	R^{D161}	L_{C656}	R^{D145}	R^{D116}
L_{C81}	R^{D81}	R^{D81}	L_{C273}	R^{D4}	R^{D133}	L_{C465}	R^{D50}	R^{D175}	L_{C657}	R^{D145}	R^{D117}
L_{C82}	R^{D82}	R^{D82}	L_{C274}	R^{D4}	R^{D134}	L_{C466}	R^{D55}	R^{D3}	L_{C658}	R^{D145}	R^{D118}
L_{C83}	R^{D83}	R^{D83}	L_{C275}	R^{D4}	R^{D135}	L_{C467}	R^{D55}	R^{D5}	L_{C659}	R^{D145}	R^{D119}
L_{C84}	R^{D84}	R^{D84}	L_{C276}	R^{D4}	R^{D136}	L_{C468}	R^{D55}	R^{D18}	L_{C660}	R^{D145}	R^{D120}
L_{C85}	R^{D85}	R^{D85}	L_{C277}	R^{D4}	R^{D143}	L_{C469}	R^{D55}	R^{D20}	L_{C661}	R^{D145}	R^{D133}
L_{C86}	R^{D86}	R^{D86}	L_{C278}	R^{D4}	R^{D144}	L_{C470}	R^{D55}	R^{D22}	L_{C662}	R^{D145}	R^{D134}
L_{C87}	R^{D87}	R^{D87}	L_{C279}	R^{D4}	R^{D145}	L_{C471}	R^{D55}	R^{D37}	L_{C663}	R^{D145}	R^{D135}
L_{C88}	R^{D88}	R^{D88}	L_{C280}	R^{D4}	R^{D146}	L_{C472}	R^{D55}	R^{D40}	L_{C664}	R^{D145}	R^{D136}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C89}	R^{D89}	R^{D89}	L_{C281}	R^{D4}	R^{D147}	L_{C473}	R^{D55}	R^{D41}	L_{C665}	R^{D145}	R^{D146}
L_{C90}	R^{D90}	R^{D90}	L_{C282}	R^{D4}	R^{D149}	L_{C474}	R^{D55}	R^{D42}	L_{C666}	R^{D145}	R^{D147}
L_{C91}	R^{D91}	R^{D91}	L_{C283}	R^{D4}	R^{D151}	L_{C475}	R^{D55}	R^{D43}	L_{C667}	R^{D145}	R^{D149}
L_{C92}	R^{D92}	R^{D92}	L_{C284}	R^{D4}	R^{D154}	L_{C476}	R^{D55}	R^{D48}	L_{C668}	R^{D145}	R^{D151}
L_{C93}	R^{D93}	R^{D93}	L_{C285}	R^{D4}	R^{D155}	L_{C477}	R^{D55}	R^{D49}	L_{C669}	R^{D145}	R^{D154}
L_{C94}	R^{D94}	R^{D94}	L_{C286}	R^{D4}	R^{D161}	L_{C478}	R^{D55}	R^{D54}	L_{C670}	R^{D145}	R^{D155}
L_{C95}	R^{D95}	R^{D95}	L_{C287}	R^{D4}	R^{D175}	L_{C479}	R^{D55}	R^{D58}	L_{C671}	R^{D145}	R^{D161}
L_{C96}	R^{D96}	R^{D96}	L_{C288}	R^{D9}	R^{D3}	L_{C480}	R^{D55}	R^{D59}	L_{C672}	R^{D145}	R^{D175}
L_{C97}	R^{D97}	R^{D97}	L_{C289}	R^{D9}	R^{D5}	L_{C481}	R^{D55}	R^{D78}	L_{C673}	R^{D146}	R^{D3}
L_{C98}	R^{D98}	R^{D98}	L_{C290}	R^{D9}	R^{D10}	L_{C482}	R^{D55}	R^{D79}	L_{C674}	R^{D146}	R^{D5}
L_{C99}	R^{D99}	R^{D99}	L_{C291}	R^{D9}	R^{D17}	L_{C483}	R^{D55}	R^{D81}	L_{C675}	R^{D146}	R^{D17}
L_{C100}	R^{D100}	R^{D100}	L_{C292}	R^{D9}	R^{D18}	L_{C484}	R^{D55}	R^{D87}	L_{C676}	R^{D146}	R^{D18}
L_{C101}	R^{D101}	R^{D101}	L_{C293}	R^{D9}	R^{D20}	L_{C485}	R^{D55}	R^{D88}	L_{C677}	R^{D146}	R^{D20}
L_{C102}	R^{D102}	R^{D102}	L_{C294}	R^{D9}	R^{D22}	L_{C486}	R^{D55}	R^{D89}	L_{C678}	R^{D146}	R^{D22}
L_{C103}	R^{D103}	R^{D103}	L_{C295}	R^{D9}	R^{D37}	L_{C487}	R^{D55}	R^{D93}	L_{C679}	R^{D146}	R^{D37}
L_{C104}	R^{D104}	R^{D104}	L_{C296}	R^{D9}	R^{D40}	L_{C488}	R^{D55}	R^{D116}	L_{C680}	R^{D146}	R^{D40}
L_{C105}	R^{D105}	R^{D105}	L_{C297}	R^{D9}	R^{D41}	L_{C489}	R^{D55}	R^{D117}	L_{C681}	R^{D146}	R^{D41}
L_{C106}	R^{D106}	R^{D106}	L_{C298}	R^{D9}	R^{D42}	L_{C490}	R^{D55}	R^{D118}	L_{C682}	R^{D146}	R^{D42}
L_{C107}	R^{D107}	R^{D107}	L_{C299}	R^{D9}	R^{D43}	L_{C491}	R^{D55}	R^{D119}	L_{C683}	R^{D146}	R^{D43}
L_{C108}	R^{D108}	R^{D108}	L_{C300}	R^{D9}	R^{D48}	L_{C492}	R^{D55}	R^{D120}	L_{C684}	R^{D146}	R^{D48}
L_{C109}	R^{D109}	R^{D109}	L_{C301}	R^{D9}	R^{D49}	L_{C493}	R^{D55}	R^{D133}	L_{C685}	R^{D146}	R^{D49}
L_{C110}	R^{D110}	R^{D110}	L_{C302}	R^{D9}	R^{D50}	L_{C494}	R^{D55}	R^{D134}	L_{C686}	R^{D146}	R^{D54}
L_{C111}	R^{D111}	R^{D111}	L_{C303}	R^{D9}	R^{D54}	L_{C495}	R^{D55}	R^{D135}	L_{C687}	R^{D146}	R^{D58}
L_{C112}	R^{D112}	R^{D112}	L_{C304}	R^{D9}	R^{D55}	L_{C496}	R^{D55}	R^{D136}	L_{C688}	R^{D146}	R^{D59}
L_{C113}	R^{D113}	R^{D113}	L_{C305}	R^{D9}	R^{D58}	L_{C497}	R^{D55}	R^{D143}	L_{C689}	R^{D146}	R^{D78}
L_{C114}	R^{D114}	R^{D114}	L_{C306}	R^{D9}	R^{D59}	L_{C498}	R^{D55}	R^{D144}	L_{C690}	R^{D146}	R^{D79}
L_{C115}	R^{D115}	R^{D115}	L_{C307}	R^{D9}	R^{D78}	L_{C499}	R^{D55}	R^{D145}	L_{C691}	R^{D146}	R^{D81}
L_{C116}	R^{D116}	R^{D116}	L_{C308}	R^{D9}	R^{D79}	L_{C500}	R^{D55}	R^{D146}	L_{C692}	R^{D146}	R^{D87}
L_{C117}	R^{D117}	R^{D117}	L_{C309}	R^{D9}	R^{D81}	L_{C501}	R^{D55}	R^{D147}	L_{C693}	R^{D146}	R^{D88}
L_{C118}	R^{D118}	R^{D118}	L_{C310}	R^{D9}	R^{D87}	L_{C502}	R^{D55}	R^{D149}	L_{C694}	R^{D146}	R^{D89}
L_{C119}	R^{D119}	R^{D119}	L_{C311}	R^{D9}	R^{D88}	L_{C503}	R^{D55}	R^{D151}	L_{C695}	R^{D146}	R^{D93}
L_{C120}	R^{D120}	R^{D120}	L_{C312}	R^{D9}	R^{D89}	L_{C504}	R^{D55}	R^{D154}	L_{C696}	R^{D146}	R^{D117}
L_{C121}	R^{D121}	R^{D121}	L_{C313}	R^{D9}	R^{D93}	L_{C505}	R^{D55}	R^{D155}	L_{C697}	R^{D146}	R^{D118}
L_{C122}	R^{D122}	R^{D122}	L_{C314}	R^{D9}	R^{D116}	L_{C506}	R^{D55}	R^{D161}	L_{C698}	R^{D146}	R^{D119}
L_{C123}	R^{D123}	R^{D123}	L_{C315}	R^{D9}	R^{D117}	L_{C507}	R^{D55}	R^{D175}	L_{C699}	R^{D146}	R^{D120}
L_{C124}	R^{D124}	R^{D124}	L_{C316}	R^{D9}	R^{D118}	L_{C508}	R^{D116}	R^{D3}	L_{C700}	R^{D146}	R^{D133}
L_{C125}	R^{D125}	R^{D125}	L_{C317}	R^{D9}	R^{D119}	L_{C509}	R^{D116}	R^{D5}	L_{C701}	R^{D146}	R^{D134}
L_{C126}	R^{D126}	R^{D126}	L_{C318}	R^{D9}	R^{D120}	L_{C510}	R^{D116}	R^{D17}	L_{C702}	R^{D146}	R^{D135}
L_{C127}	R^{D127}	R^{D127}	L_{C319}	R^{D9}	R^{D133}	L_{C511}	R^{D116}	R^{D18}	L_{C703}	R^{D146}	R^{D136}
L_{C128}	R^{D128}	R^{D128}	L_{C320}	R^{D9}	R^{D134}	L_{C512}	R^{D116}	R^{D20}	L_{C704}	R^{D146}	R^{D146}
L_{C129}	R^{D129}	R^{D129}	L_{C321}	R^{D9}	R^{D135}	L_{C513}	R^{D116}	R^{D22}	L_{C705}	R^{D146}	R^{D147}
L_{C130}	R^{D130}	R^{D130}	L_{C322}	R^{D9}	R^{D136}	L_{C514}	R^{D116}	R^{D37}	L_{C706}	R^{D146}	R^{D149}
L_{C131}	R^{D131}	R^{D131}	L_{C323}	R^{D9}	R^{D143}	L_{C515}	R^{D116}	R^{D40}	L_{C707}	R^{D146}	R^{D151}
L_{C132}	R^{D132}	R^{D132}	L_{C324}	R^{D9}	R^{D144}	L_{C516}	R^{D116}	R^{D41}	L_{C708}	R^{D146}	R^{D154}
L_{C133}	R^{D133}	R^{D133}	L_{C325}	R^{D9}	R^{D145}	L_{C517}	R^{D116}	R^{D42}	L_{C709}	R^{D146}	R^{D155}
L_{C134}	R^{D134}	R^{D134}	L_{C326}	R^{D9}	R^{D146}	L_{C518}	R^{D116}	R^{D43}	L_{C710}	R^{D146}	R^{D161}
L_{C135}	R^{D135}	R^{D135}	L_{C327}	R^{D9}	R^{D147}	L_{C519}	R^{D116}	R^{D48}	L_{C711}	R^{D146}	R^{D175}
L_{C136}	R^{D136}	R^{D136}	L_{C328}	R^{D9}	R^{D149}	L_{C520}	R^{D116}	R^{D49}	L_{C712}	R^{D133}	R^{D3}
L_{C137}	R^{D137}	R^{D137}	L_{C329}	R^{D9}	R^{D151}	L_{C521}	R^{D116}	R^{D54}	L_{C713}	R^{D133}	R^{D5}
L_{C138}	R^{D138}	R^{D138}	L_{C330}	R^{D9}	R^{D154}	L_{C522}	R^{D116}	R^{D58}	L_{C714}	R^{D133}	R^{D3}
L_{C139}	R^{D139}	R^{D139}	L_{C331}	R^{D9}	R^{D155}	L_{C523}	R^{D116}	R^{D59}	L_{C715}	R^{D133}	R^{D18}
L_{C140}	R^{D140}	R^{D140}	L_{C332}	R^{D9}	R^{D161}	L_{C524}	R^{D116}	R^{D78}	L_{C716}	R^{D133}	R^{D20}
L_{C141}	R^{D141}	R^{D141}	L_{C333}	R^{D9}	R^{D175}	L_{C525}	R^{D116}	R^{D79}	L_{C717}	R^{D133}	R^{D22}
L_{C142}	R^{D142}	R^{D142}	L_{C334}	R^{D10}	R^{D3}	L_{C526}	R^{D116}	R^{D81}	L_{C718}	R^{D133}	R^{D37}
L_{C143}	R^{D143}	R^{D143}	L_{C335}	R^{D10}	R^{D5}	L_{C527}	R^{D116}	R^{D87}	L_{C719}	R^{D133}	R^{D40}
L_{C144}	R^{D144}	R^{D144}	L_{C336}	R^{D10}	R^{D17}	L_{C528}	R^{D116}	R^{D88}	L_{C720}	R^{D133}	R^{D41}
L_{C145}	R^{D145}	R^{D145}	L_{C337}	R^{D10}	R^{D18}	L_{C529}	R^{D116}	R^{D89}	L_{C721}	R^{D133}	R^{D42}
L_{C146}	R^{D146}	R^{D146}	L_{C338}	R^{D10}	R^{D20}	L_{C530}	R^{D116}	R^{D93}	L_{C722}	R^{D133}	R^{D43}
L_{C147}	R^{D147}	R^{D147}	L_{C339}	R^{D10}	R^{D22}	L_{C531}	R^{D116}	R^{D117}	L_{C723}	R^{D133}	R^{D48}
L_{C148}	R^{D148}	R^{D148}	L_{C340}	R^{D10}	R^{D37}	L_{C532}	R^{D116}	R^{D118}	L_{C724}	R^{D133}	R^{D49}
L_{C149}	R^{D149}	R^{D149}	L_{C341}	R^{D10}	R^{D40}	L_{C533}	R^{D116}	R^{D119}	L_{C725}	R^{D133}	R^{D54}
L_{C150}	R^{D150}	R^{D150}	L_{C342}	R^{D10}	R^{D41}	L_{C534}	R^{D116}	R^{D120}	L_{C726}	R^{D133}	R^{D58}
L_{C151}	R^{D151}	R^{D151}	L_{C343}	R^{D10}	R^{D42}	L_{C535}	R^{D116}	R^{D133}	L_{C727}	R^{D133}	R^{D59}
L_{C152}	R^{D152}	R^{D152}	L_{C344}	R^{D10}	R^{D43}	L_{C536}	R^{D116}	R^{D134}	L_{C728}	R^{D133}	R^{D78}
L_{C153}	R^{D153}	R^{D153}	L_{C345}	R^{D10}	R^{D48}	L_{C537}	R^{D116}	R^{D135}	L_{C729}	R^{D133}	R^{D79}
L_{C154}	R^{D154}	R^{D154}	L_{C346}	R^{D10}	R^{D49}	L_{C538}	R^{D116}	R^{D136}	L_{C730}	R^{D133}	R^{D81}
L_{C155}	R^{D155}	R^{D155}	L_{C347}	R^{D10}	R^{D50}	L_{C539}	R^{D116}	R^{D143}	L_{C731}	R^{D133}	R^{D87}
L_{C156}	R^{D156}	R^{D156}	L_{C348}	R^{D10}	R^{D54}	L_{C540}	R^{D116}	R^{D144}	L_{C732}	R^{D133}	R^{D88}
L_{C157}	R^{D157}	R^{D157}	L_{C349}	R^{D10}	R^{D55}	L_{C541}	R^{D116}	R^{D145}	L_{C733}	R^{D133}	R^{D89}
L_{C158}	R^{D158}	R^{D158}	L_{C350}	R^{D10}	R^{D58}	L_{C542}	R^{D116}	R^{D146}	L_{C734}	R^{D133}	R^{D93}
L_{C159}	R^{D159}	R^{D159}	L_{C351}	R^{D10}	R^{D59}	L_{C543}	R^{D116}	R^{D147}	L_{C735}	R^{D133}	R^{D117}
L_{C160}	R^{D160}	R^{D160}	L_{C352}	R^{D10}	R^{D78}	L_{C544}	R^{D116}	R^{D149}	L_{C736}	R^{D133}	R^{D118}
L_{C161}	R^{D161}	R^{D161}	L_{C353}	R^{D10}	R^{D79}	L_{C545}	R^{D116}	R^{D151}	L_{C737}	R^{D133}	R^{D119}
L_{C162}	R^{D162}	R^{D162}	L_{C354}	R^{D10}	R^{D81}	L_{C546}	R^{D116}	R^{D154}	L_{C738}	R^{D133}	R^{D120}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C163}	R^{D163}	R^{D163}	L_{C355}	R^{D10}	R^{D87}	L_{C547}	R^{D116}	R^{D155}	L_{C739}	R^{D133}	R^{D133}
L_{C164}	R^{D164}	R^{D164}	L_{C356}	R^{D10}	R^{D88}	L_{C548}	R^{D116}	R^{D161}	L_{C740}	R^{D133}	R^{D134}
L_{C165}	R^{D165}	R^{D165}	L_{C357}	R^{D10}	R^{D89}	L_{C549}	R^{D116}	R^{D175}	L_{C741}	R^{D133}	R^{D135}
L_{C166}	R^{D166}	R^{D166}	L_{C358}	R^{D10}	R^{D93}	L_{C550}	R^{D143}	R^{D3}	L_{C742}	R^{D133}	R^{D136}
L_{C167}	R^{D167}	R^{D167}	L_{C359}	R^{D10}	R^{D116}	L_{C551}	R^{D143}	R^{D5}	L_{C743}	R^{D133}	R^{D146}
L_{C168}	R^{D168}	R^{D168}	L_{C360}	R^{D10}	R^{D117}	L_{C552}	R^{D143}	R^{D17}	L_{C744}	R^{D133}	R^{D147}
L_{C169}	R^{D169}	R^{D169}	L_{C361}	R^{D10}	R^{D118}	L_{C553}	R^{D143}	R^{D18}	L_{C745}	R^{D133}	R^{D149}
L_{C170}	R^{D170}	R^{D170}	L_{C362}	R^{D10}	R^{D119}	L_{C554}	R^{D143}	R^{D20}	L_{C746}	R^{D133}	R^{D151}
L_{C171}	R^{D171}	R^{D171}	L_{C363}	R^{D10}	R^{D120}	L_{C555}	R^{D143}	R^{D22}	L_{C747}	R^{D133}	R^{D154}
L_{C172}	R^{D172}	R^{D172}	L_{C364}	R^{D10}	R^{D133}	L_{C556}	R^{D143}	R^{D37}	L_{C748}	R^{D133}	R^{D155}
L_{C173}	R^{D173}	R^{D173}	L_{C365}	R^{D10}	R^{D134}	L_{C557}	R^{D143}	R^{D40}	L_{C749}	R^{D133}	R^{D161}
L_{C174}	R^{D174}	R^{D174}	L_{C366}	R^{D10}	R^{D135}	L_{C558}	R^{D143}	R^{D41}	L_{C750}	R^{D133}	R^{D175}
L_{C175}	R^{D175}	R^{D175}	L_{C367}	R^{D10}	R^{D136}	L_{C559}	R^{D143}	R^{D42}	L_{C751}	R^{D175}	R^{D3}
L_{C176}	R^{D176}	R^{D176}	L_{C368}	R^{D10}	R^{D143}	L_{C560}	R^{D143}	R^{D43}	L_{C752}	R^{D175}	R^{D5}
L_{C177}	R^{D177}	R^{D177}	L_{C369}	R^{D10}	R^{D144}	L_{C561}	R^{D143}	R^{D48}	L_{C753}	R^{D175}	R^{D18}
L_{C178}	R^{D178}	R^{D178}	L_{C370}	R^{D10}	R^{D145}	L_{C562}	R^{D143}	R^{D49}	L_{C754}	R^{D175}	R^{D20}
L_{C179}	R^{D179}	R^{D179}	L_{C371}	R^{D10}	R^{D146}	L_{C563}	R^{D143}	R^{D54}	L_{C755}	R^{D175}	R^{D22}
L_{C180}	R^{D180}	R^{D180}	L_{C372}	R^{D10}	R^{D147}	L_{C564}	R^{D143}	R^{D58}	L_{C756}	R^{D175}	R^{D37}
L_{C181}	R^{D181}	R^{D181}	L_{C373}	R^{D10}	R^{D149}	L_{C565}	R^{D143}	R^{D59}	L_{C757}	R^{D175}	R^{D40}
L_{C182}	R^{D182}	R^{D182}	L_{C374}	R^{D10}	R^{D151}	L_{C566}	R^{D143}	R^{D78}	L_{C758}	R^{D175}	R^{D41}
L_{C183}	R^{D183}	R^{D183}	L_{C375}	R^{D10}	R^{D154}	L_{C567}	R^{D143}	R^{D79}	L_{C759}	R^{D175}	R^{D42}
L_{C184}	R^{D184}	R^{D184}	L_{C376}	R^{D10}	R^{D155}	L_{C568}	R^{D143}	R^{D81}	L_{C760}	R^{D175}	R^{D43}
L_{C185}	R^{D185}	R^{D185}	L_{C377}	R^{D10}	R^{D161}	L_{C569}	R^{D143}	R^{D87}	L_{C761}	R^{D175}	R^{D48}
L_{C186}	R^{D186}	R^{D186}	L_{C378}	R^{D10}	R^{D175}	L_{C570}	R^{D143}	R^{D88}	L_{C762}	R^{D175}	R^{D49}
L_{C187}	R^{D187}	R^{D187}	L_{C379}	R^{D17}	R^{D3}	L_{C571}	R^{D143}	R^{D89}	L_{C763}	R^{D175}	R^{D54}
L_{C188}	R^{D188}	R^{D188}	L_{C380}	R^{D17}	R^{D5}	L_{C572}	R^{D143}	R^{D93}	L_{C764}	R^{D175}	R^{D58}
L_{C189}	R^{D189}	R^{D189}	L_{C381}	R^{D17}	R^{D18}	L_{C573}	R^{D143}	R^{D116}	L_{C765}	R^{D175}	R^{D59}
L_{C190}	R^{D190}	R^{D190}	L_{C382}	R^{D17}	R^{D20}	L_{C574}	R^{D143}	R^{D117}	L_{C766}	R^{D175}	R^{D78}
L_{C191}	R^{D191}	R^{D191}	L_{C383}	R^{D17}	R^{D22}	L_{C575}	R^{D143}	R^{D118}	L_{C767}	R^{D175}	R^{D79}
L_{C192}	R^{D192}	R^{D192}	L_{C384}	R^{D17}	R^{D37}	L_{C576}	R^{D143}	R^{D119}	L_{C768}	R^{D175}	R^{D81}
L_{C769}	R^{D193}	R^{D193}	L_{C877}	R^{D1}	R^{D193}	L_{C985}	R^{D4}	R^{D193}	L_{C1093}	R^{D9}	R^{D193}
L_{C770}	R^{D194}	R^{D194}	L_{C878}	R^{D1}	R^{D194}	L_{C986}	R^{D4}	R^{D194}	L_{C1094}	R^{D9}	R^{D194}
L_{C771}	R^{D195}	R^{D195}	L_{C879}	R^{D1}	R^{D195}	L_{C987}	R^{D4}	R^{D195}	L_{C1095}	R^{D9}	R^{D195}
L_{C772}	R^{D196}	R^{D196}	L_{C880}	R^{D1}	R^{D196}	L_{C988}	R^{D4}	R^{D196}	L_{C1096}	R^{D9}	R^{D196}
L_{C773}	R^{D197}	R^{D197}	L_{C881}	R^{D1}	R^{D197}	L_{C989}	R^{D4}	R^{D197}	L_{C1097}	R^{D9}	R^{D197}
L_{C774}	R^{D198}	R^{D198}	L_{C882}	R^{D1}	R^{D198}	L_{C990}	R^{D4}	R^{D198}	L_{C1098}	R^{D9}	R^{D198}
L_{C775}	R^{D199}	R^{D199}	L_{C883}	R^{D1}	R^{D199}	L_{C991}	R^{D4}	R^{D199}	L_{C1099}	R^{D9}	R^{D199}
L_{C776}	R^{D200}	R^{D200}	L_{C884}	R^{D1}	R^{D200}	L_{C992}	R^{D4}	R^{D200}	L_{C1100}	R^{D9}	R^{D200}
L_{C777}	R^{D201}	R^{D201}	L_{C885}	R^{D1}	R^{D201}	L_{C993}	R^{D4}	R^{D201}	L_{C1101}	R^{D9}	R^{D201}
L_{C778}	R^{D202}	R^{D202}	L_{C886}	R^{D1}	R^{D202}	L_{C994}	R^{D4}	R^{D202}	L_{C1102}	R^{D9}	R^{D202}
L_{C779}	R^{D203}	R^{D203}	L_{C887}	R^{D1}	R^{D203}	L_{C995}	R^{D4}	R^{D203}	L_{C1103}	R^{D9}	R^{D203}
L_{C780}	R^{D204}	R^{D204}	L_{C888}	R^{D1}	R^{D204}	L_{C996}	R^{D4}	R^{D204}	L_{C1104}	R^{D9}	R^{D204}
L_{C781}	R^{D205}	R^{D205}	L_{C889}	R^{D1}	R^{D205}	L_{C997}	R^{D4}	R^{D205}	L_{C1105}	R^{D9}	R^{D205}
L_{C782}	R^{D206}	R^{D206}	L_{C890}	R^{D1}	R^{D206}	L_{C998}	R^{D4}	R^{D206}	L_{C1106}	R^{D9}	R^{D206}
L_{C783}	R^{D207}	R^{D207}	L_{C891}	R^{D1}	R^{D207}	L_{C999}	R^{D4}	R^{D207}	L_{C1107}	R^{D9}	R^{D207}
L_{C784}	R^{D208}	R^{D208}	L_{C892}	R^{D1}	R^{D208}	L_{C1000}	R^{D4}	R^{D208}	L_{C1108}	R^{D9}	R^{D208}
L_{C785}	R^{D209}	R^{D209}	L_{C893}	R^{D1}	R^{D209}	L_{C1001}	R^{D4}	R^{D209}	L_{C1109}	R^{D9}	R^{D209}
L_{C786}	R^{D210}	R^{D210}	L_{C894}	R^{D1}	R^{D210}	L_{C1002}	R^{D4}	R^{D210}	L_{C1110}	R^{D9}	R^{D210}
L_{C787}	R^{D211}	R^{D211}	L_{C895}	R^{D1}	R^{D211}	L_{C1003}	R^{D4}	R^{D211}	L_{C1111}	R^{D9}	R^{D211}
L_{C788}	R^{D212}	R^{D212}	L_{C896}	R^{D1}	R^{D212}	L_{C1004}	R^{D4}	R^{D212}	L_{C1112}	R^{D9}	R^{D212}
L_{C789}	R^{D213}	R^{D213}	L_{C897}	R^{D1}	R^{D213}	L_{C1005}	R^{D4}	R^{D213}	L_{C1113}	R^{D9}	R^{D213}
L_{C790}	R^{D214}	R^{D214}	L_{C898}	R^{D1}	R^{D214}	L_{C1006}	R^{D4}	R^{D214}	L_{C1114}	R^{D9}	R^{D214}
L_{C791}	R^{D215}	R^{D215}	L_{C899}	R^{D1}	R^{D215}	L_{C1007}	R^{D4}	R^{D215}	L_{C1115}	R^{D9}	R^{D215}
L_{C792}	R^{D216}	R^{D216}	L_{C900}	R^{D1}	R^{D216}	L_{C1008}	R^{D4}	R^{D216}	L_{C1116}	R^{D9}	R^{D216}
L_{C793}	R^{D217}	R^{D217}	L_{C901}	R^{D1}	R^{D217}	L_{C1009}	R^{D4}	R^{D217}	L_{C1117}	R^{D9}	R^{D217}
L_{C794}	R^{D218}	R^{D218}	L_{C902}	R^{D1}	R^{D218}	L_{C1010}	R^{D4}	R^{D218}	L_{C1118}	R^{D9}	R^{D218}
L_{C795}	R^{D219}	R^{D219}	L_{C903}	R^{D1}	R^{D219}	L_{C1011}	R^{D4}	R^{D219}	L_{C1119}	R^{D9}	R^{D219}
L_{C796}	R^{D220}	R^{D220}	L_{C904}	R^{D1}	R^{D220}	L_{C1012}	R^{D4}	R^{D220}	L_{C1120}	R^{D9}	R^{D220}
L_{C797}	R^{D221}	R^{D221}	L_{C905}	R^{D1}	R^{D221}	L_{C1013}	R^{D4}	R^{D221}	L_{C1121}	R^{D9}	R^{D221}
L_{C798}	R^{D222}	R^{D222}	L_{C906}	R^{D1}	R^{D222}	L_{C1014}	R^{D4}	R^{D222}	L_{C1122}	R^{D9}	R^{D222}
L_{C799}	R^{D223}	R^{D223}	L_{C907}	R^{D1}	R^{D223}	L_{C1015}	R^{D4}	R^{D223}	L_{C1123}	R^{D9}	R^{D223}
L_{C800}	R^{D224}	R^{D224}	L_{C908}	R^{D1}	R^{D224}	L_{C1016}	R^{D4}	R^{D224}	L_{C1124}	R^{D9}	R^{D224}
L_{C801}	R^{D225}	R^{D225}	L_{C909}	R^{D1}	R^{D225}	L_{C1017}	R^{D4}	R^{D225}	L_{C1125}	R^{D9}	R^{D225}
L_{C802}	R^{D226}	R^{D226}	L_{C910}	R^{D1}	R^{D226}	L_{C1018}	R^{D4}	R^{D226}	L_{C1126}	R^{D9}	R^{D226}
L_{C803}	R^{D227}	R^{D227}	L_{C911}	R^{D1}	R^{D227}	L_{C1019}	R^{D4}	R^{D227}	L_{C1127}	R^{D9}	R^{D227}
L_{C804}	R^{D228}	R^{D228}	L_{C912}	R^{D1}	R^{D228}	L_{C1020}	R^{D4}	R^{D228}	L_{C1128}	R^{D9}	R^{D228}
L_{C805}	R^{D229}	R^{D229}	L_{C913}	R^{D1}	R^{D229}	L_{C1021}	R^{D4}	R^{D229}	L_{C1129}	R^{D9}	R^{D229}
L_{C806}	R^{D230}	R^{D230}	L_{C914}	R^{D1}	R^{D230}	L_{C1022}	R^{D4}	R^{D230}	L_{C1130}	R^{D9}	R^{D230}
L_{C807}	R^{D231}	R^{D231}	L_{C915}	R^{D1}	R^{D231}	L_{C1023}	R^{D4}	R^{D231}	L_{C1131}	R^{D9}	R^{D231}
L_{C808}	R^{D232}	R^{D232}	L_{C916}	R^{D1}	R^{D232}	L_{C1024}	R^{D4}	R^{D232}	L_{C1132}	R^{D9}	R^{D232}
L_{C809}	R^{D233}	R^{D233}	L_{C917}	R^{D1}	R^{D233}	L_{C1025}	R^{D4}	R^{D233}	L_{C1133}	R^{D9}	R^{D233}
L_{C810}	R^{D234}	R^{D234}	L_{C918}	R^{D1}	R^{D234}	L_{C1026}	R^{D4}	R^{D234}	L_{C1134}	R^{D9}	R^{D234}
L_{C811}	R^{D235}	R^{D235}	L_{C919}	R^{D1}	R^{D235}	L_{C1027}	R^{D4}	R^{D235}	L_{C1135}	R^{D9}	R^{D235}
L_{C812}	R^{D236}	R^{D236}	L_{C920}	R^{D1}	R^{D236}	L_{C1028}	R^{D4}	R^{D236}	L_{C1136}	R^{D9}	R^{D236}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C813}	R^{D237}	R^{D237}	L_{C921}	R^{D1}	R^{D237}	L_{C1029}	R^{D4}	R^{D237}	L_{C1137}	R^{D9}	R^{D237}
L_{C814}	R^{D238}	R^{D238}	L_{C922}	R^{D1}	R^{D238}	L_{C1030}	R^{D4}	R^{D238}	L_{C1138}	R^{D9}	R^{D238}
L_{C815}	R^{D239}	R^{D239}	L_{C923}	R^{D1}	R^{D239}	L_{C1031}	R^{D4}	R^{D239}	L_{C1139}	R^{D9}	R^{D239}
L_{C816}	R^{D240}	R^{D240}	L_{C924}	R^{D1}	R^{D240}	L_{C1032}	R^{D4}	R^{D240}	L_{C1140}	R^{D9}	R^{D240}
L_{C817}	R^{D241}	R^{D241}	L_{C925}	R^{D1}	R^{D241}	L_{C1033}	R^{D4}	R^{D241}	L_{C1141}	R^{D9}	R^{D241}
L_{C818}	R^{D242}	R^{D242}	L_{C926}	R^{D1}	R^{D242}	L_{C1034}	R^{D4}	R^{D242}	L_{C1142}	R^{D9}	R^{D242}
L_{C819}	R^{D243}	R^{D243}	L_{C927}	R^{D1}	R^{D243}	L_{C1035}	R^{D4}	R^{D243}	L_{C1143}	R^{D9}	R^{D243}
L_{C820}	R^{D244}	R^{D244}	L_{C928}	R^{D1}	R^{D244}	L_{C1036}	R^{D4}	R^{D244}	L_{C1144}	R^{D9}	R^{D244}
L_{C821}	R^{D245}	R^{D245}	L_{C929}	R^{D1}	R^{D245}	L_{C1037}	R^{D4}	R^{D245}	L_{C1145}	R^{D9}	R^{D245}
L_{C822}	R^{D246}	R^{D246}	L_{C930}	R^{D1}	R^{D246}	L_{C1038}	R^{D4}	R^{D246}	L_{C1146}	R^{D9}	R^{D246}
L_{C823}	R^{D17}	R^{D193}	L_{C931}	R^{D50}	R^{D193}	L_{C1039}	R^{D145}	R^{D193}	L_{C1147}	R^{D168}	R^{D193}
L_{C824}	R^{D17}	R^{D194}	L_{C932}	R^{D50}	R^{D194}	L_{C1040}	R^{D145}	R^{D194}	L_{C1148}	R^{D168}	R^{D194}
L_{C825}	R^{D17}	R^{D195}	L_{C933}	R^{D50}	R^{D195}	L_{C1041}	R^{D145}	R^{D195}	L_{C1149}	R^{D168}	R^{D195}
L_{C826}	R^{D17}	R^{D196}	L_{C934}	R^{D50}	R^{D196}	L_{C1042}	R^{D145}	R^{D196}	L_{C1150}	R^{D168}	R^{D196}
L_{C827}	R^{D17}	R^{D197}	L_{C935}	R^{D50}	R^{D197}	L_{C1043}	R^{D145}	R^{D197}	L_{C1151}	R^{D168}	R^{D197}
L_{C828}	R^{D17}	R^{D198}	L_{C936}	R^{D50}	R^{D198}	L_{C1044}	R^{D145}	R^{D198}	L_{C1152}	R^{D168}	R^{D198}
L_{C829}	R^{D17}	R^{D199}	L_{C937}	R^{D50}	R^{D199}	L_{C1045}	R^{D145}	R^{D199}	L_{C1153}	R^{D168}	R^{D199}
L_{C830}	R^{D17}	R^{D200}	L_{C938}	R^{D50}	R^{D200}	L_{C1046}	R^{D145}	R^{D200}	L_{C1154}	R^{D168}	R^{D200}
L_{C831}	R^{D17}	R^{D201}	L_{C939}	R^{D50}	R^{D201}	L_{C1047}	R^{D145}	R^{D201}	L_{C1155}	R^{D168}	R^{D201}
L_{C832}	R^{D17}	R^{D202}	L_{C940}	R^{D50}	R^{D202}	L_{C1048}	R^{D145}	R^{D202}	L_{C1156}	R^{D168}	R^{D202}
L_{C833}	R^{D17}	R^{D203}	L_{C941}	R^{D50}	R^{D203}	L_{C1049}	R^{D145}	R^{D203}	L_{C1157}	R^{D168}	R^{D203}
L_{C834}	R^{D17}	R^{D204}	L_{C942}	R^{D50}	R^{D204}	L_{C1050}	R^{D145}	R^{D204}	L_{C1158}	R^{D168}	R^{D204}
L_{C835}	R^{D17}	R^{D205}	L_{C943}	R^{D50}	R^{D205}	L_{C1051}	R^{D145}	R^{D205}	L_{C1159}	R^{D168}	R^{D205}
L_{C836}	R^{D17}	R^{D206}	L_{C944}	R^{D50}	R^{D206}	L_{C1052}	R^{D145}	R^{D206}	L_{C1160}	R^{D168}	R^{D206}
L_{C837}	R^{D17}	R^{D207}	L_{C945}	R^{D50}	R^{D207}	L_{C1053}	R^{D145}	R^{D207}	L_{C1161}	R^{D168}	R^{D207}
L_{C838}	R^{D17}	R^{D208}	L_{C946}	R^{D50}	R^{D208}	L_{C1054}	R^{D145}	R^{D208}	L_{C1162}	R^{D168}	R^{D208}
L_{C839}	R^{D17}	R^{D209}	L_{C947}	R^{D50}	R^{D209}	L_{C1055}	R^{D145}	R^{D209}	L_{C1163}	R^{D168}	R^{D209}
L_{C840}	R^{D17}	R^{D210}	L_{C948}	R^{D50}	R^{D210}	L_{C1056}	R^{D145}	R^{D210}	L_{C1164}	R^{D168}	R^{D210}
L_{C841}	R^{D17}	R^{D211}	L_{C949}	R^{D50}	R^{D211}	L_{C1057}	R^{D145}	R^{D211}	L_{C1165}	R^{D168}	R^{D211}
L_{C842}	R^{D17}	R^{D212}	L_{C950}	R^{D50}	R^{D212}	L_{C1058}	R^{D145}	R^{D212}	L_{C1166}	R^{D168}	R^{D212}
L_{C843}	R^{D17}	R^{D213}	L_{C951}	R^{D50}	R^{D213}	L_{C1059}	R^{D145}	R^{D213}	L_{C1167}	R^{D168}	R^{D213}
L_{C844}	R^{D17}	R^{D214}	L_{C952}	R^{D50}	R^{D214}	L_{C1060}	R^{D145}	R^{D214}	L_{C1168}	R^{D168}	R^{D214}
L_{C845}	R^{D17}	R^{D215}	L_{C953}	R^{D50}	R^{D215}	L_{C1061}	R^{D145}	R^{D215}	L_{C1169}	R^{D168}	R^{D215}
L_{C846}	R^{D17}	R^{D216}	L_{C954}	R^{D50}	R^{D216}	L_{C1062}	R^{D145}	R^{D216}	L_{C1170}	R^{D168}	R^{D216}
L_{C847}	R^{D17}	R^{D217}	L_{C955}	R^{D50}	R^{D217}	L_{C1063}	R^{D145}	R^{D217}	L_{C1171}	R^{D168}	R^{D217}
L_{C848}	R^{D17}	R^{D218}	L_{C956}	R^{D50}	R^{D218}	L_{C1064}	R^{D145}	R^{D218}	L_{C1172}	R^{D168}	R^{D218}
L_{C849}	R^{D17}	R^{D219}	L_{C957}	R^{D50}	R^{D219}	L_{C1065}	R^{D145}	R^{D219}	L_{C1173}	R^{D168}	R^{D219}
L_{C850}	R^{D17}	R^{D220}	L_{C958}	R^{D50}	R^{D220}	L_{C1066}	R^{D145}	R^{D220}	L_{C1174}	R^{D168}	R^{D220}
L_{C851}	R^{D17}	R^{D221}	L_{C959}	R^{D50}	R^{D221}	L_{C1067}	R^{D145}	R^{D221}	L_{C1175}	R^{D168}	R^{D221}
L_{C852}	R^{D17}	R^{D222}	L_{C960}	R^{D50}	R^{D222}	L_{C1068}	R^{D145}	R^{D222}	L_{C1176}	R^{D168}	R^{D222}
L_{C853}	R^{D17}	R^{D223}	L_{C961}	R^{D50}	R^{D223}	L_{C1069}	R^{D145}	R^{D223}	L_{C1177}	R^{D168}	R^{D223}
L_{C854}	R^{D17}	R^{D224}	L_{C962}	R^{D50}	R^{D224}	L_{C1070}	R^{D145}	R^{D224}	L_{C1178}	R^{D168}	R^{D224}
L_{C855}	R^{D17}	R^{D225}	L_{C963}	R^{D50}	R^{D225}	L_{C1071}	R^{D145}	R^{D225}	L_{C1179}	R^{D168}	R^{D225}
L_{C856}	R^{D17}	R^{D226}	L_{C964}	R^{D50}	R^{D226}	L_{C1072}	R^{D145}	R^{D226}	L_{C1180}	R^{D168}	R^{D226}
L_{C857}	R^{D17}	R^{D227}	L_{C965}	R^{D50}	R^{D227}	L_{C1073}	R^{D145}	R^{D227}	L_{C1181}	R^{D168}	R^{D227}
L_{C858}	R^{D17}	R^{D228}	L_{C966}	R^{D50}	R^{D228}	L_{C1074}	R^{D145}	R^{D228}	L_{C1182}	R^{D168}	R^{D228}
L_{C859}	R^{D17}	R^{D229}	L_{C967}	R^{D50}	R^{D229}	L_{C1075}	R^{D145}	R^{D229}	L_{C1183}	R^{D168}	R^{D229}
L_{C860}	R^{D17}	R^{D230}	L_{C968}	R^{D50}	R^{D230}	L_{C1076}	R^{D145}	R^{D230}	L_{C1184}	R^{D168}	R^{D230}
L_{C861}	R^{D17}	R^{D231}	L_{C969}	R^{D50}	R^{D231}	L_{C1077}	R^{D145}	R^{D231}	L_{C1185}	R^{D168}	R^{D231}
L_{C862}	R^{D17}	R^{D232}	L_{C970}	R^{D50}	R^{D232}	L_{C1078}	R^{D145}	R^{D232}	L_{C1186}	R^{D168}	R^{D232}
L_{C863}	R^{D17}	R^{D233}	L_{C971}	R^{D50}	R^{D233}	L_{C1079}	R^{D145}	R^{D233}	L_{C1187}	R^{D168}	R^{D233}
L_{C864}	R^{D17}	R^{D234}	L_{C972}	R^{D50}	R^{D234}	L_{C1080}	R^{D145}	R^{D234}	L_{C1188}	R^{D168}	R^{D234}
L_{C865}	R^{D17}	R^{D235}	L_{C973}	R^{D50}	R^{D235}	L_{C1081}	R^{D145}	R^{D235}	L_{C1189}	R^{D168}	R^{D235}
L_{C866}	R^{D17}	R^{D236}	L_{C974}	R^{D50}	R^{D236}	L_{C1082}	R^{D145}	R^{D236}	L_{C1190}	R^{D168}	R^{D236}
L_{C867}	R^{D17}	R^{D237}	L_{C975}	R^{D50}	R^{D237}	L_{C1083}	R^{D145}	R^{D237}	L_{C1191}	R^{D168}	R^{D237}
L_{C868}	R^{D17}	R^{D238}	L_{C976}	R^{D50}	R^{D238}	L_{C1084}	R^{D145}	R^{D238}	L_{C1192}	R^{D168}	R^{D238}
L_{C869}	R^{D17}	R^{D239}	L_{C977}	R^{D50}	R^{D239}	L_{C1085}	R^{D145}	R^{D239}	L_{C1193}	R^{D168}	R^{D239}
L_{C870}	R^{D17}	R^{D240}	L_{C978}	R^{D50}	R^{D240}	L_{C1086}	R^{D145}	R^{D240}	L_{C1194}	R^{D168}	R^{D240}
L_{C871}	R^{D17}	R^{D241}	L_{C979}	R^{D50}	R^{D241}	L_{C1087}	R^{D145}	R^{D241}	L_{C1195}	R^{D168}	R^{D241}
L_{C872}	R^{D17}	R^{D242}	L_{C980}	R^{D50}	R^{D242}	L_{C1088}	R^{D145}	R^{D242}	L_{C1196}	R^{D168}	R^{D242}
L_{C873}	R^{D17}	R^{D243}	L_{C981}	R^{D50}	R^{D243}	L_{C1089}	R^{D145}	R^{D243}	L_{C1197}	R^{D168}	R^{D243}
L_{C874}	R^{D17}	R^{D244}	L_{C982}	R^{D50}	R^{D244}	L_{C1090}	R^{D145}	R^{D244}	L_{C1198}	R^{D168}	R^{D244}
L_{C875}	R^{D17}	R^{D245}	L_{C983}	R^{D50}	R^{D245}	L_{C1091}	R^{D145}	R^{D245}	L_{C1199}	R^{D168}	R^{D245}
L_{C876}	R^{D17}	R^{D246}	L_{C984}	R^{D50}	R^{D246}	L_{C1092}	R^{D145}	R^{D246}	L_{C1200}	R^{D168}	R^{D246}
L_{C1201}	R^{D10}	R^{D193}	L_{C1255}	R^{D55}	R^{D193}	L_{C1309}	R^{D37}	R^{D193}	L_{C1363}	R^{D143}	R^{D193}
L_{C1202}	R^{D10}	R^{D194}	L_{C1256}	R^{D55}	R^{D194}	L_{C1310}	R^{D37}	R^{D194}	L_{C1364}	R^{D143}	R^{D194}
L_{C1203}	R^{D10}	R^{D195}	L_{C1257}	R^{D55}	R^{D195}	L_{C1311}	R^{D37}	R^{D195}	L_{C1365}	R^{D143}	R^{D195}
L_{C1204}	R^{D10}	R^{D196}	L_{C1258}	R^{D55}	R^{D196}	L_{C1312}	R^{D37}	R^{D196}	L_{C1366}	R^{D143}	R^{D196}
L_{C1205}	R^{D10}	R^{D197}	L_{C1259}	R^{D55}	R^{D197}	L_{C1313}	R^{D37}	R^{D197}	L_{C1367}	R^{D143}	R^{D197}
L_{C1206}	R^{D10}	R^{D198}	L_{C1260}	R^{D55}	R^{D198}	L_{C1314}	R^{D37}	R^{D198}	L_{C1368}	R^{D143}	R^{D198}
L_{C1207}	R^{D10}	R^{D199}	L_{C1261}	R^{D55}	R^{D199}	L_{C1315}	R^{D37}	R^{D199}	L_{C1369}	R^{D143}	R^{D199}
L_{C1208}	R^{D10}	R^{D200}	L_{C1262}	R^{D55}	R^{D200}	L_{C1316}	R^{D37}	R^{D200}	L_{C1370}	R^{D143}	R^{D200}
L_{C1209}	R^{D10}	R^{D201}	L_{C1263}	R^{D55}	R^{D201}	L_{C1317}	R^{D37}	R^{D201}	L_{C1371}	R^{D143}	R^{D201}
L_{C1210}	R^{D10}	R^{D202}	L_{C1264}	R^{D55}	R^{D202}	L_{C1318}	R^{D37}	R^{D202}	L_{C1372}	R^{D143}	R^{D202}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C1211}	R^{D10}	R^{D203}	L_{C1265}	R^{D55}	R^{D203}	L_{C1319}	R^{D37}	R^{D203}	L_{C1373}	R^{D143}	R^{D203}
L_{C1212}	R^{D10}	R^{D204}	L_{C1266}	R^{D55}	R^{D204}	L_{C1320}	R^{D37}	R^{D204}	L_{C1374}	R^{D143}	R^{D204}
L_{C1213}	R^{D10}	R^{D205}	L_{C1267}	R^{D55}	R^{D205}	L_{C1321}	R^{D37}	R^{D205}	L_{C1375}	R^{D143}	R^{D205}
L_{C1214}	R^{D10}	R^{D206}	L_{C1268}	R^{D55}	R^{D206}	L_{C1322}	R^{D37}	R^{D206}	L_{C1376}	R^{D143}	R^{D206}
L_{C1215}	R^{D10}	R^{D207}	L_{C1269}	R^{D55}	R^{D207}	L_{C1323}	R^{D37}	R^{D207}	L_{C1377}	R^{D143}	R^{D207}
L_{C1216}	R^{D10}	R^{D208}	L_{C1270}	R^{D55}	R^{D208}	L_{C1324}	R^{D37}	R^{D208}	L_{C1378}	R^{D143}	R^{D208}
L_{C1217}	R^{D10}	R^{D209}	L_{C1271}	R^{D55}	R^{D209}	L_{C1325}	R^{D37}	R^{D209}	L_{C1379}	R^{D143}	R^{D209}
L_{C1218}	R^{D10}	R^{D210}	L_{C1272}	R^{D55}	R^{D210}	L_{C1326}	R^{D37}	R^{D210}	L_{C1380}	R^{D143}	R^{D210}
L_{C1219}	R^{D10}	R^{D211}	L_{C1273}	R^{D55}	R^{D211}	L_{C1327}	R^{D37}	R^{D211}	L_{C1381}	R^{D143}	R^{D211}
L_{C1220}	R^{D10}	R^{D212}	L_{C1274}	R^{D55}	R^{D212}	L_{C1328}	R^{D37}	R^{D212}	L_{C1382}	R^{D143}	R^{D212}
L_{C1221}	R^{D10}	R^{D213}	L_{C1275}	R^{D55}	R^{D213}	L_{C1329}	R^{D37}	R^{D213}	L_{C1383}	R^{D143}	R^{D213}
L_{C1222}	R^{D10}	R^{D214}	L_{C1276}	R^{D55}	R^{D214}	L_{C1330}	R^{D37}	R^{D214}	L_{C1384}	R^{D143}	R^{D214}
L_{C1223}	R^{D10}	R^{D215}	L_{C1277}	R^{D55}	R^{D215}	L_{C1331}	R^{D37}	R^{D215}	L_{C1385}	R^{D143}	R^{D215}
L_{C1224}	R^{D10}	R^{D216}	L_{C1278}	R^{D55}	R^{D216}	L_{C1332}	R^{D37}	R^{D216}	L_{C1386}	R^{D143}	R^{D216}
L_{C1225}	R^{D10}	R^{D217}	L_{C1279}	R^{D55}	R^{D217}	L_{C1333}	R^{D37}	R^{D217}	L_{C1387}	R^{D143}	R^{D217}
L_{C1226}	R^{D10}	R^{D218}	L_{C1280}	R^{D55}	R^{D218}	L_{C1334}	R^{D37}	R^{D218}	L_{C1388}	R^{D143}	R^{D218}
L_{C1227}	R^{D10}	R^{D219}	L_{C1281}	R^{D55}	R^{D219}	L_{C1335}	R^{D37}	R^{D219}	L_{C1389}	R^{D143}	R^{D219}
L_{C1228}	R^{D10}	R^{D220}	L_{C1282}	R^{D55}	R^{D220}	L_{C1336}	R^{D37}	R^{D220}	L_{C1390}	R^{D143}	R^{D220}
L_{C1229}	R^{D10}	R^{D221}	L_{C1283}	R^{D55}	R^{D221}	L_{C1337}	R^{D37}	R^{D221}	L_{C1391}	R^{D143}	R^{D221}
L_{C1230}	R^{D10}	R^{D222}	L_{C1284}	R^{D55}	R^{D222}	L_{C1338}	R^{D37}	R^{D222}	L_{C1392}	R^{D143}	R^{D222}
L_{C1231}	R^{D10}	R^{D223}	L_{C1285}	R^{D55}	R^{D223}	L_{C1339}	R^{D37}	R^{D223}	L_{C1393}	R^{D143}	R^{D223}
L_{C1232}	R^{D10}	R^{D224}	L_{C1286}	R^{D55}	R^{D224}	L_{C1340}	R^{D37}	R^{D224}	L_{C1394}	R^{D143}	R^{D224}
L_{C1233}	R^{D10}	R^{D225}	L_{C1287}	R^{D55}	R^{D225}	L_{C1341}	R^{D37}	R^{D225}	L_{C1395}	R^{D143}	R^{D225}
L_{C1234}	R^{D10}	R^{D226}	L_{C1288}	R^{D55}	R^{D226}	L_{C1342}	R^{D37}	R^{D226}	L_{C1396}	R^{D143}	R^{D226}
L_{C1235}	R^{D10}	R^{D227}	L_{C1289}	R^{D55}	R^{D227}	L_{C1343}	R^{D37}	R^{D227}	L_{C1397}	R^{D143}	R^{D227}
L_{C1236}	R^{D10}	R^{D228}	L_{C1290}	R^{D55}	R^{D228}	L_{C1344}	R^{D37}	R^{D228}	L_{C1398}	R^{D143}	R^{D228}
L_{C1237}	R^{D10}	R^{D229}	L_{C1291}	R^{D55}	R^{D229}	L_{C1345}	R^{D37}	R^{D229}	L_{C1399}	R^{D143}	R^{D229}
L_{C1238}	R^{D10}	R^{D230}	L_{C1292}	R^{D55}	R^{D230}	L_{C1346}	R^{D37}	R^{D230}	L_{C1400}	R^{D143}	R^{D230}
L_{C1239}	R^{D10}	R^{D231}	L_{C1293}	R^{D55}	R^{D231}	L_{C1347}	R^{D37}	R^{D231}	L_{C1401}	R^{D143}	R^{D231}
L_{C1240}	R^{D10}	R^{D232}	L_{C1294}	R^{D55}	R^{D232}	L_{C1348}	R^{D37}	R^{D232}	L_{C1402}	R^{D143}	R^{D232}
L_{C1241}	R^{D10}	R^{D233}	L_{C1295}	R^{D55}	R^{D233}	L_{C1349}	R^{D37}	R^{D233}	L_{C1403}	R^{D143}	R^{D233}
L_{C1242}	R^{D10}	R^{D234}	L_{C1296}	R^{D55}	R^{D234}	L_{C1350}	R^{D37}	R^{D234}	L_{C1404}	R^{D143}	R^{D234}
L_{C1243}	R^{D10}	R^{D235}	L_{C1297}	R^{D55}	R^{D235}	L_{C1351}	R^{D37}	R^{D235}	L_{C1405}	R^{D143}	R^{D235}
L_{C1244}	R^{D10}	R^{D236}	L_{C1298}	R^{D55}	R^{D236}	L_{C1352}	R^{D37}	R^{D236}	L_{C1406}	R^{D143}	R^{D236}
L_{C1245}	R^{D10}	R^{D237}	L_{C1299}	R^{D55}	R^{D237}	L_{C1353}	R^{D37}	R^{D237}	L_{C1407}	R^{D143}	R^{D237}
L_{C1246}	R^{D10}	R^{D238}	L_{C1300}	R^{D55}	R^{D238}	L_{C1354}	R^{D37}	R^{D238}	L_{C1408}	R^{D143}	R^{D238}
L_{C1247}	R^{D10}	R^{D239}	L_{C1301}	R^{D55}	R^{D239}	L_{C1355}	R^{D37}	R^{D239}	L_{C1409}	R^{D143}	R^{D239}
L_{C1248}	R^{D10}	R^{D240}	L_{C1302}	R^{D55}	R^{D240}	L_{C1356}	R^{D37}	R^{D240}	L_{C1410}	R^{D143}	R^{D240}
L_{C1249}	R^{D10}	R^{D241}	L_{C1303}	R^{D55}	R^{D241}	L_{C1357}	R^{D37}	R^{D241}	L_{C1411}	R^{D143}	R^{D241}
L_{C1250}	R^{D10}	R^{D242}	L_{C1304}	R^{D55}	R^{D242}	L_{C1358}	R^{D37}	R^{D242}	L_{C1412}	R^{D143}	R^{D242}
L_{C1251}	R^{D10}	R^{D243}	L_{C1305}	R^{D55}	R^{D243}	L_{C1359}	R^{D37}	R^{D243}	L_{C1413}	R^{D143}	R^{D243}
L_{C1252}	R^{D10}	R^{D244}	L_{C1306}	R^{D55}	R^{D244}	L_{C1360}	R^{D37}	R^{D244}	L_{C1414}	R^{D143}	R^{D244}
L_{C1253}	R^{D10}	R^{D245}	L_{C1307}	R^{D55}	R^{D245}	L_{C1361}	R^{D37}	R^{D245}	L_{C1415}	R^{D143}	R^{D245}
L_{C1254}	R^{D10}	R^{D246}	L_{C1308}	R^{D55}	R^{D246}	L_{C1362}	R^{D37}	R^{D246}	L_{C1416}	R^{D143}	R^{D246}

[0229] wherein R^{D1} to R^{D246} have the structures defined in the following LIST 10:

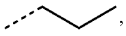
R^{D1}

R^{D2}

R^{D3}

R^{D4}

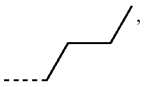
R^{D5}



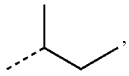
R^{D6}

-continued

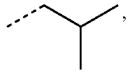
R^{D7}



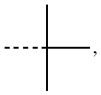
R^{D8}



R^{D9}



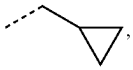
R^{D10}



R^{D11}

-continued

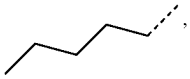
R^{D12}



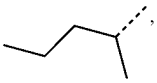
R^{D13}

R^{D14}

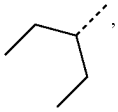
R^{D15}



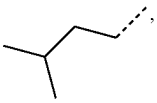
R^{D16}



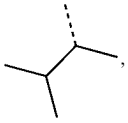
R^{D17}



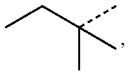
R^{D18}



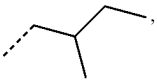
R^{D19}



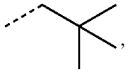
R^{D20}



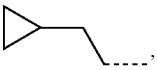
R^{D21}



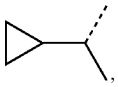
R^{D22}



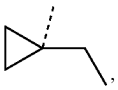
R^{D23}



R^{D24}



R^{D25}



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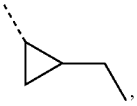
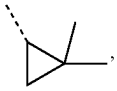
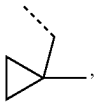
R^{D26}



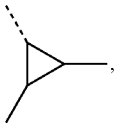
R^{D27}



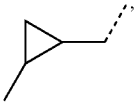
R^{D28}



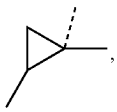
R^{D29}



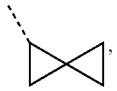
R^{D30}



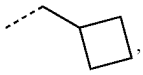
R^{D31}



R^{D32}

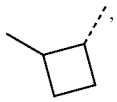


R^{D33}



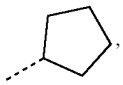
R^{D34}

R^{D35}

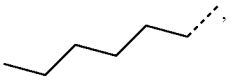


R^{D36}

R^{D37}



R^{D38}



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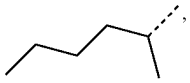
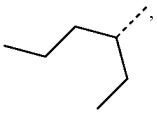
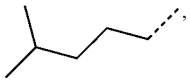
R^{D39}



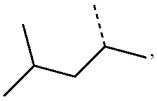
R^{D40}



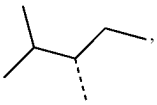
R^{D41}



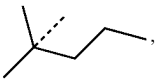
R^{D42}



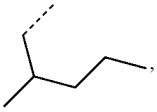
R^{D43}



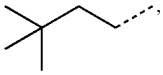
R^{D44}



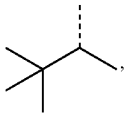
R^{D45}



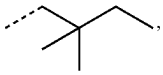
R^{D46}



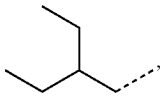
R^{D47}



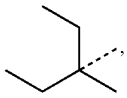
R^{D48}



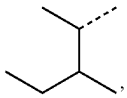
R^{D49}



R^{D50}



R^{D51}



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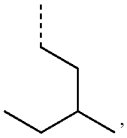
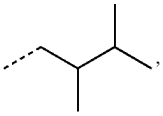
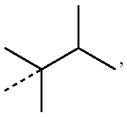
R^{D52}



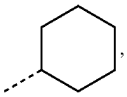
R^{D53}



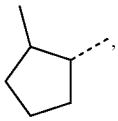
R^{D54}



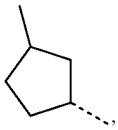
R^{D55}



R^{D56}

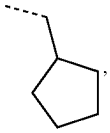


R^{D57}

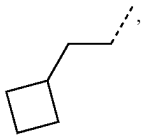


R^{D58}

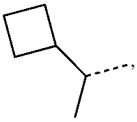
R^{D59}



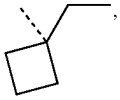
R^{D60}



R^{D61}



R^{D62}



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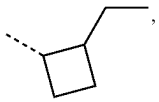
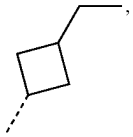
R^{D63}

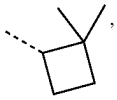


R^{D64}

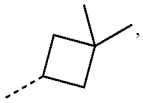


R^{D65}

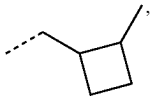
R^{D66}



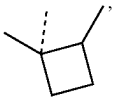
R^{D67}



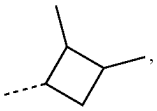
R^{D68}



R^{D69}



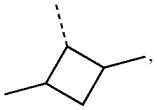
R^{D70}



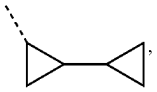
R^{D71}

R^{D72}

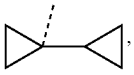
R^{D73}



R^{D74}



R^{D75}



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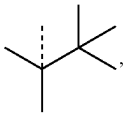
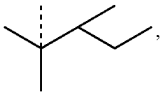
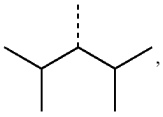
R^{D76}



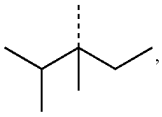
R^{D77}



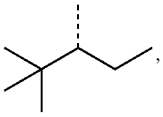
R^{D78}



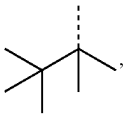
R^{D79}



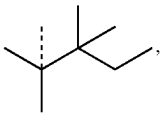
R^{D80}



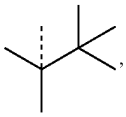
R^{D81}



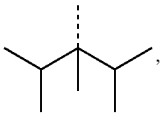
R^{D82}



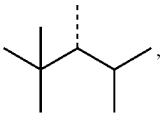
R^{D83}



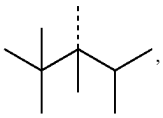
R^{D84}



R^{D85}



R^{D86}



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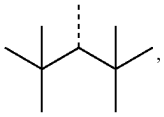
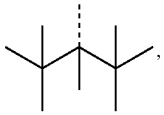
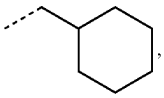
R^{D87}



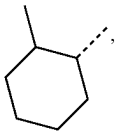
R^{D88}



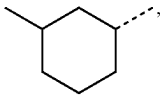
R^{D89}



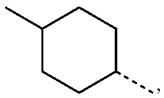
R^{D90}



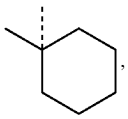
R^{D91}



R^{D92}

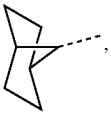


R^{D93}

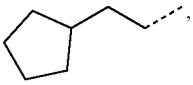


R^{D94}

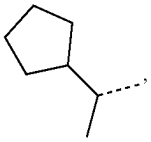
R^{D95}



R^{D96}



R^{D97}



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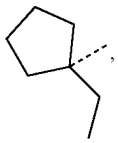
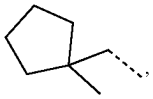
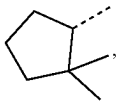
R^{D98}



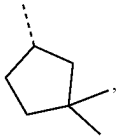
R^{D99}



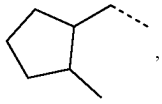
R^{D100}



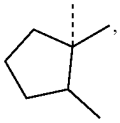
R^{D101}



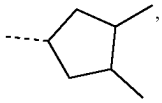
R^{D102}



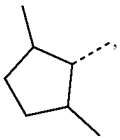
R^{D103}



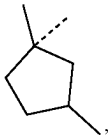
R^{D104}



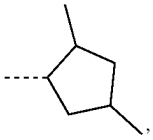
R^{D105}



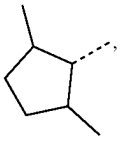
R^{D106}



R^{D107}



R^{D108}



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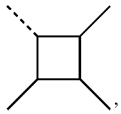
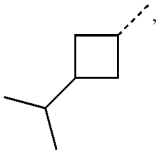
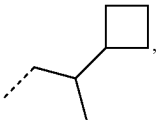
R^{D109}



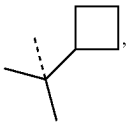
R^{D110}



R^{D111}

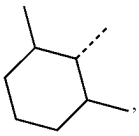


R^{D112}

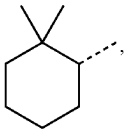


R^{D113}

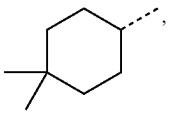
R^{D114}



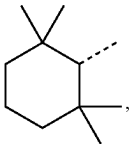
R^{D115}



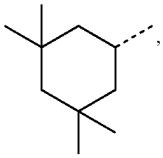
R^{D116}



R^{D117}



R^{D118}



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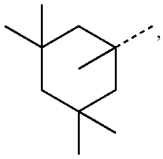
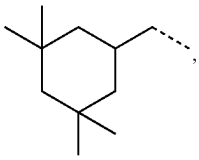
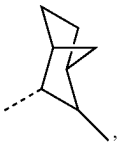
R^{D119}



R^{D120}

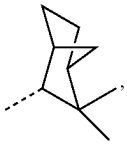


R^{D121}

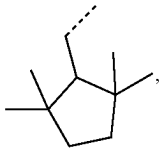


R^{D122}

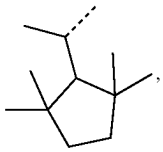
R^{D123}



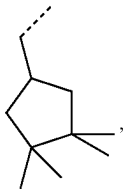
R^{D124}



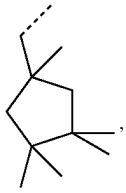
R^{D125}



R^{D126}



R^{D127}



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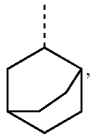
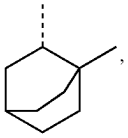
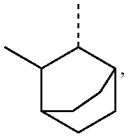
R^{D128}



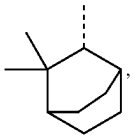
R^{D129}



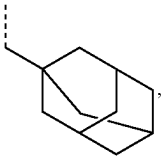
R^{D130}



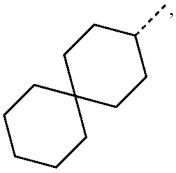
R^{D131}



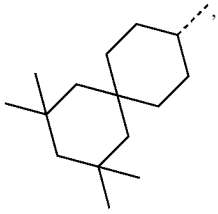
R^{D132}



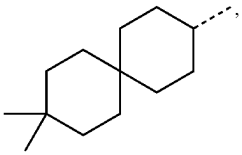
R^{D133}



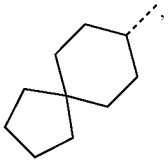
R^{D134}



R^{D135}



R^{D136}



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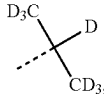
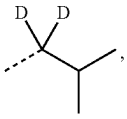
R^{D137}

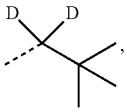
R^{D138}



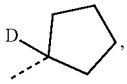
R^{D139}



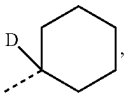
R^{D140}



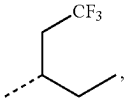
R^{D141}



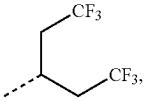
R^{D142}



R^{D143}

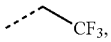


R^{D144}

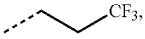


R^{D145}

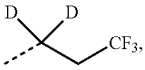
R^{D146}



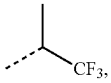
R^{D147}



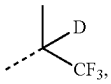
R^{D148}



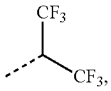
R^{D149}



R^{D150}



R^{D151}



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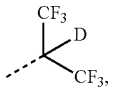
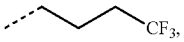
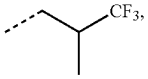
R^{D152}



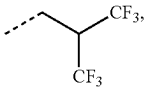
R^{D153}



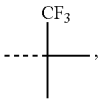
R^{D154}



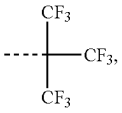
R^{D155}



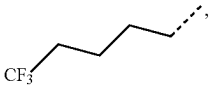
R^{D156}



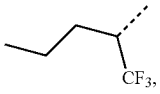
R^{D157}



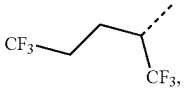
R^{D158}



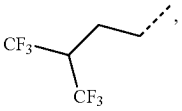
R^{D159}



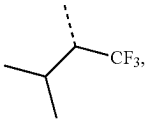
R^{D160}



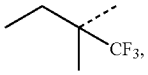
R^{D161}



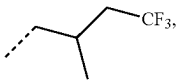
R^{D162}



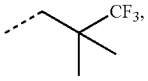
R^{D163}



R^{D164}



R^{D165}



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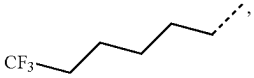
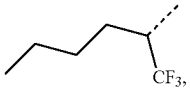
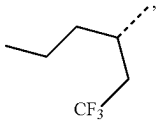
R^{D166}



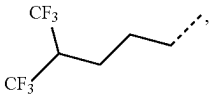
R^{D167}



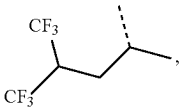
R^{D168}



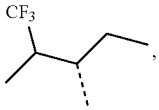
R^{D169}



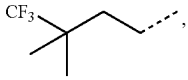
R^{D170}



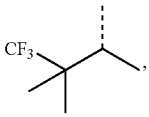
R^{D171}



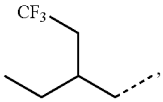
R^{D172}



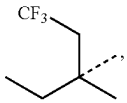
R^{D173}



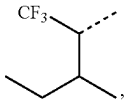
R^{D174}



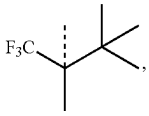
R^{D175}



R^{D176}



R^{D177}



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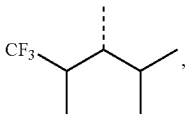
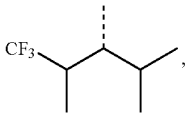
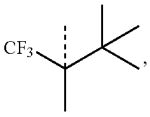
R^{D178}



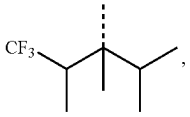
R^{D179}



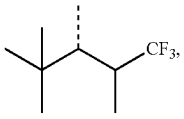
R^{D180}



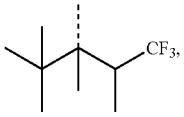
R^{D181}



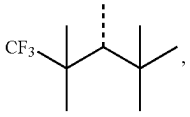
R^{D182}



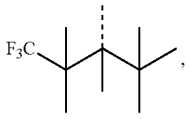
R^{D183}



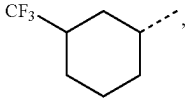
R^{D184}



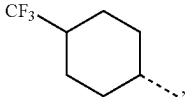
R^{D185}



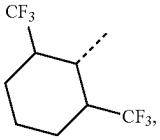
R^{D186}



R^{D187}



R^{D188}



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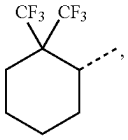
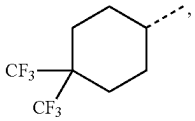
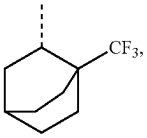
R^{D189}



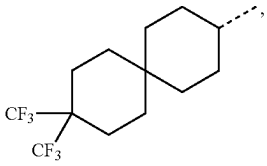
R^{D190}



R^{D191}



R^{D192}

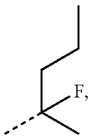


R^{D193}

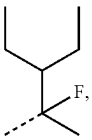
R^{D194}

R^{D195}

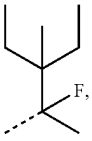
R^{D196}



R^{D197}



R^{D198}



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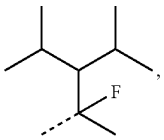
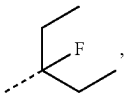
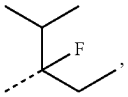
R^{D199}



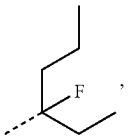
R^{D200}



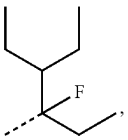
R^{D201}



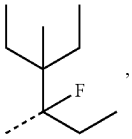
R^{D202}



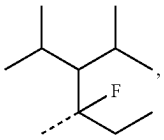
R^{D203}



R^{D204}



R^{D205}



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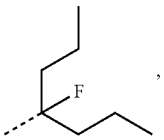
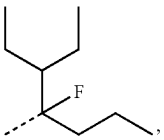
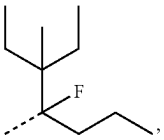


R^{D207}



R^{D208}



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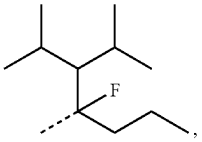
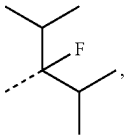
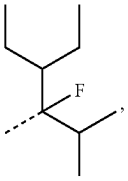
R^{D209}



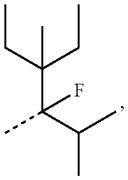
R^{D210}



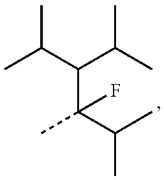
R^{D211}



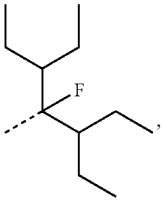
R^{D212}



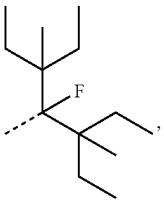
R^{D213}



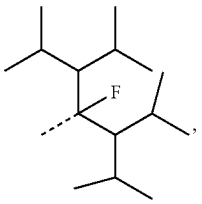
R^{D214}



R^{D215}



R^{D216}



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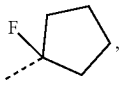
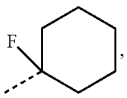
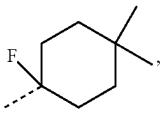
R^{D217}



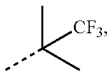
R^{D218}



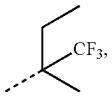
R^{D219}



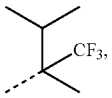
R^{D220}



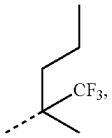
R^{D221}



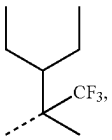
R^{D222}



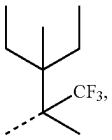
R^{D223}



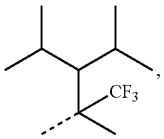
R^{D224}



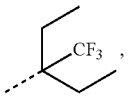
R^{D225}



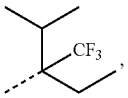
R^{D226}



R^{D227}



R^{D228}



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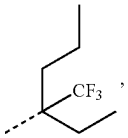
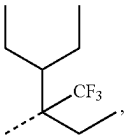
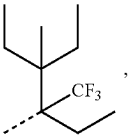
R^{D229}



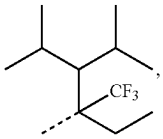
R^{D230}



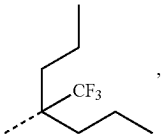
R^{D231}



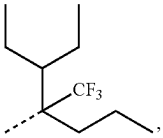
R^{D232}



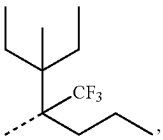
R^{D233}



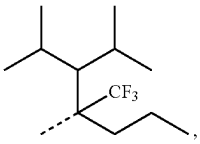
R^{D234}



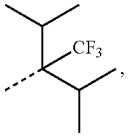
R^{D235}



R^{D236}



R^{D237}



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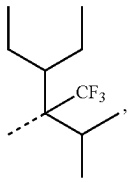
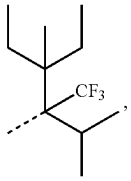
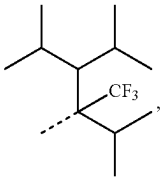
R^{D238}



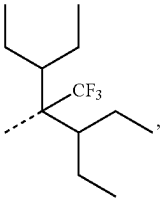
R^{D239}



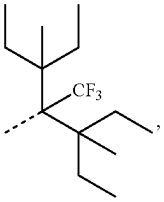
R^{D240}



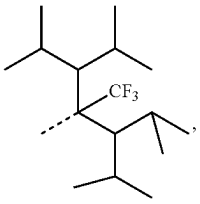
R^{D241}



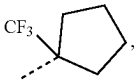
R^{D242}



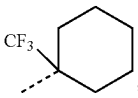
R^{D243}



R^{D244}



R^{D245}



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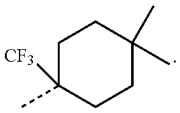
R^{D246}



[0230] In some embodiments, the compound is selected from the group consisting of only those compounds whose L_{Bk} corresponds to one of the following: L_{B1}, L_{B30}, L_{B31}, L_{B109}, L_{B110}, L_{B112}, L_{B113}, L_{B114}, L_{B125}, L_{B127}, L_{B138}, L_{B140}, L_{B149}, L_{B150}, L_{B170}, L_{B171}, L_{B172}, L_{B174}, L_{B208}, L_{B241}, L_{B312}, L_{B315}, L_{B356}, L_{B367}, L_{B371}, L_{B382}, L_{B439}, L_{B440}, L_{B455}, L_{B456}, L_{B457}, L_{B458}, L_{B461}, L_{B462}, L_{B463}, L_{B469}, and L_{B476}.

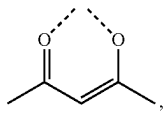
[0231] In some embodiments, the compound is selected from the group consisting of only those compounds whose L_{Bk} corresponds to one of the following: L_{B1}, L_{B30}, L_{B31}, L_{B125}, L_{B138}, L_{B171}, L_{B172}, L_{B356}, L_{B357}, L_{B367}, L_{B371}, L_{B382}, L_{B455}, and L_{B456}.

[0232] In some embodiments, the compound is selected from the group consisting of only those compounds having $L_{Cj\text{-}I}$ or $L_{Cj\text{-}II}$ ligand whose corresponding R^{201} and R^{202} are defined to be one of the following structures: R^{D1}, R^{D3}, R^{D4}, R^{D5}, R^{D9}, R^{D10}, R^{D17}, R^{D18}, R^{D20}, R^{D22}, R^{D37}, R^{D40}, R^{D41}, R^{D42}, R^{D43}, R^{D48}, R^{D49}, R^{D50}, R^{D54}, R^{D55}, R^{D58}, R^{D59}, R^{D78}, R^{D79}, R^{D81}, R^{D87}, R^{D88}, R^{D89}, R^{D93}, R^{D116}, R^{D117}, R^{D118}, R^{D119}, R^{D120}, R^{D133}, R^{D134}, R^{D135}, R^{D136}, R^{D143}, R^{D144}, R^{D145}, R^{D146}, R^{D147}, R^{D149}, R^{D151}, R^{D154}, R^{D155}, R^{D161}, R^{D175}, R^{D190}, R^{D193}, R^{D200}, R^{D201}, R^{D206}, R^{D210}, R^{D214}, R^{D215}, R^{D216}, R^{D218}, R^{D219}, R^{D220}, R^{D227}, R^{D237}, R^{D241}, R^{D242}, R^{D245}, and R^{D246}.

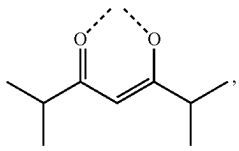
[0233] In some embodiments, the compound is selected from the group consisting of only those compounds having $L_{Cj\text{-}I}$ or $L_{Cj\text{-}II}$ ligand whose corresponding R^{201} and R^{202} are defined to be one of selected from the following structures: R^{D1}, R^{D3}, R^{D4}, R^{D5}, $R^{D9}R^{D10}$, R^{D17}, R^{D22}, R^{D43}, R^{D50}, R^{D78}, R^{D116}, R^{D118}, R^{D133}, R^{D134}, R^{D135}, R^{D136}, R^{D143}, R^{D144}, R^{D145}, R^{D146}, R^{D149}, R^{D151}, R^{D154}, R^{D155}, R^{D190}, R^{D193}, R^{D200}, R^{D201}, R^{D206}, R^{D210}, R^{D214}, R^{D215}, R^{D216}, R^{D218}, R^{D219}, R^{D220}, R^{D227}, R^{D237}, R^{D241}, R^{D242}, R^{D245}, and R^{D246}.

[0234] In some embodiments, the compound is selected from the group consisting of only those compounds having one of the structures of the following LIST 11 for the $L_{Cj\text{-}I}$ ligand:

$L_{C1\text{-}I}$



$L_{C4\text{-}I}$



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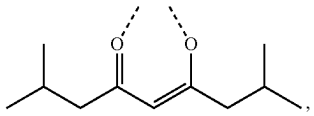
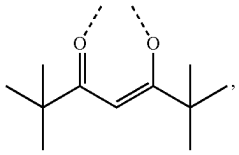
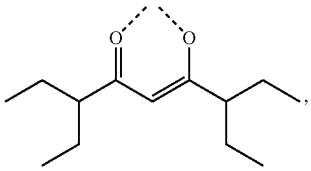
$L_{C9\text{-}I}$



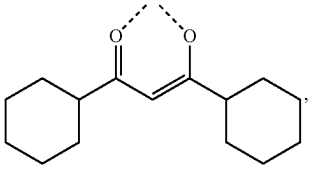
$L_{C10\text{-}I}$



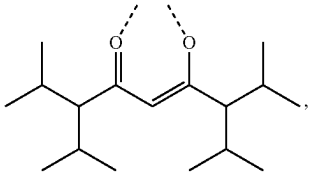
$L_{C17\text{-}I}$



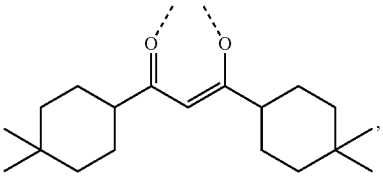
$L_{C55\text{-}I}$



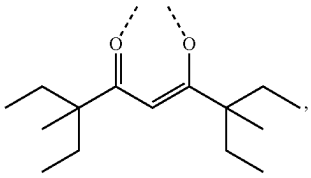
$L_{C78\text{-}I}$



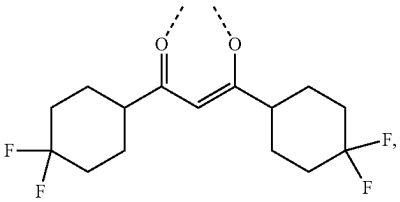
$L_{C116\text{-}I}$



$L_{C50\text{-}I}$



$L_{C190\text{-}I}$



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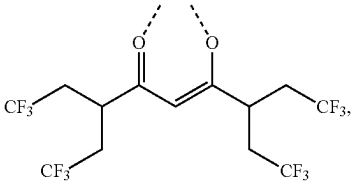
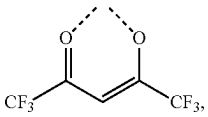
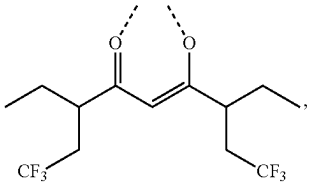
$L_{C144\text{-}I}$



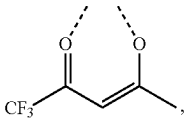
$L_{C145\text{-}I}$



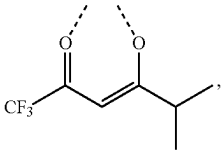
$L_{C143\text{-}I}$



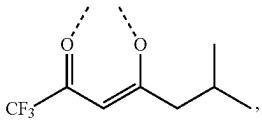
$L_{C232\text{-}I}$



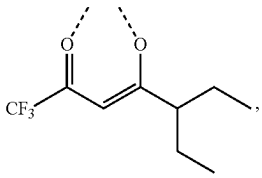
$L_{C279\text{-}I}$



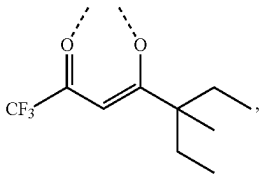
$L_{C325\text{-}I}$



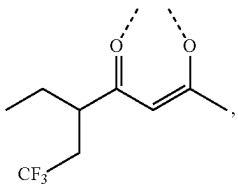
$L_{C414\text{-}I}$



$L_{C457\text{-}I}$



$L_{C230\text{-}I}$



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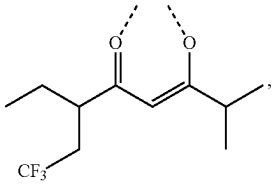
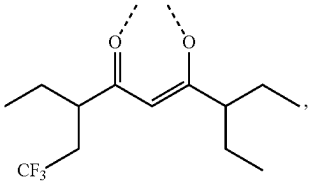
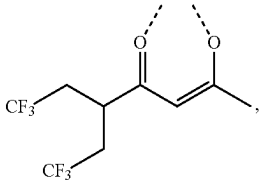
$L_{C277\text{-}I}$



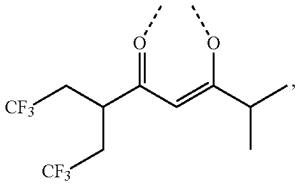
$L_{C412\text{-}I}$



$L_{C231\text{-}I}$



$L_{C278\text{-}I}$



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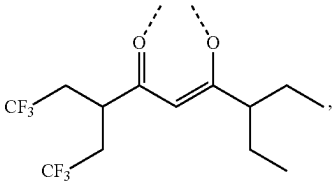
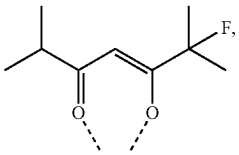
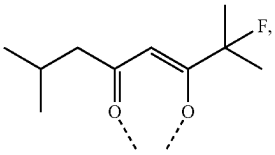


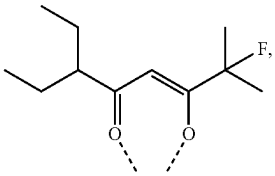
$L_{C985\text{-}I}$



$L_{C1093\text{-}I}$



$L_{C823\text{-}I}$



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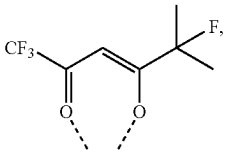
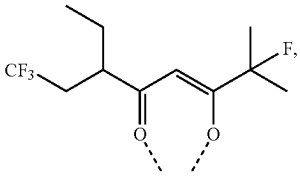
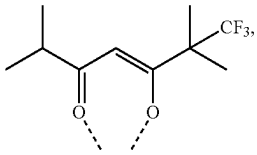
$L_{C1039\text{-}I}$



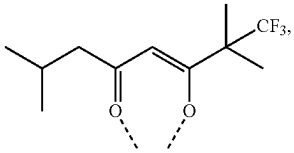
$L_{C1147\text{-}I}$



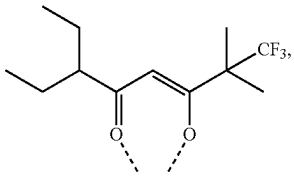
$L_{C1012\text{-}I}$



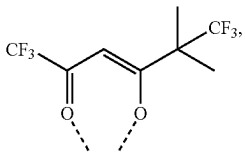
$L_{C1120\text{-}I}$



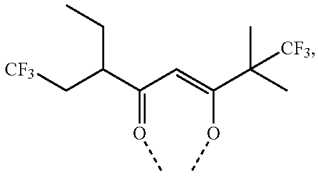
$L_{C850\text{-}I}$



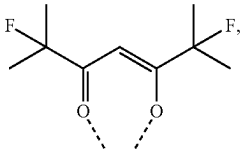
$L_{C1066\text{-}I}$



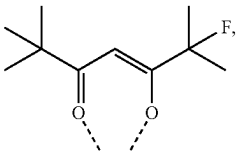
$L_{C1174\text{-}I}$



$L_{C769\text{-}I}$



$L_{C1201\text{-}I}$



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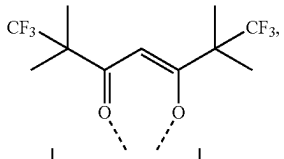
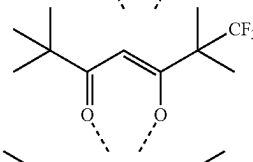
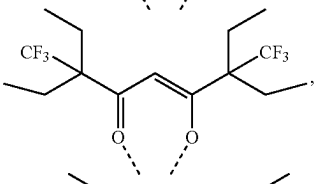
$L_{C796\text{-}I}$



$L_{C1228\text{-}I}$

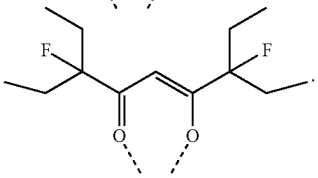


$L_{C803\text{-}I}$



and

$L_{C776\text{-}I}$

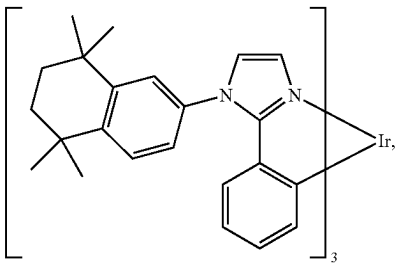


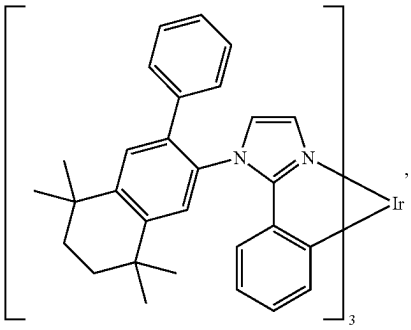
[0235] In some embodiments, the compound has a formula selected from the group consisting of $Ir(L_A)_3$, $Ir(L_A)_2(L_B)$, $Ir(L_A)(L_B)_2$, $Ir(L_A)_2(L_C)$, and $Ir(L_A)(L_B)(L_C)$. In some embodiments, L_A is selected from the group consisting of the structures of LIST 2 and LIST 3, L_B is selected from the group consisting of the structures of LIST 6, LIST 7, and LIST 8 (L_{Bk}), and L_C is selected from the group consisting of the structures of $L_{Cj\text{-}I}$ and $L_{Cj\text{-}II}$ defined herein.

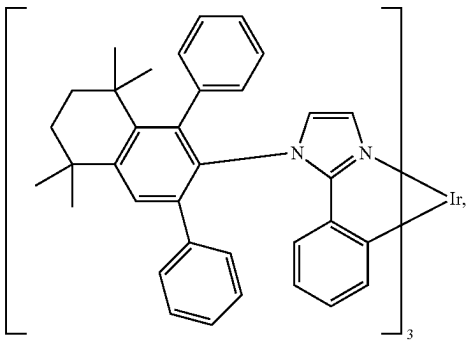
[0236] In some embodiments, L_A is selected from the group consisting of the structures of LIST 2 and L_B is selected from the group consisting of the structures of L_{Bk}. In some embodiments, L_A is selected from the group consisting of the structures of LIST 3 and L_B is selected from the group consisting of the structures of L_{Bk}, wherein k is an integer from 1 to 530. In some embodiments, L_A is selected from LIST 3 defined herein, and L_C is selected from the group consisting of the structures of $L_{Cj\text{-}I}$ and $L_{Cj\text{-}II}$ wherein j is an integer from 1 to 1416.

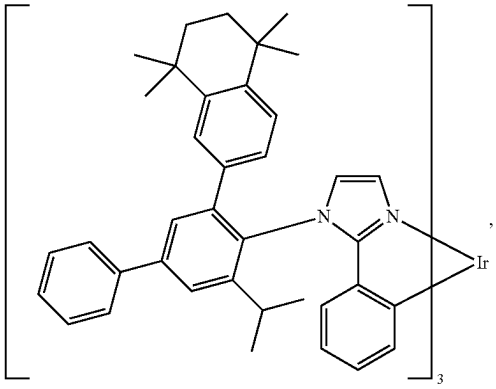
[0237] In some embodiments, the compound can have the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))_3$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))_3$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468))_3$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))(L_B)_2$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))_2(L_B)$, the formula $Ir(L_A)(L_{Bk})_2$, the formula $Ir(L_A)_2(L_{Bk})$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))(L_{Bk})_2$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))(L_{Bl})_2$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468))(L_{B530})_2$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))_2(L_{Bk})$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))_2(L_{Bl})$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468))_2(L_{B530})$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))_2(L_{Cj\text{-}I})$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))_2(L_{Cl\text{-}I})$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468))_2(L_{C1416\text{-}II})$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))_2(L_{Cj\text{-}II})$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))_2(L_{Cl\text{-}II})$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468)))_2(L_{C1416\text{-}II})$, the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))(L_{Bk})(L_{Cj\text{-}I})$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))(L_{Bl})(L_{Cl\text{-}I})$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468)))(L_{B530})(L_{C1416\text{-}I})$, or the formula $Ir(L_Ai\text{-}(Ti)(Rj)(Rk)(Rl))(L_{Bk})(L_{Cj\text{-}II})$ consisting of the compounds of $Ir(L_A1\text{-}(T1)(R1)(R1)(R1))(L_{Bl})(L_{Cl\text{-}II})$ to $Ir(L_A24\text{-}(T76)(R468)(R468)(R468)))(L_{B530})(L_{C1416\text{-}II})$, wherein $L_Ai\text{-}(Ti)(Rj)(Rk)(Rl)$, L_Bk, and $L_{Cj\text{-}I}$ and $L_{Cj\text{-}II}$ are all defined herein.

[0238] In some embodiments, the compound is selected from the group consisting of the structures of the following LIST 12:









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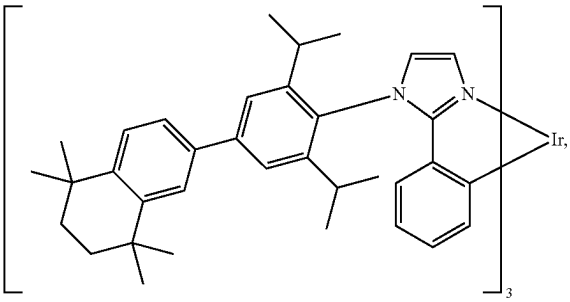

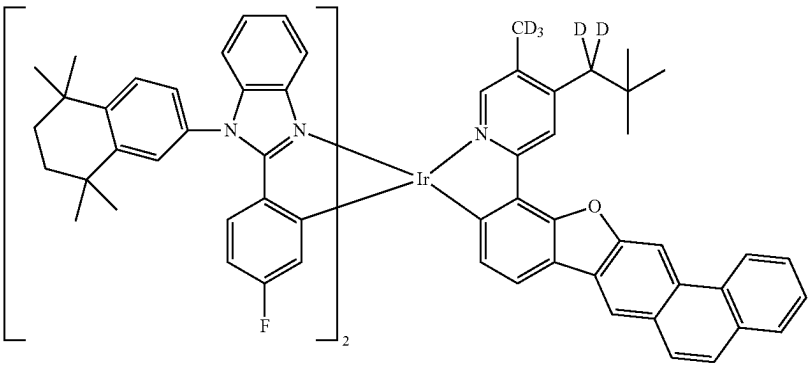

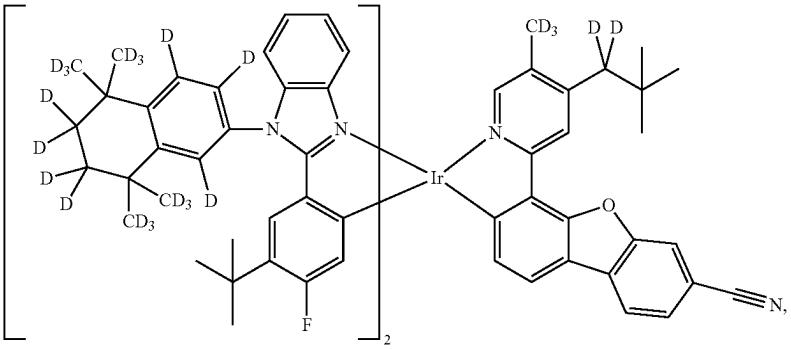

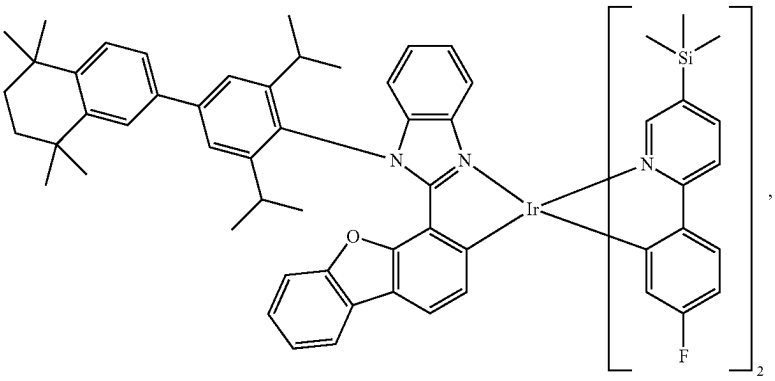

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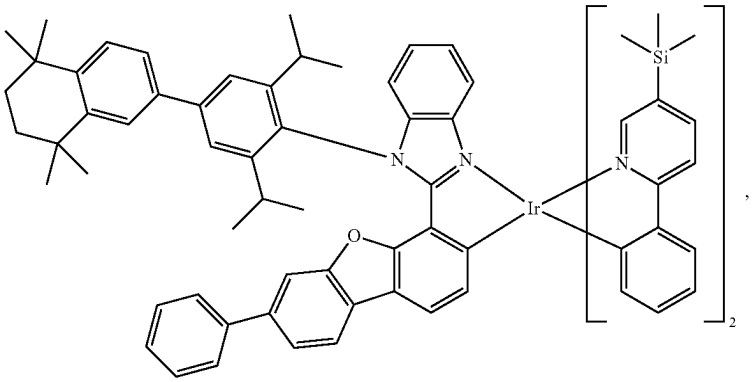

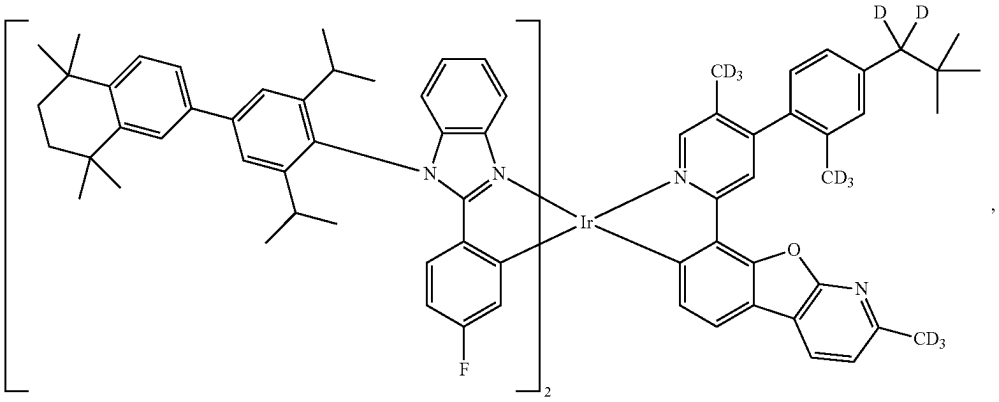

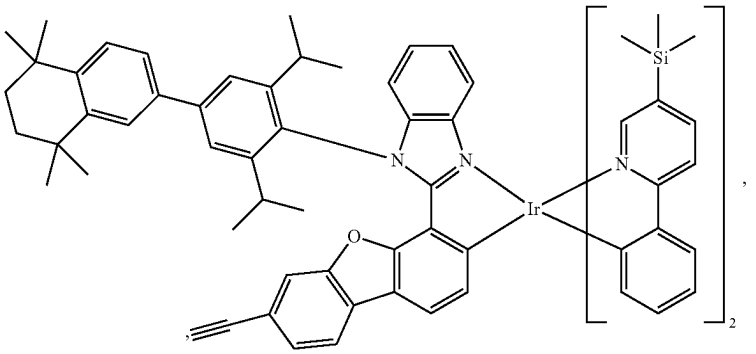

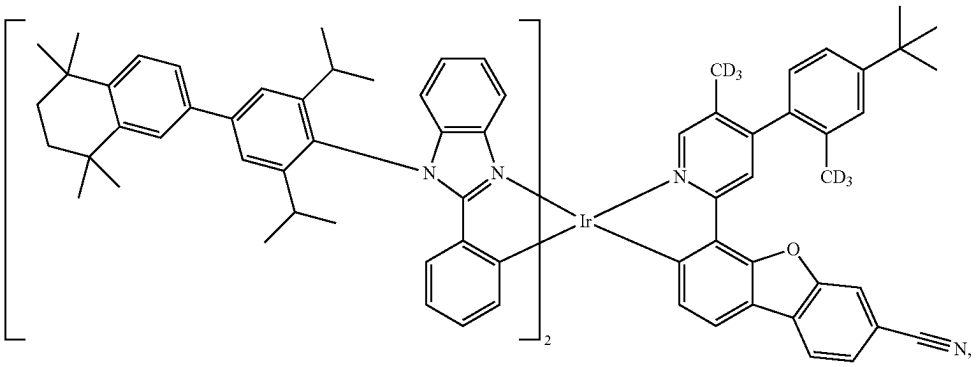

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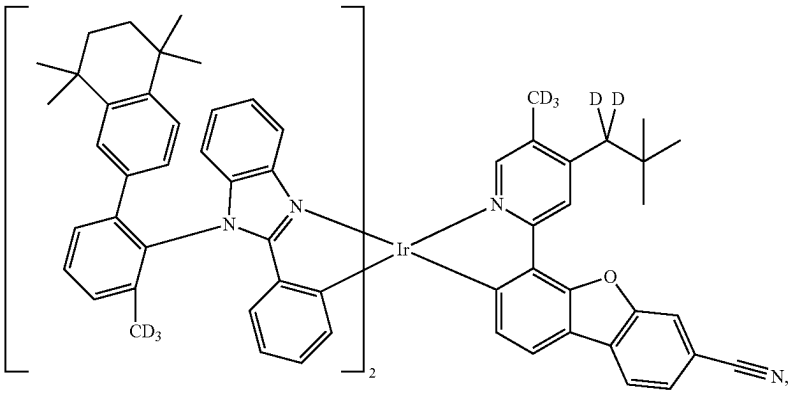

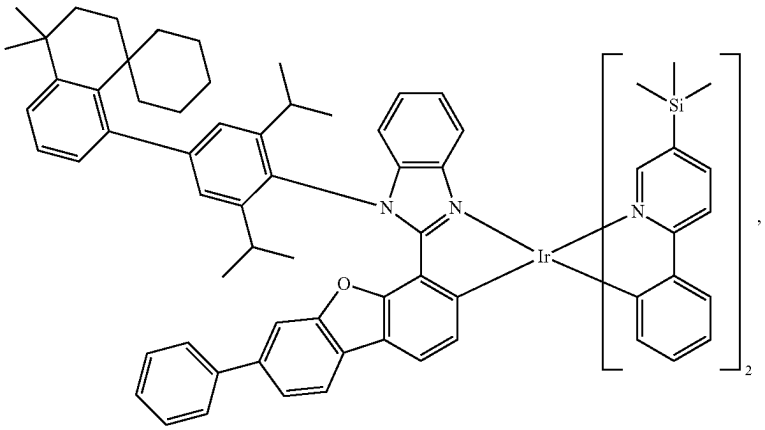

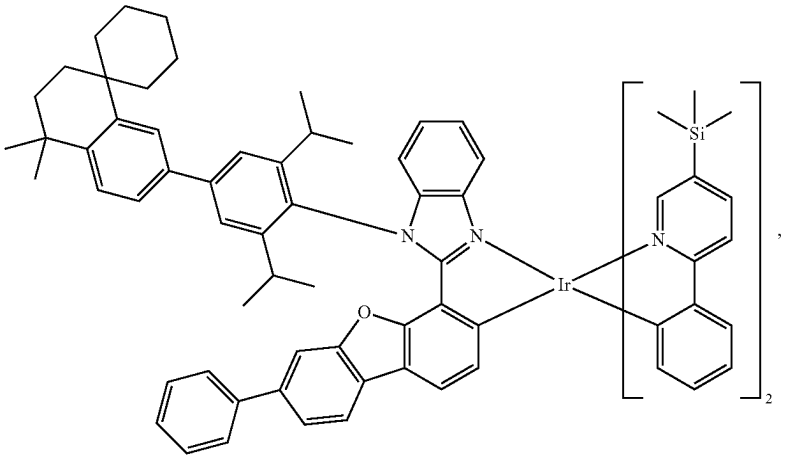

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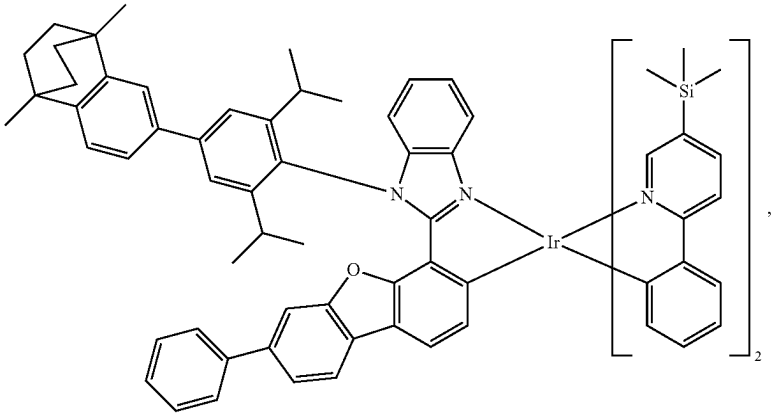

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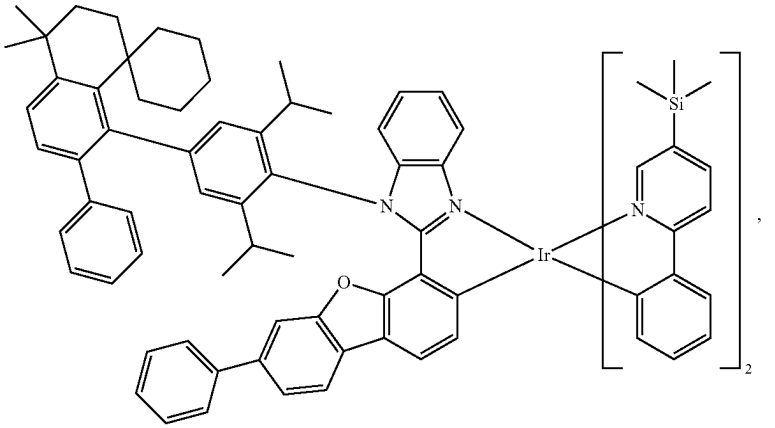

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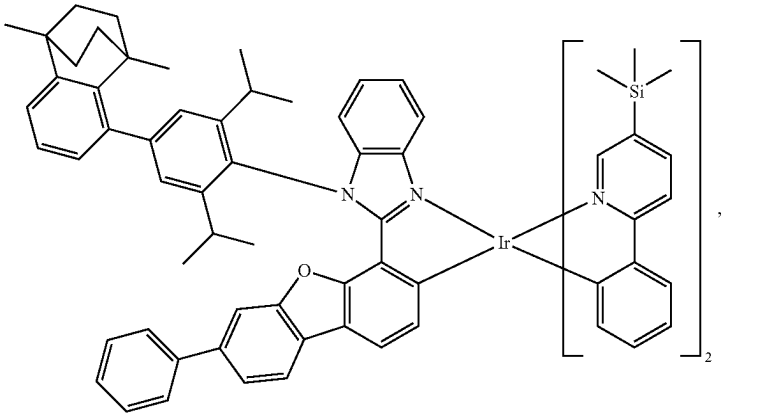

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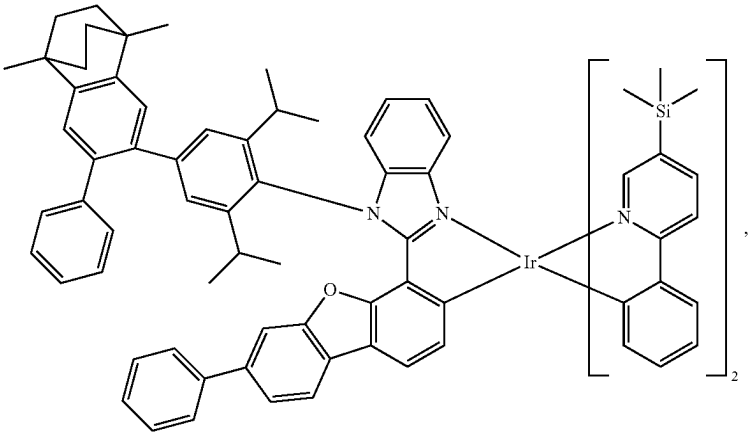

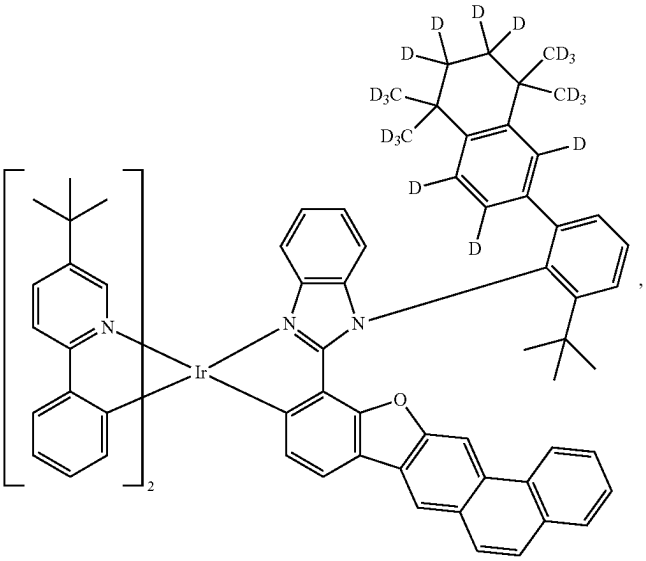

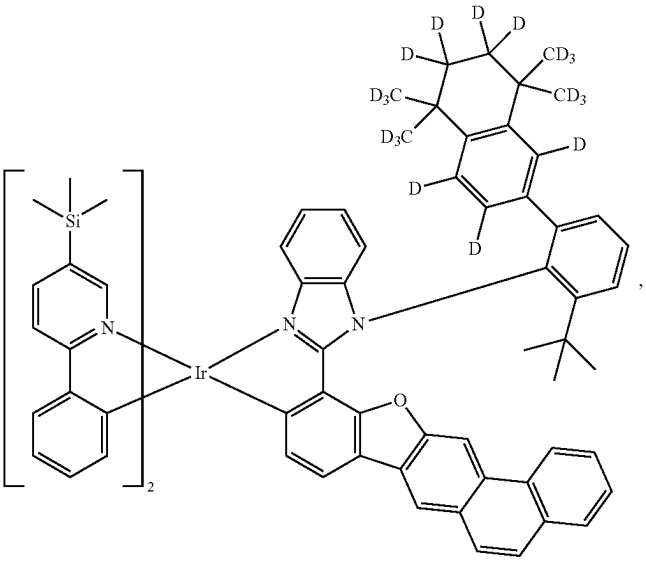

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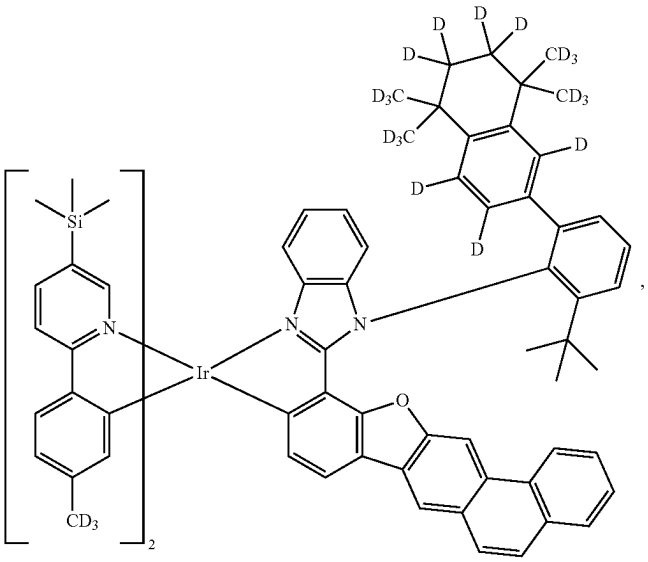
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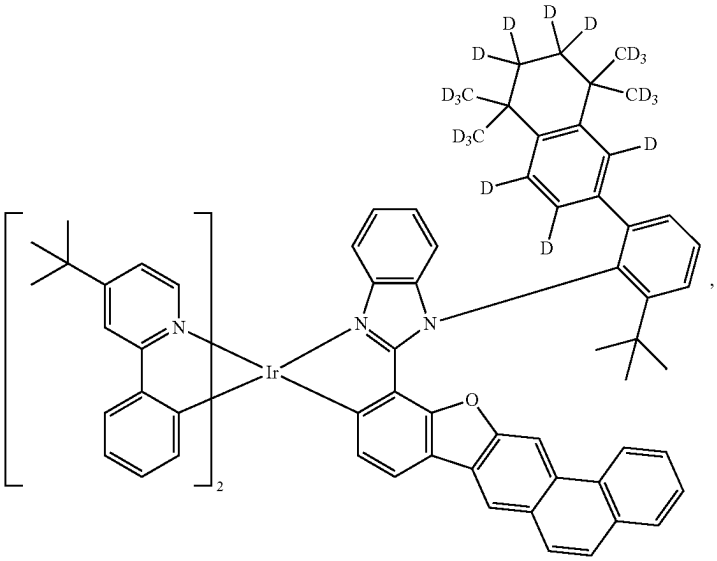
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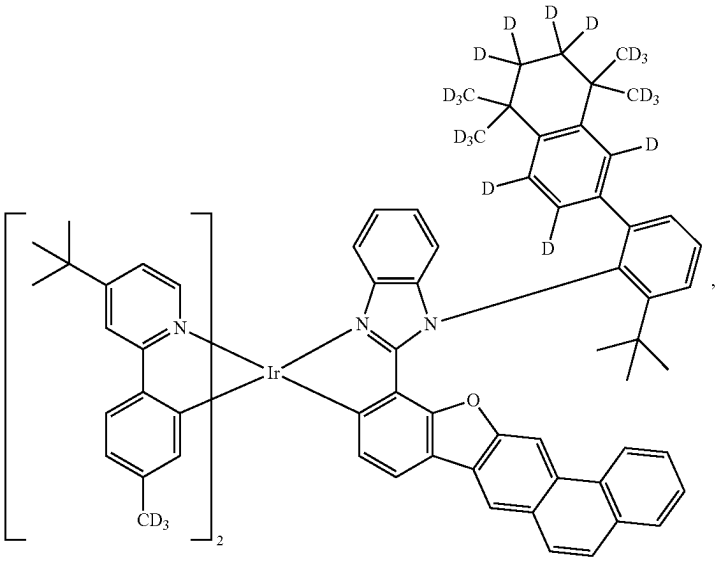

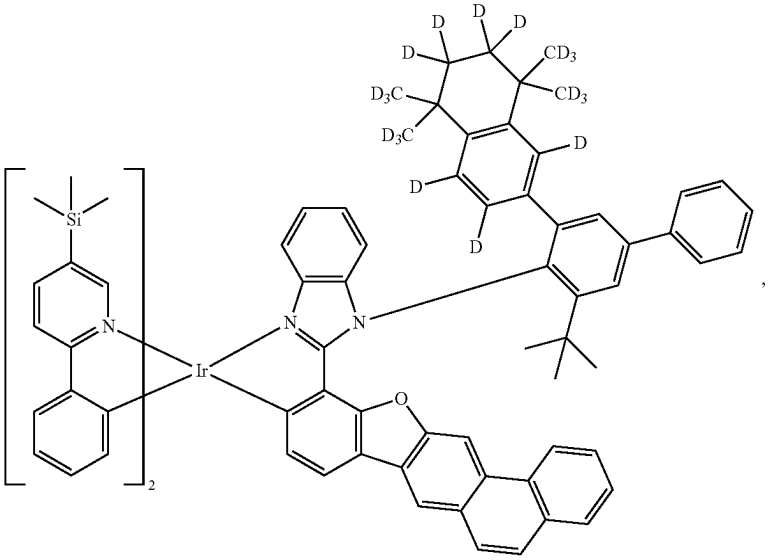

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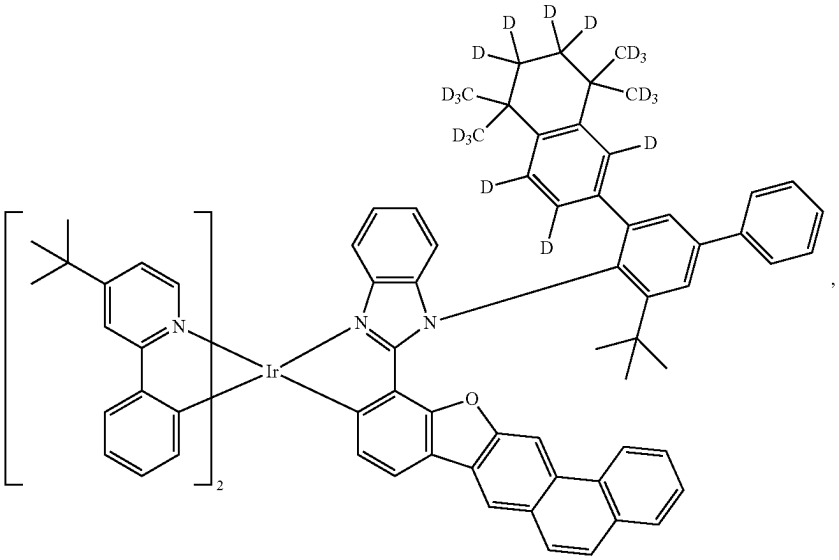
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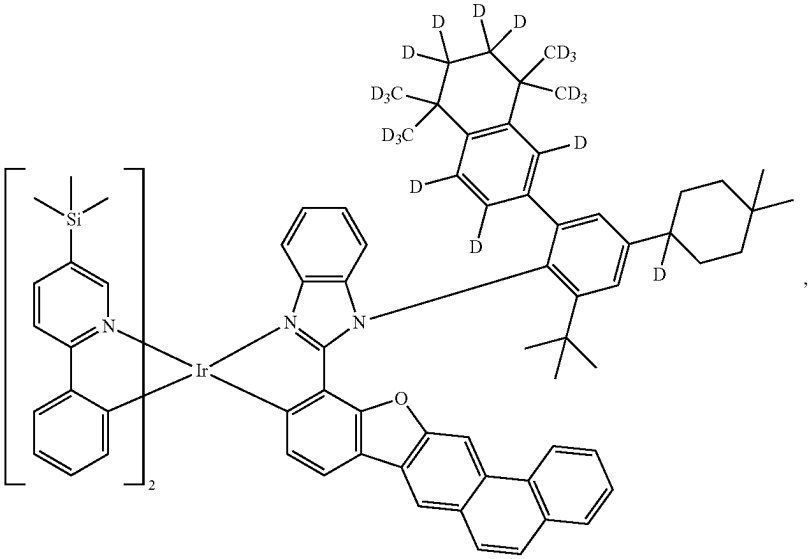
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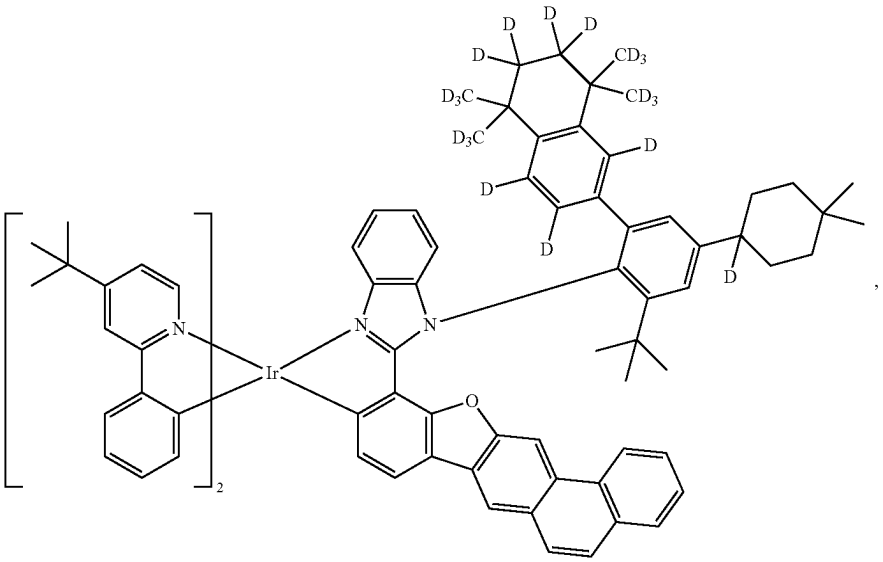
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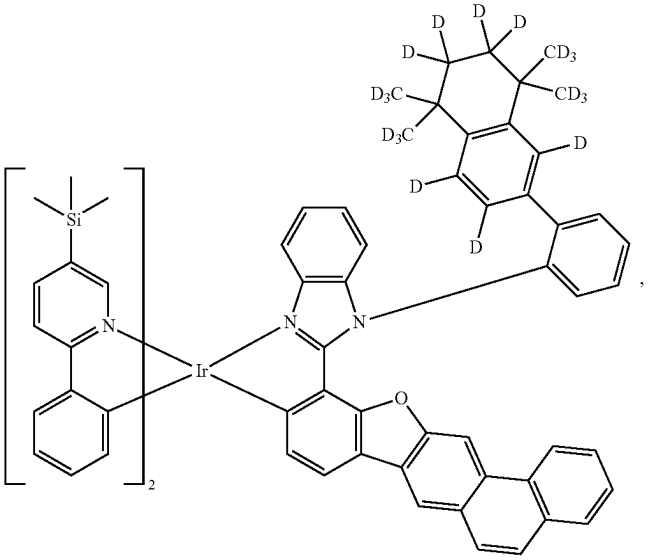
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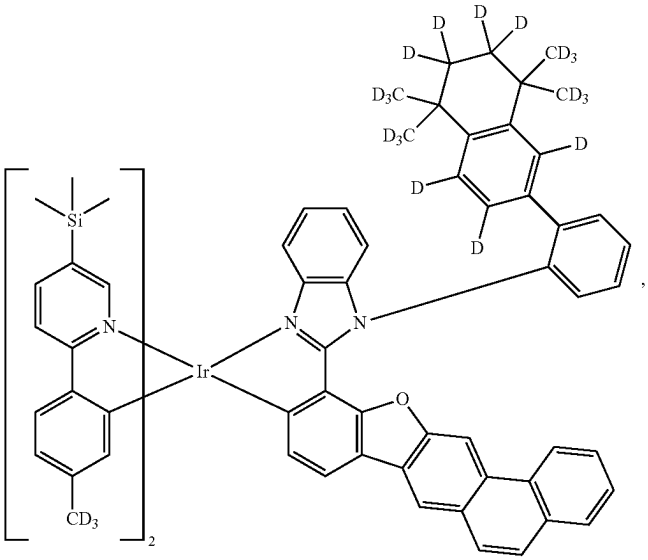
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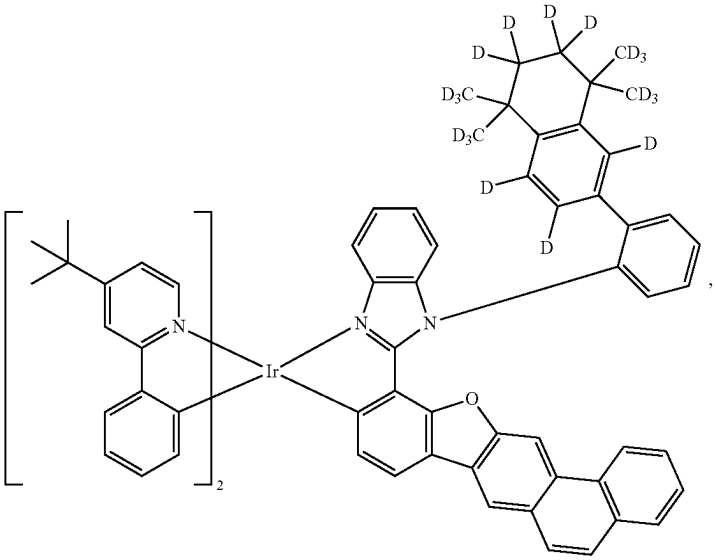
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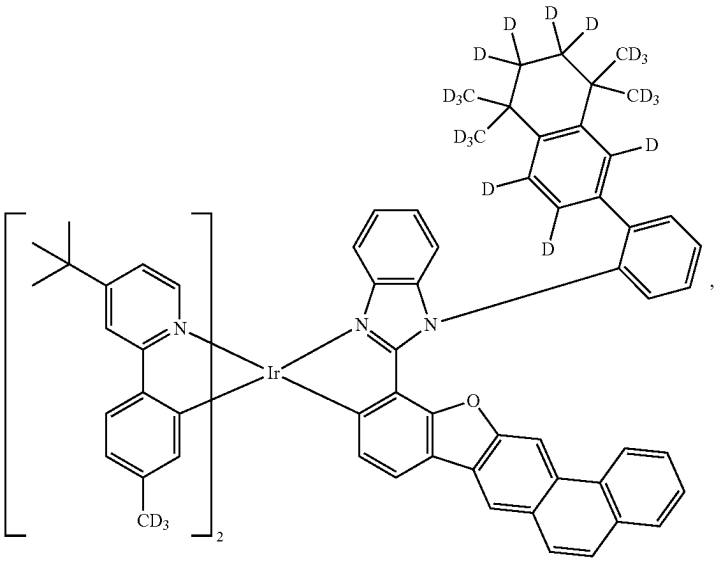

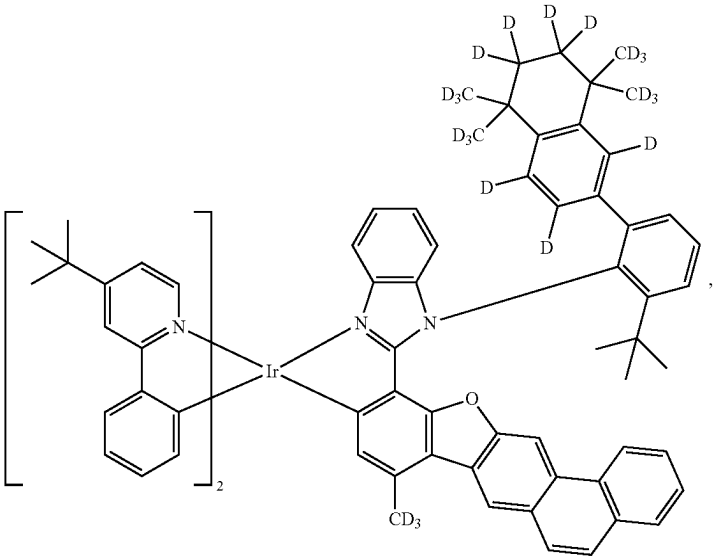

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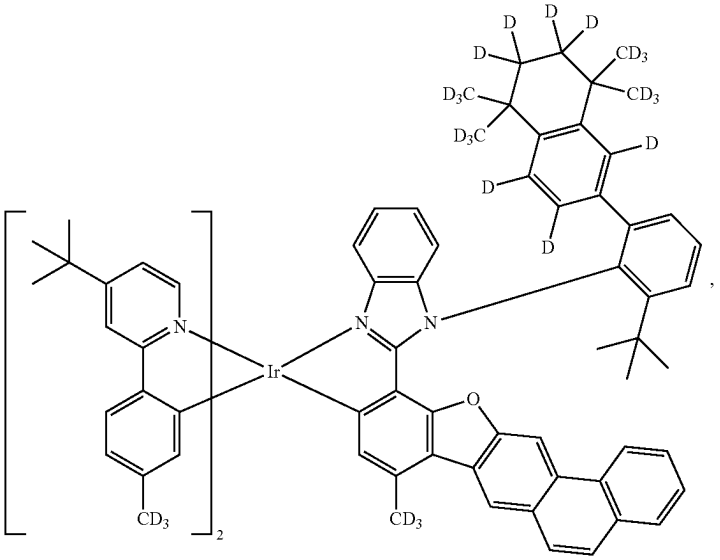

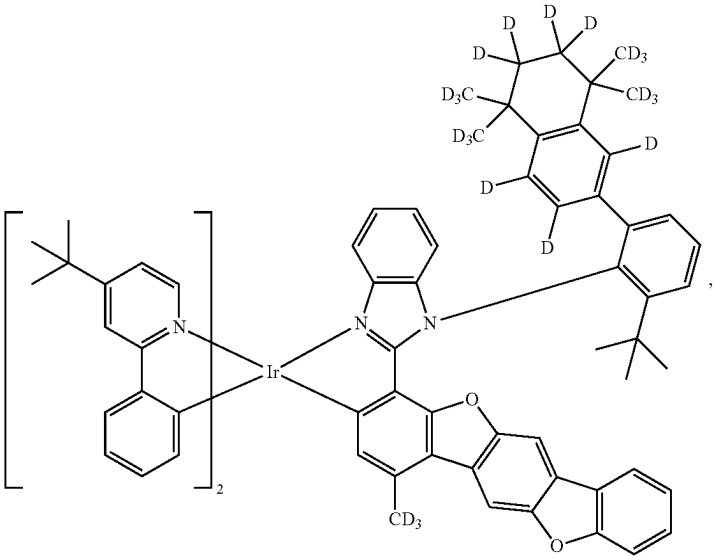

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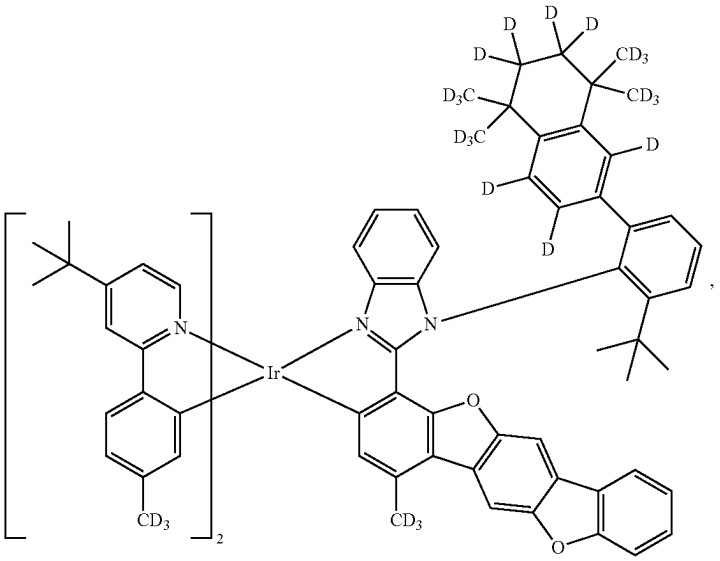

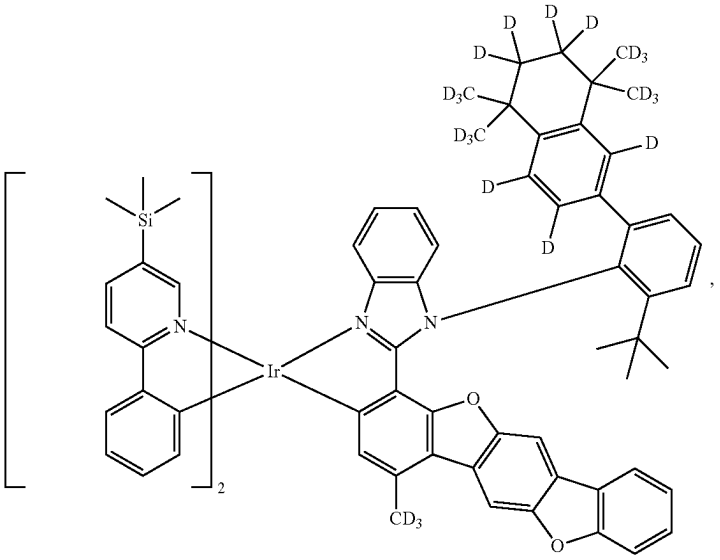

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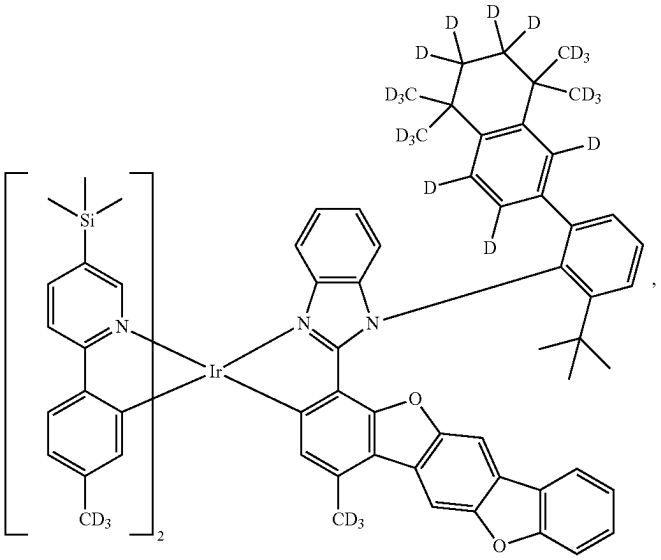

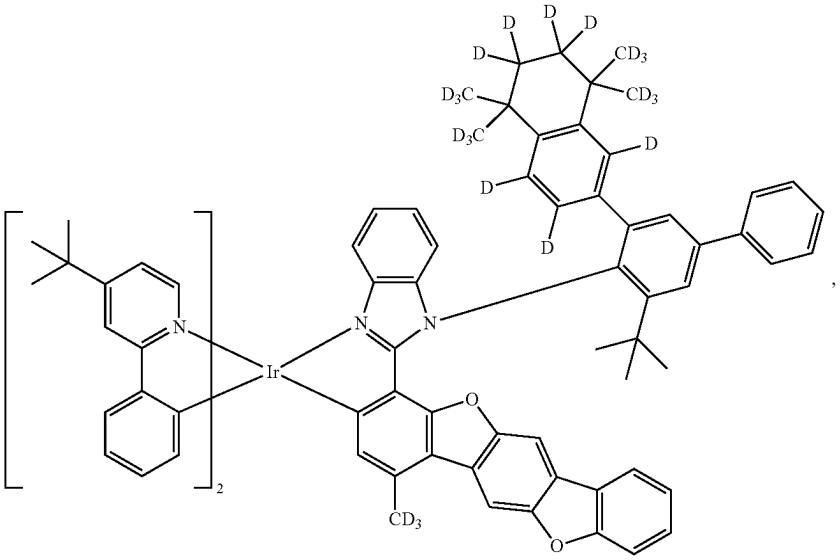

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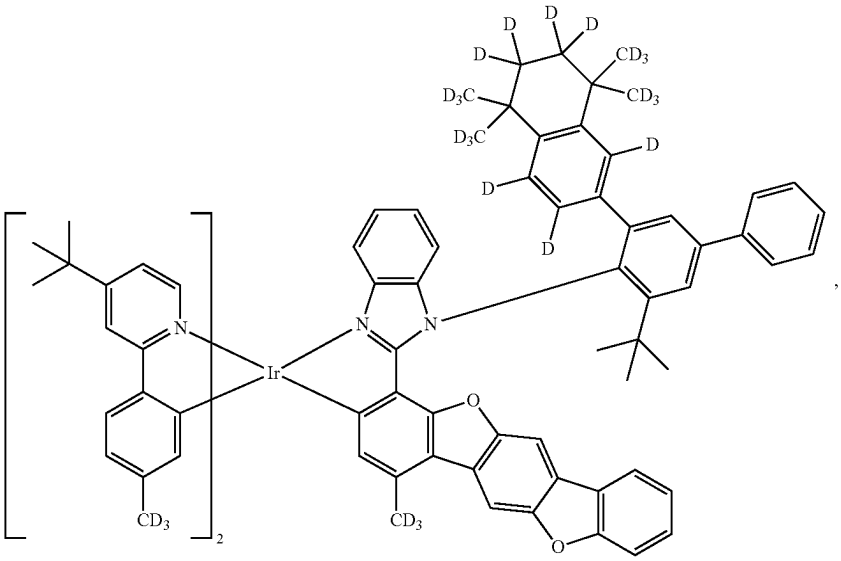

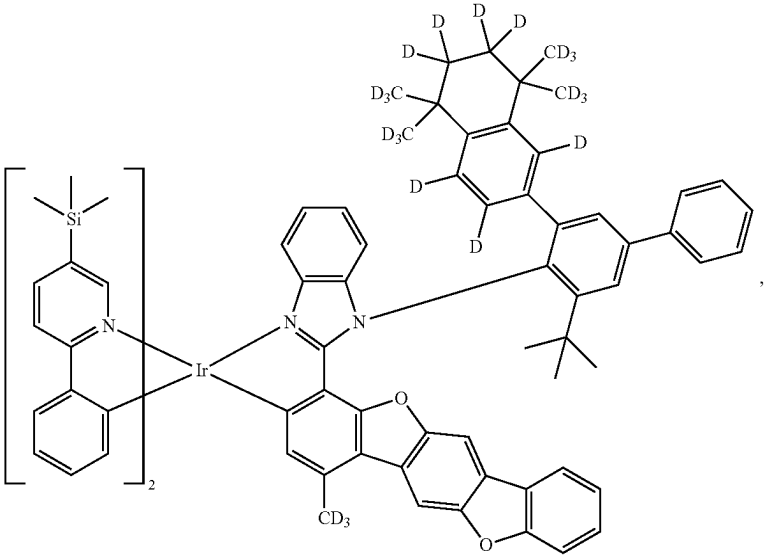

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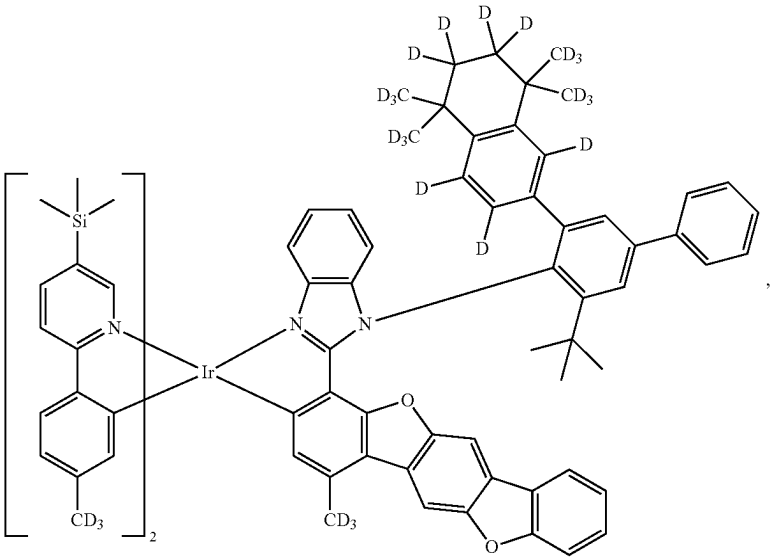

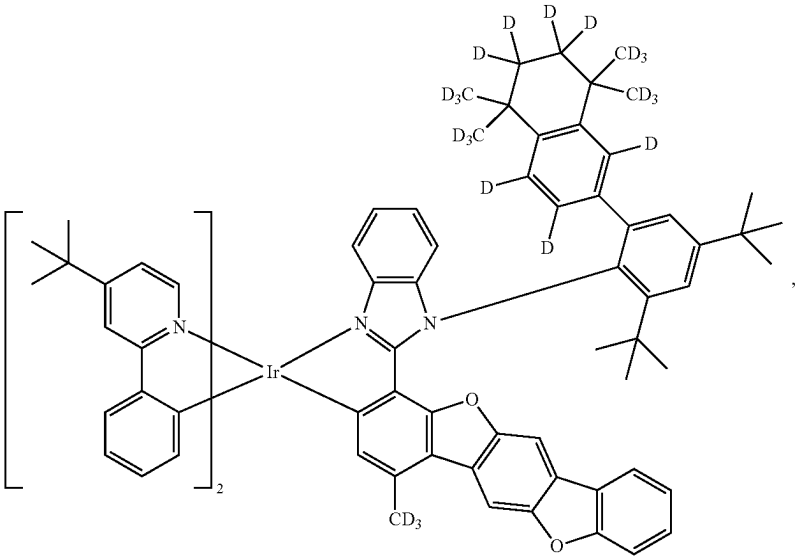

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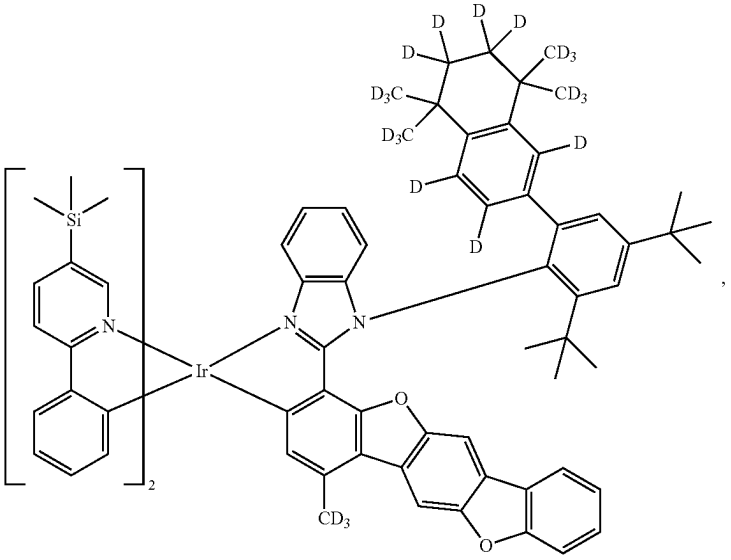

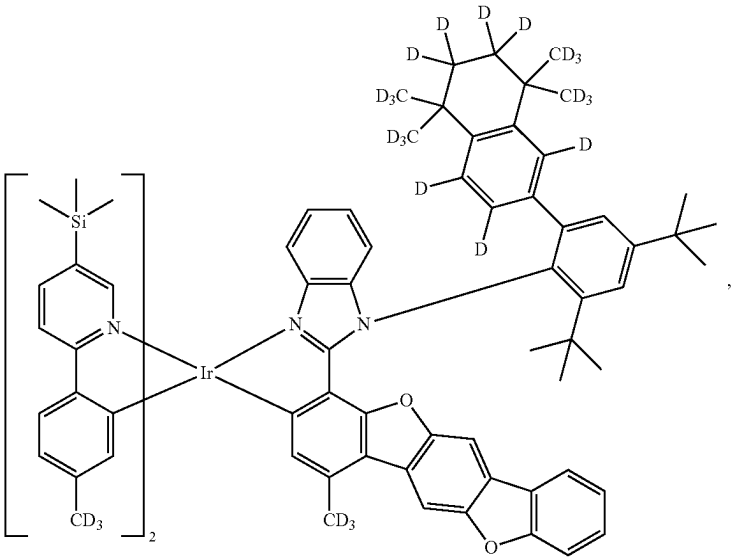

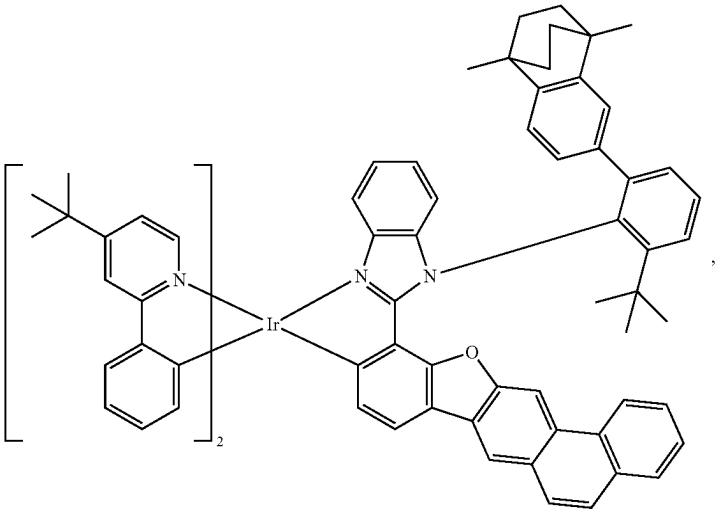

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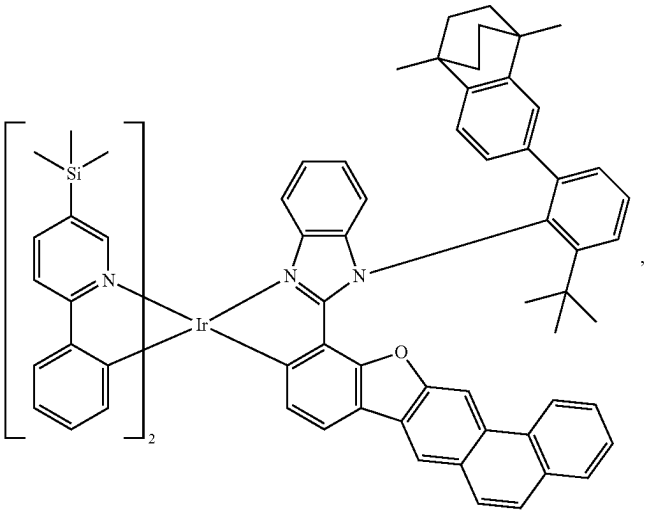

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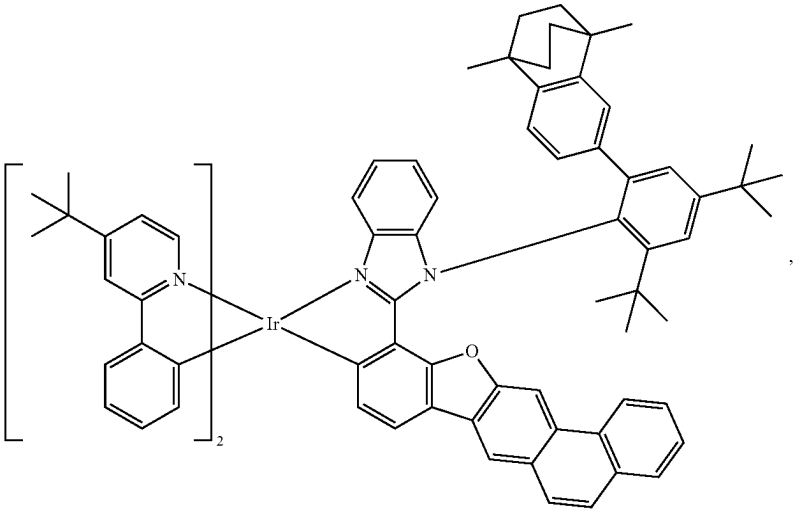

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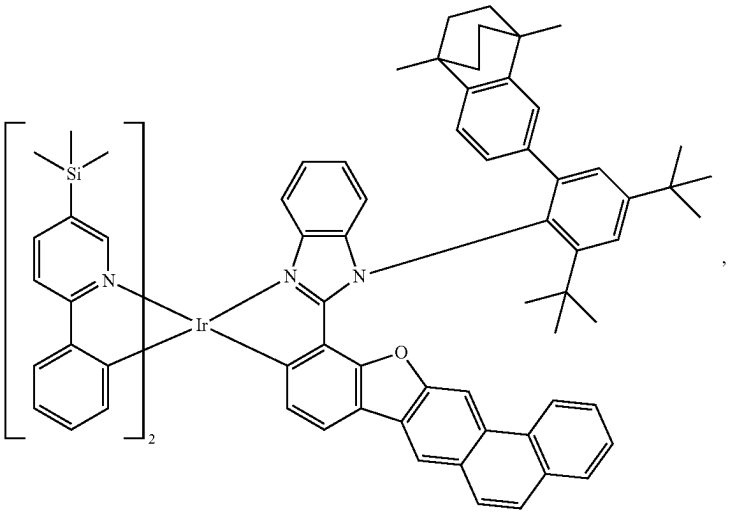

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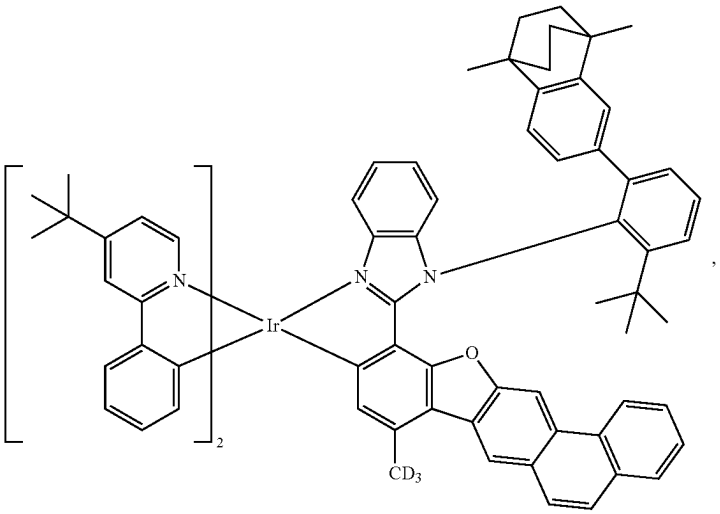

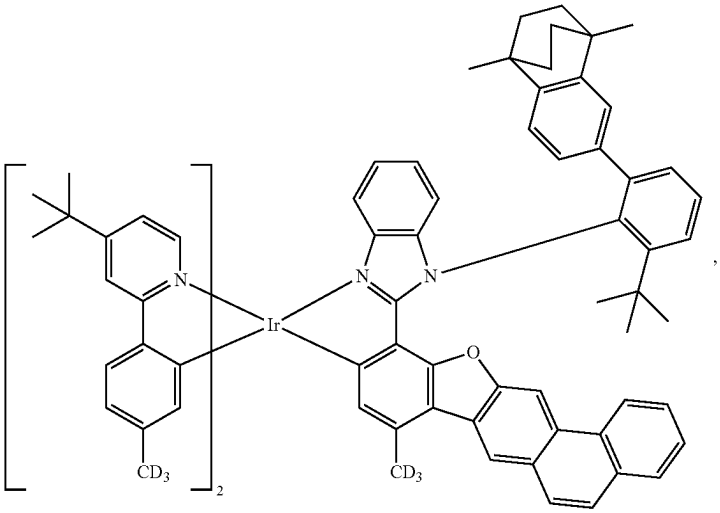

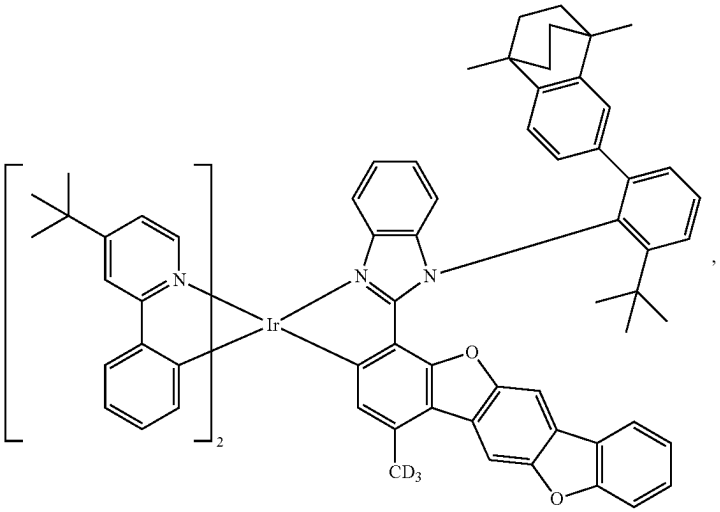

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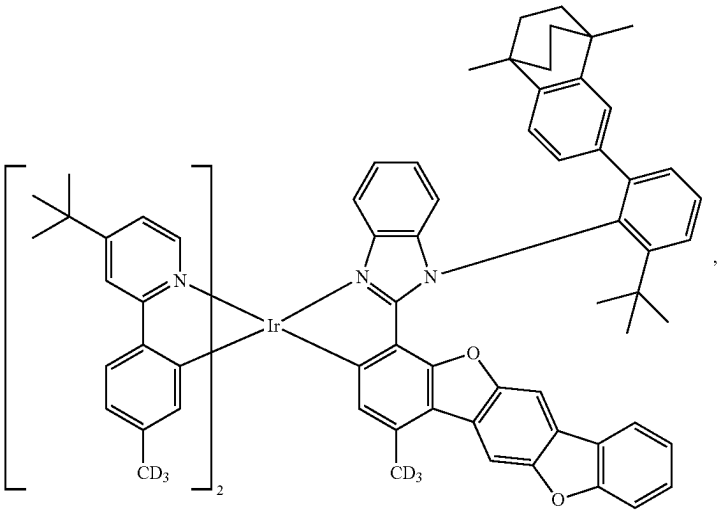

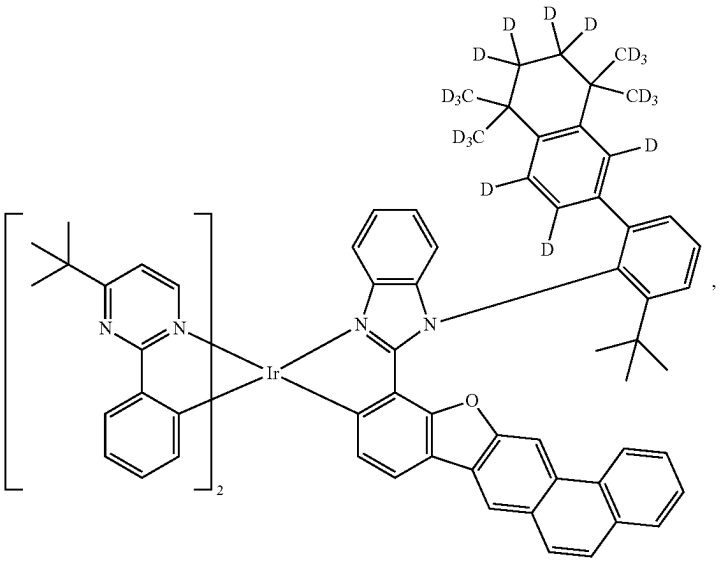

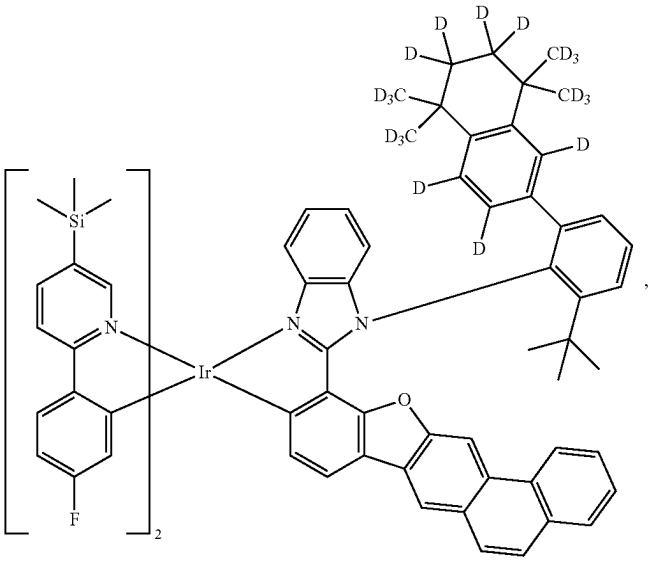

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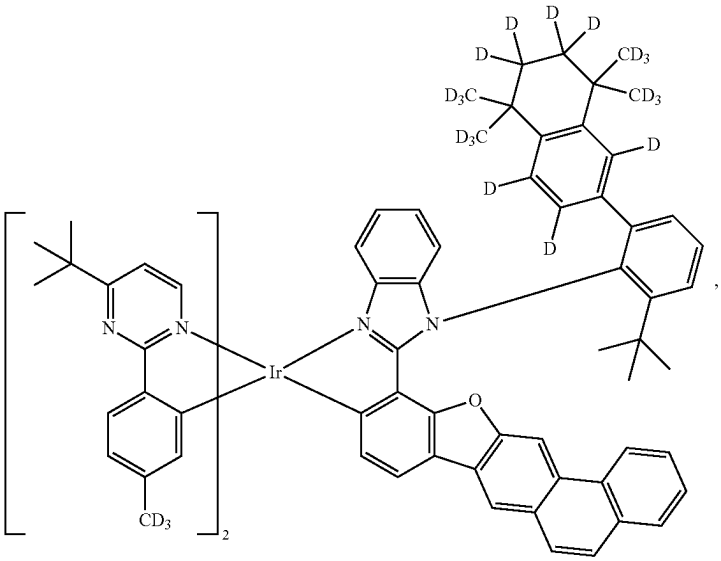

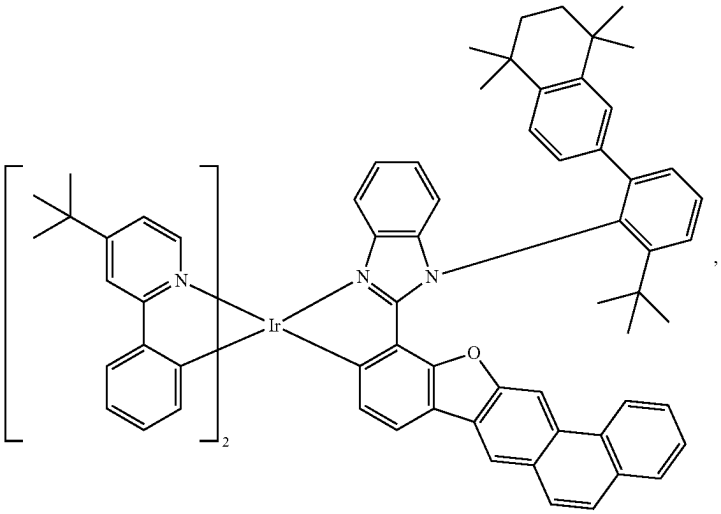

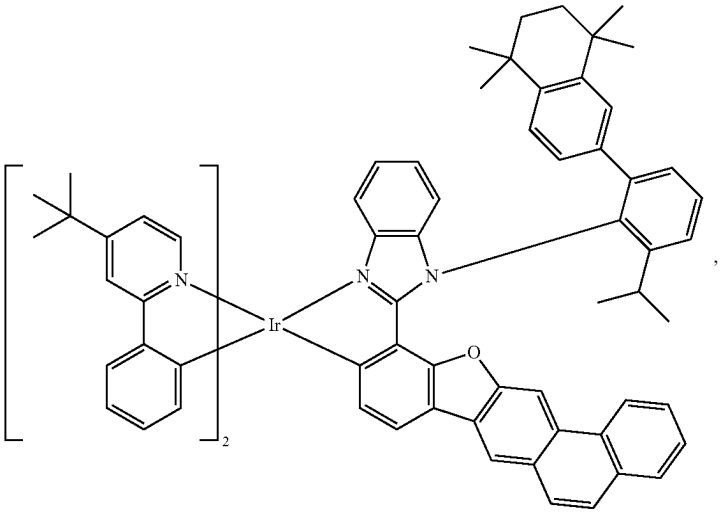

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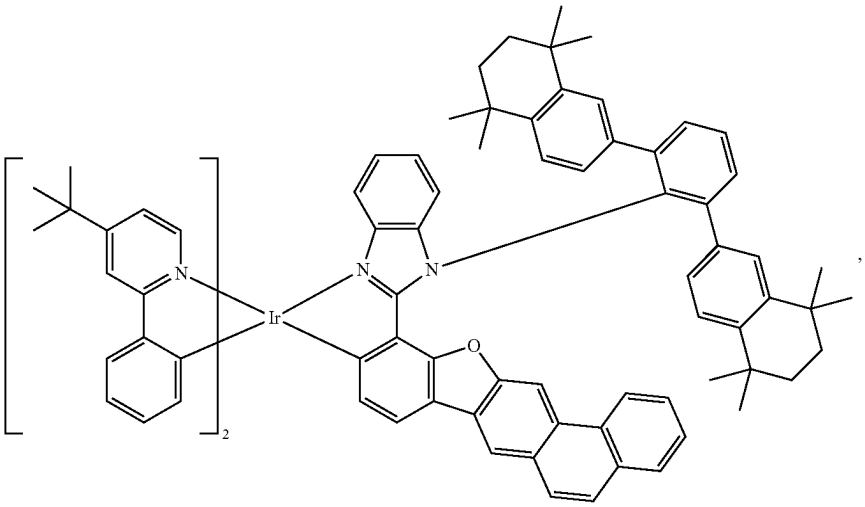

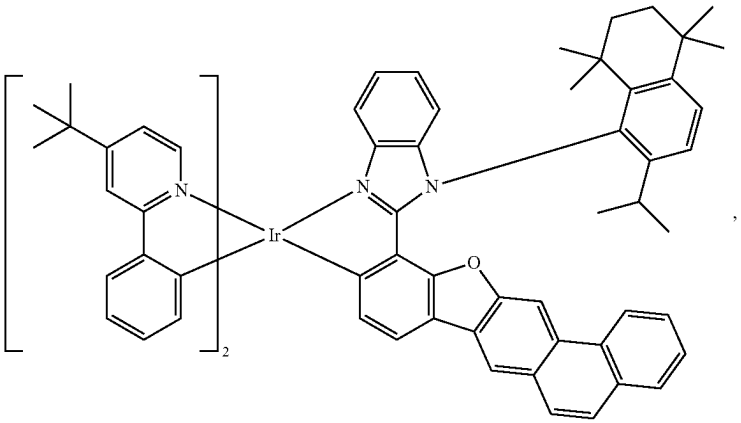

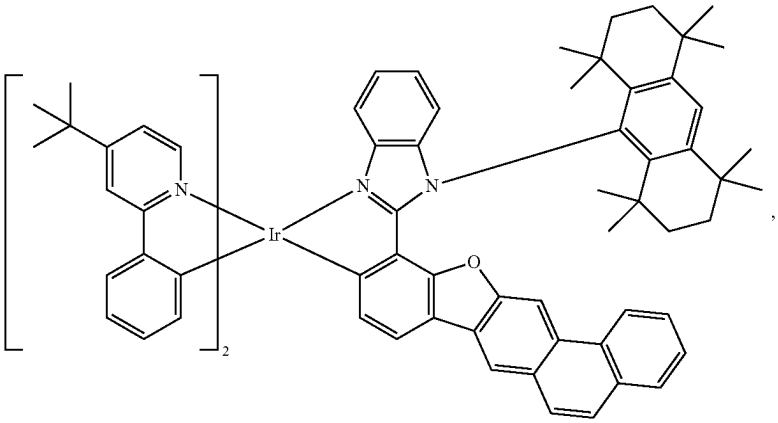

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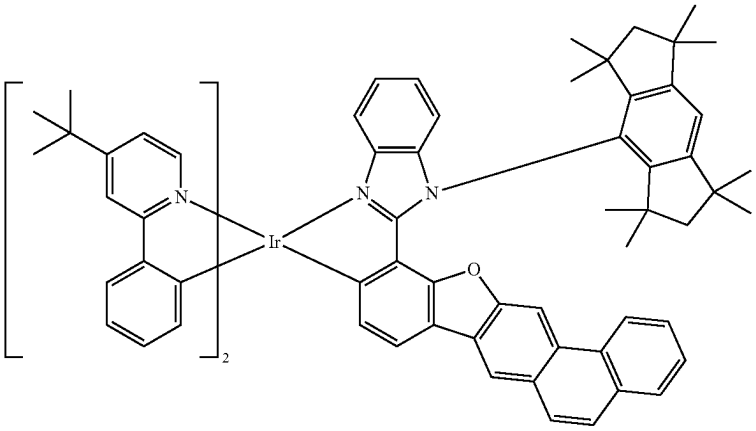

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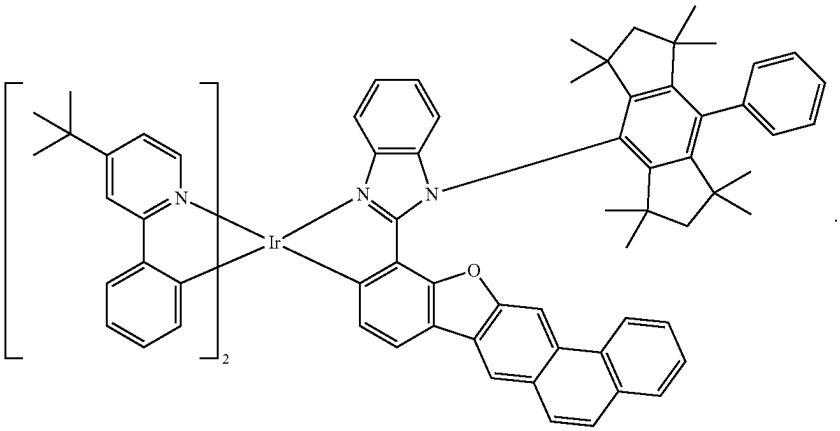
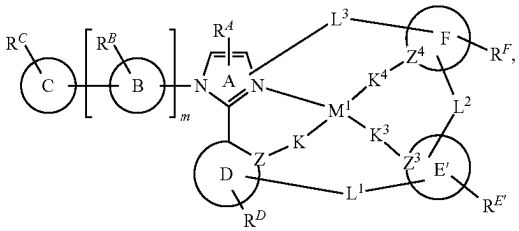


.

[0239] In some embodiments, the compound has the Formula III:



wherein:

[0240] M^1 is Pd or Pt;

[0241] moieties E' and F are each independently monocyclic or polycyclic ring structure comprising 5-membered and/or 6-membered carbocyclic or heterocyclic rings;

[0242] Z^3 and Z^4 are each independently C or N;

[0243] K, K^3, and K^4 are each independently selected from the group consisting of a direct bond, O, and S, wherein at least two of them are direct bonds;

[0244] L^1, L^2, and L^3 are each independently absent or selected from the group consisting of a direct bond, BR, BRR', NR, PR, P(O)R, O, S, Se, C═O, C═S, C═Se, C═NR, C═CRR', S═O, SO_2, CR, CRR', SiRR', GeRR', alkylene, cycloalkyl, aryl, cycloalkylene, arylene, heteroarylene, and combinations thereof, wherein at least one of L^1 and L^2 is present;

[0245] $R^{E'}$ and R^F each independently represents zero, mono, or up to a maximum allowed number of substitutions to its associated ring;

[0246] each of R, R', $R^{E'}$, and R^F is independently a hydrogen or a substituent selected from the group consisting of the General Substituents defined herein; and

[0247] two adjacent R^A, R^B, R^C, $R^{E'}$, and R^F can be joined or fused together to form a ring.

[0248] In some embodiments of Formula III, each of R, R', $R^{E'}$, and R^F is independently a hydrogen or a substituent selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, heteroalkyl, alkoxy, aryloxy, amino, silyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, aryl, heteroaryl, nitrile, isonitrile, sulfanyl, and combinations thereof.

[0249] In some embodiments of Formula III, at least one R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^A is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^B is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^C is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^D is a substituent selected from the group consisting of the General Substituents

defined herein. In some embodiments, at least one R^E is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one $R^{E'}$ is a substituent selected from the group consisting of the General Substituents defined herein. In some embodiments, at least one R^F is a substituent selected from the group consisting of the General Substituents defined herein.

[0250] In some embodiments of Formula III, at least one R, R', R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is partially or fully deuterated. In some embodiments, at least one R^A is partially or fully deuterated. In some embodiments, at least one R^B is partially or fully deuterated. In some embodiments, at least one R^C is partially or fully deuterated. In some embodiments, at least one R^D is partially or fully deuterated. In some embodiments, at least one R^E is partially or fully deuterated. In some embodiments, at least one R^F is partially or fully deuterated. In some embodiments of Formula II, at least R or R' is present and is partially or fully deuterated.

[0251] In some embodiments of Formula III, at least one R, R', R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R, R', R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R, R', R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R, R', R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R, R', R^A, R^B, R^C, R^D, R^E, $R^{E'}$, or R^F is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0252] In some embodiments of Formula III, at least one R^A is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^A is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0253] In some embodiments of Formula III, at least one R^B is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^B is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0254] In some embodiments of Formula III, at least one R^C is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^C is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0255] In some embodiments of Formula III, at least one R^D is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^D is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0256] In some embodiments of Formula III, at least one R^E is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^E is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0257] In some embodiments of Formula III, at least one $R^{E'}$ is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one $R^{E'}$ is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one $R^{E'}$ is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one $R^{E'}$ is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one $R^{E'}$ is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0258] In some embodiments of Formula III, at least one R^F is or comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, at least one R^F is or comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, at least one R^F is or comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, at least one R^F is or comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, at least one R^F is or comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0259] In some embodiments, Formula III comprises an electron-withdrawing group from the EWG1 LIST as defined herein. In some embodiments, Formula III comprises an electron-withdrawing group from the EWG2 LIST as defined herein. In some embodiments, Formula III comprises an electron-withdrawing group from the EWG3 LIST as defined herein. In some embodiments, Formula III comprises an electron-withdrawing group from the EWG4 LIST as defined herein. In some embodiments, Formula III comprises an electron-withdrawing group from the Pi-EWG LIST as defined herein.

[0260] In some embodiments of Formula III, moiety E' and moiety F are both 6-membered aromatic rings. In some embodiments of Formula III, moiety F is a 5-membered or 6-membered heteroaromatic ring.

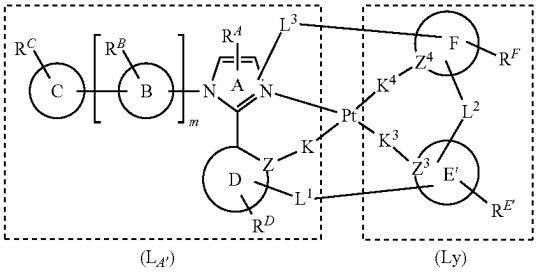
[0261] In some embodiments of Formula III, L^1 is O or CRR'.

[0262] In some embodiments of Formula III, Z^4 is N and Z^3 is C. In some embodiments of Formula III, Z^4 is C and Z^3 is N.

[0263] In some embodiments of Formula III, L^2 is a direct bond. In some embodiments of Formula III, L^2 is NR.

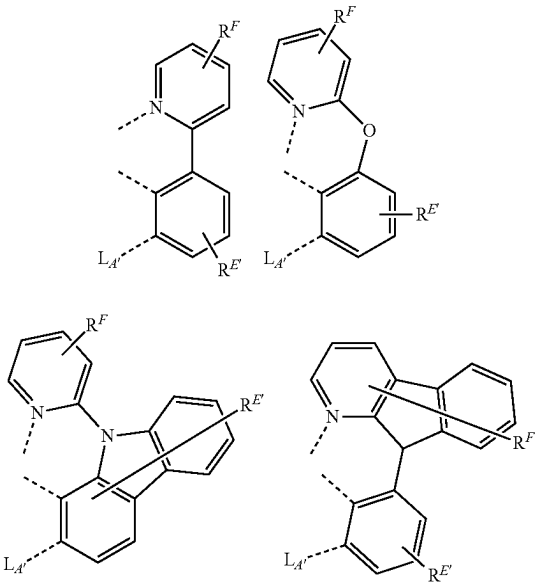
[0264] In some embodiments of Formula III, K, K^3, and K^4 are all direct bonds. In some embodiments of Formula III, one of K, K^3, and K^4 is O.

[0265] In some embodiments, the compound is selected from the group consisting of the compounds having the formula of $Pt(L_{A'})(Ly)$:



($L_{A'}$) (Ly)

wherein $L_{A'}$ is defined as above, and wherein L_y is selected from the group consisting of the following structures (LIST 16):



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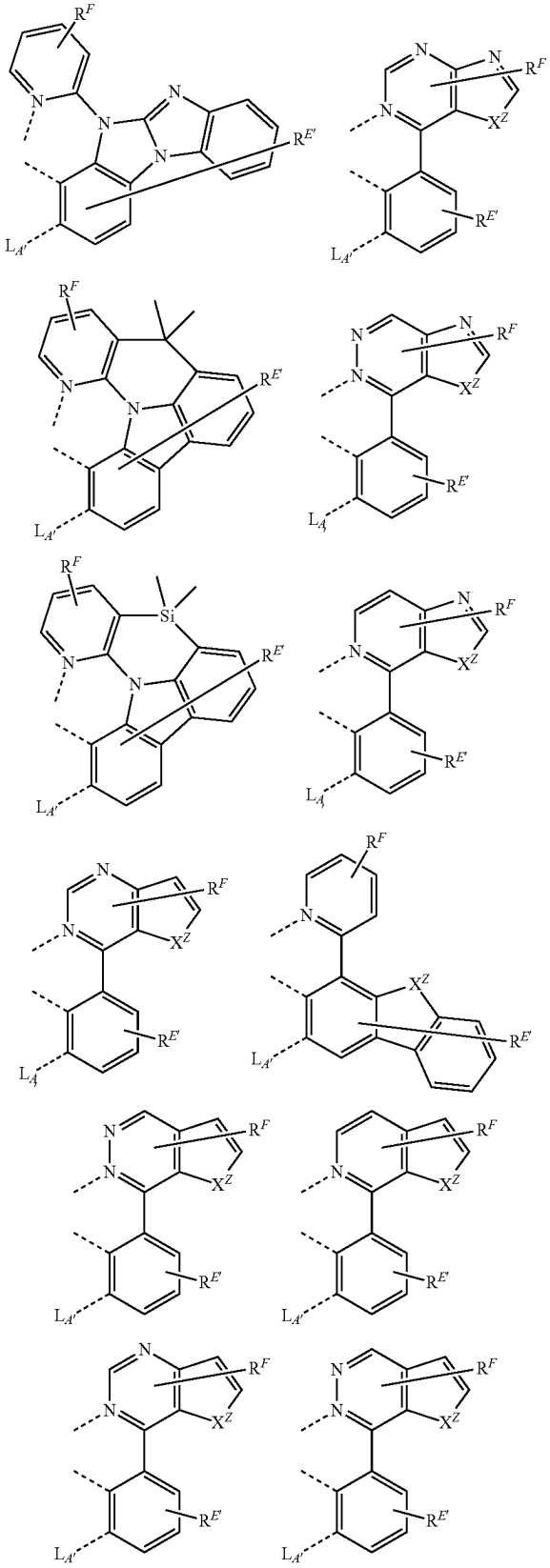

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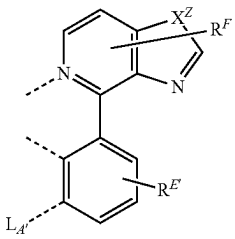

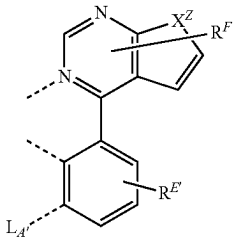

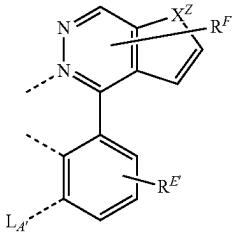

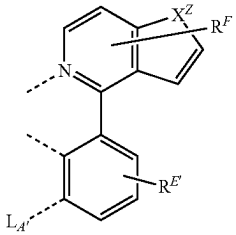

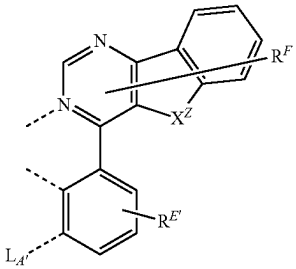

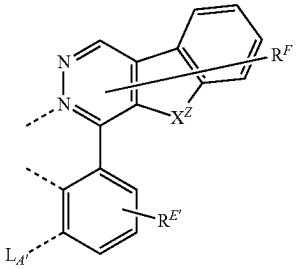

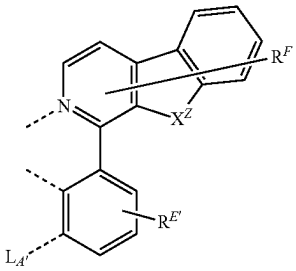

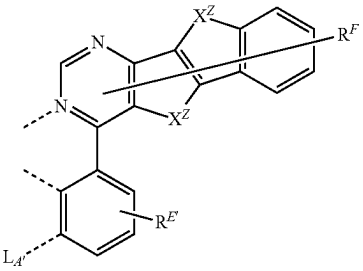

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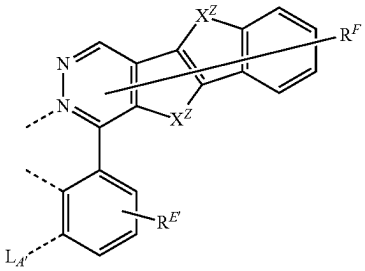

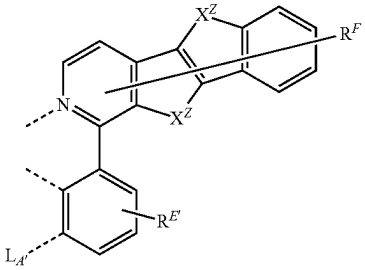

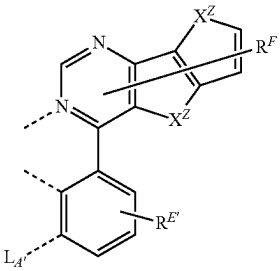

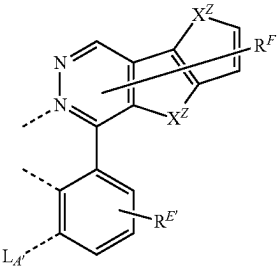

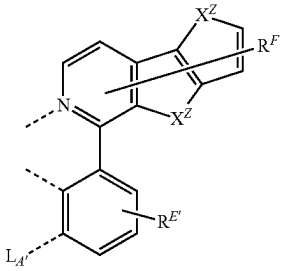

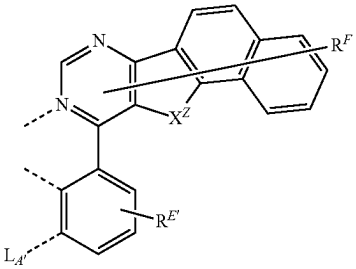

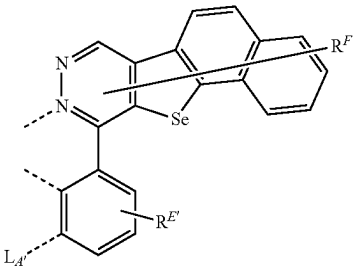

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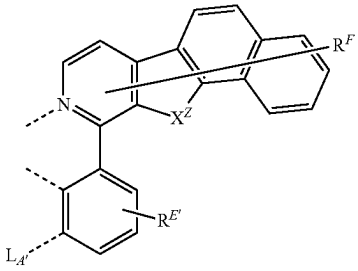

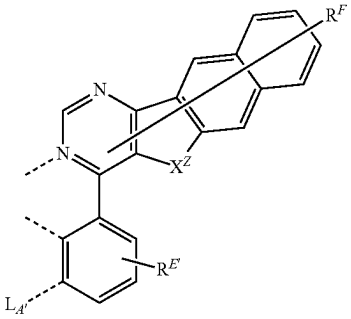

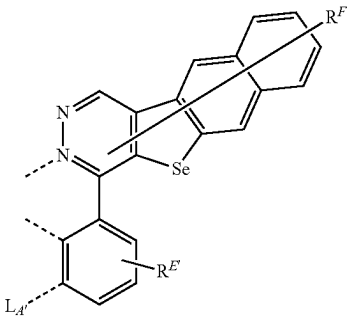

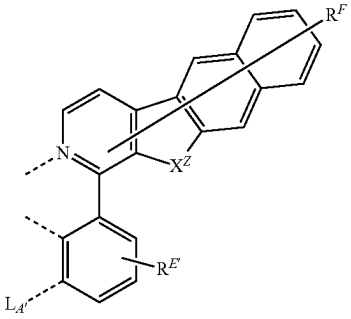

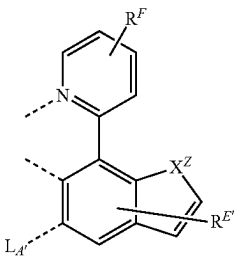

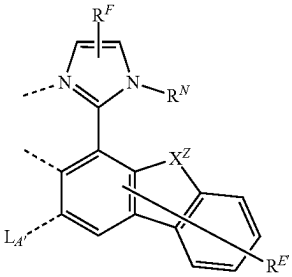

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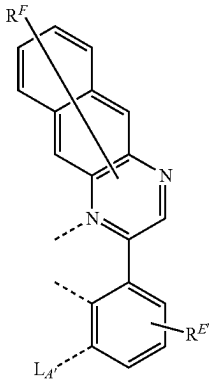

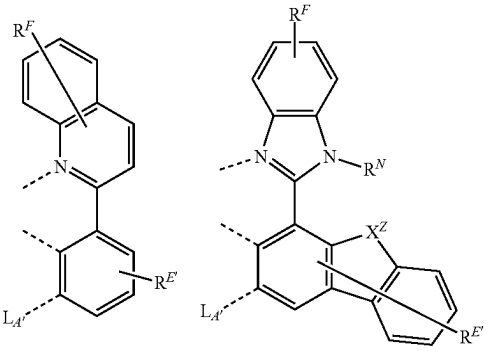

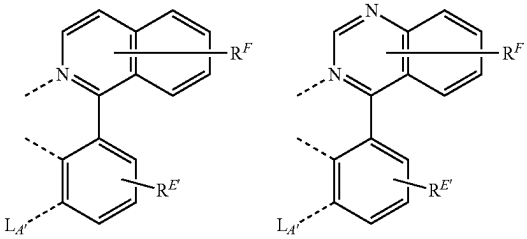

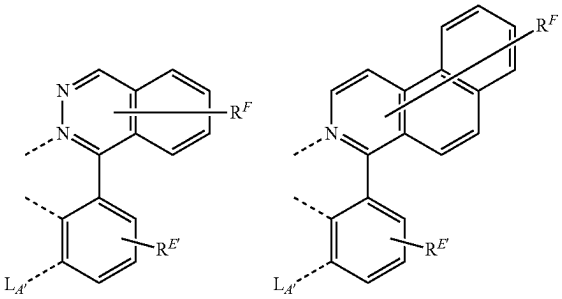

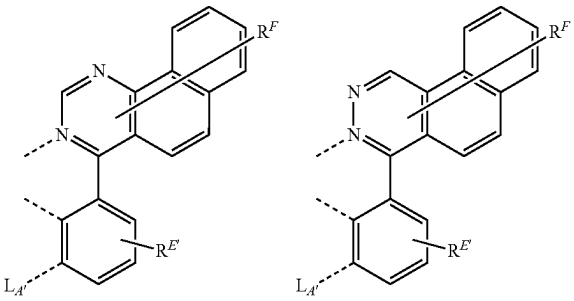

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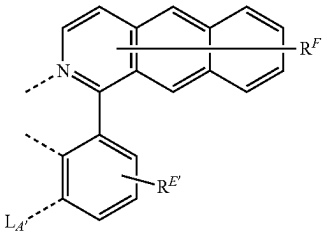

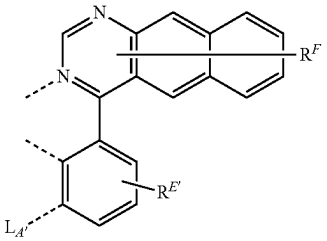

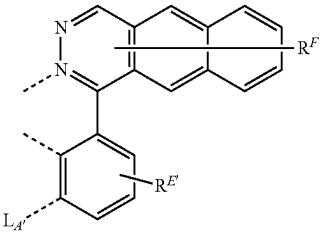

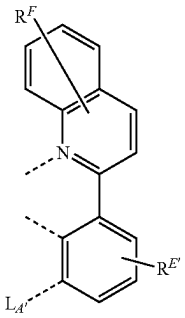

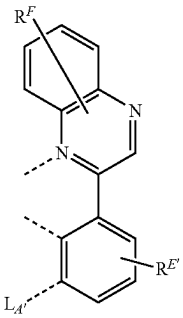

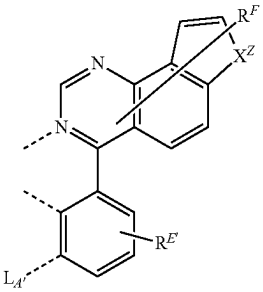

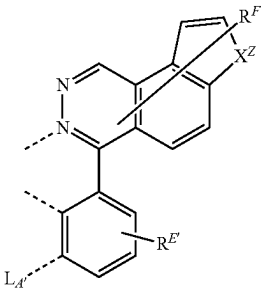

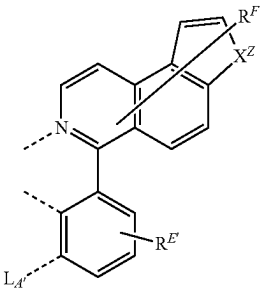

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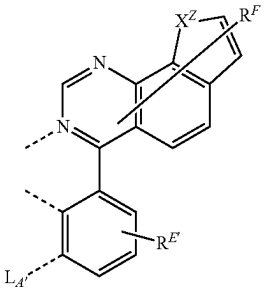

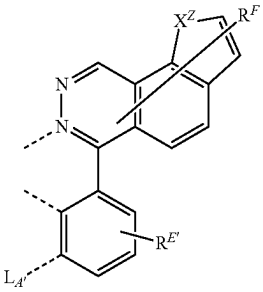

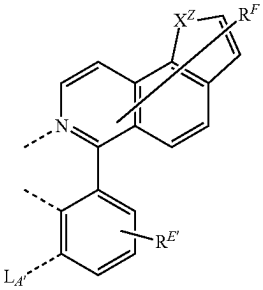

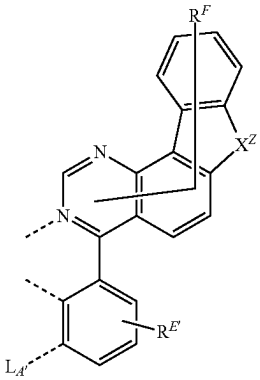

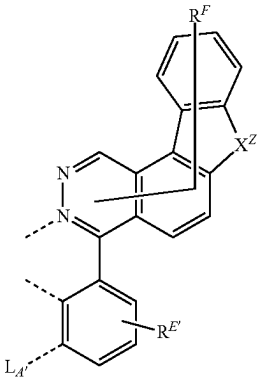

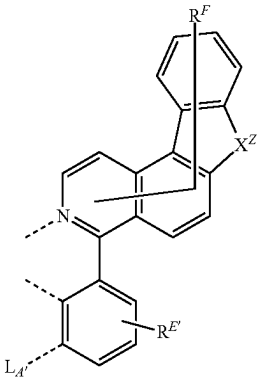

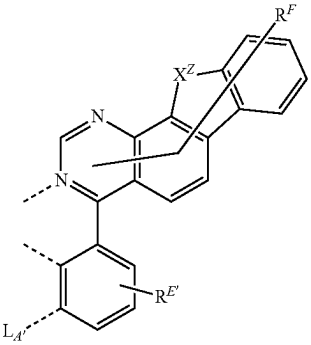

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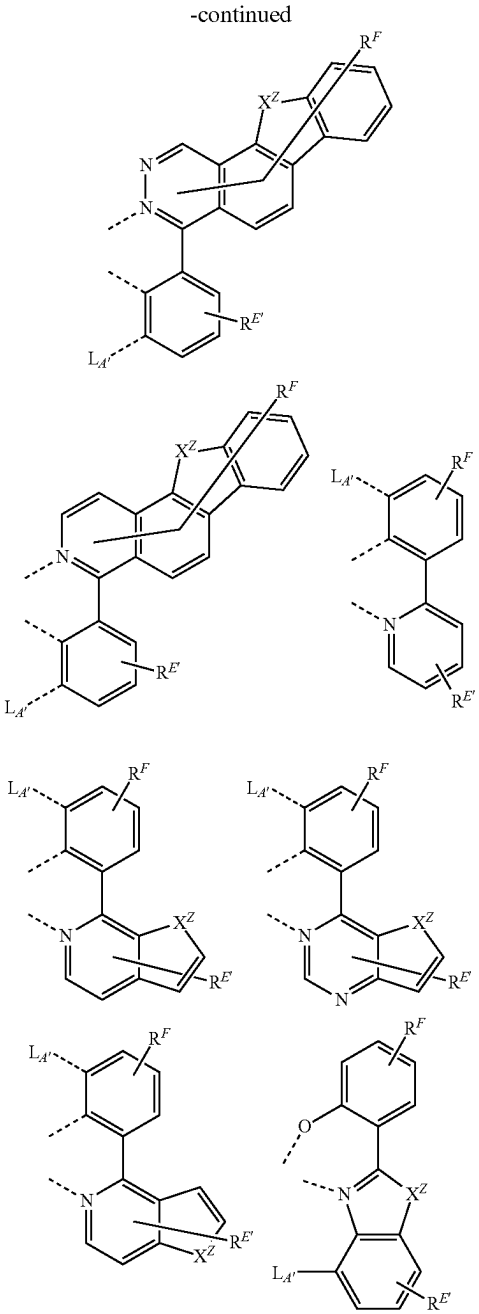
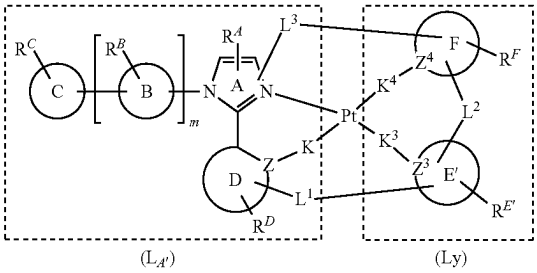


wherein R^N and X^Z for each occurrence are independently selected from the group consisting of BR, BRR', NR, PR, P(O)R, S, Se, C═O, C═S, C═Se, C═NR, C═CRR', S═O, SO_2, CR, CRR', SiRR', and GeRR';

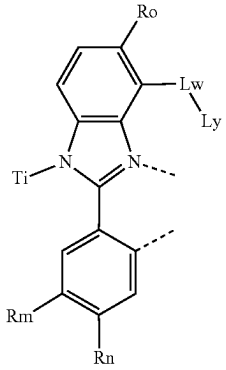
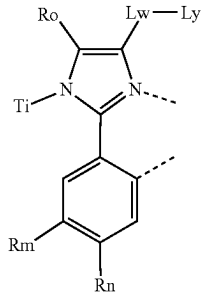
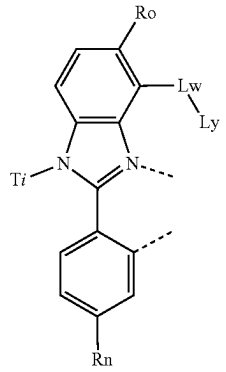
[0266] the remaining variables are the same as previously defined; and

[0267] any two substituents may be optionally fused or joined to form a ring.

[0268] In some embodiments, the compound is selected from the group consisting of the compounds having the formula of Pt($L_{A'}$)(Ly):



[0269] $L_{A'}$ is selected from $L_{A'}$ i'-(Lw)(Ti)(Rm)(Rn)(Ro), wherein i' is an integer from 1 to 27, Lw is L1 or L2, Ti is selected from the group consisting of T1 to T76, and each Rm, Rn, and Ro is independently selected from the group consisting of R1 to R468; wherein each of $L_{A'}$ i-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$26-(L2)(T63)(R468)(R468)(R468) is defined in the following LIST 13:

Compound	Structure
$L_{A'}$ 1-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 1-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 1-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 2-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 2-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 2-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 3-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 3-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 3-(L2)(T76)(R468)(R468)(R468) have the structure	

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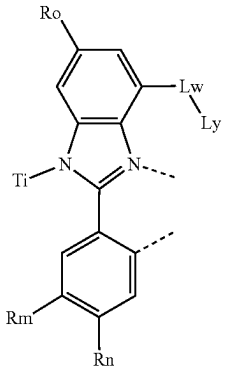
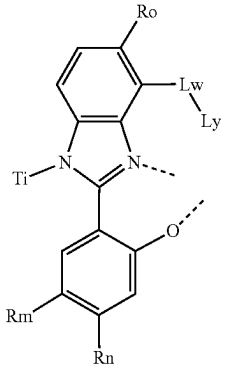
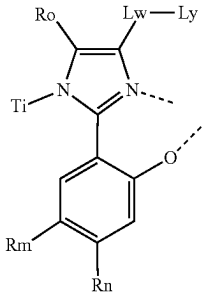
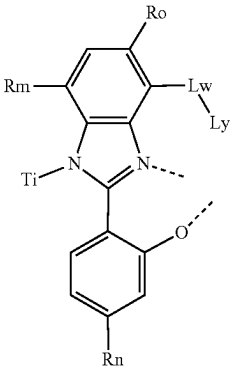
Compound	Structure
$L_{A'}$ 4-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 4-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 4-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 5-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 5-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 5-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 6-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 6-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 6-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 7-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 7-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 7-(L2)(T76)(R468)(R468)(R468) have the structure	

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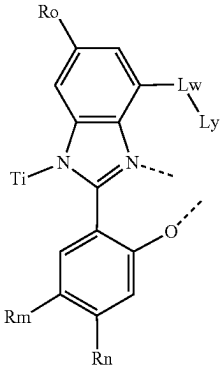
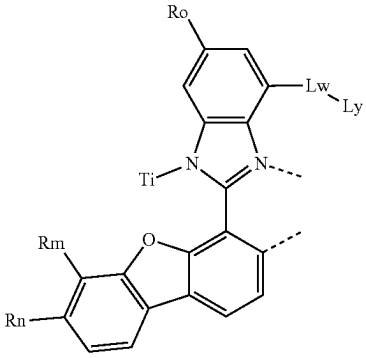
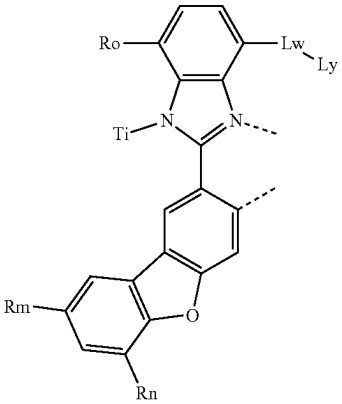
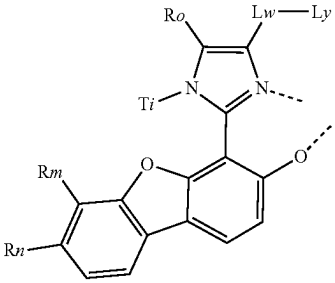
Compound	Structure
$L_{A'}$ 8-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 8-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 8-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 9-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 9-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 9-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 10-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 10-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 10-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 11-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 11-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 11-(L2)(T76)(R468)(R468)(R468) have the structure	

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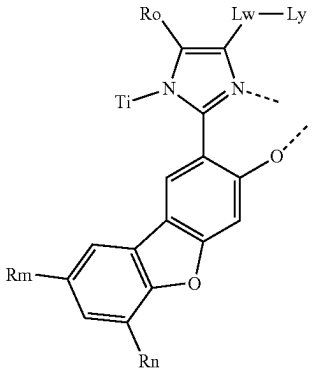
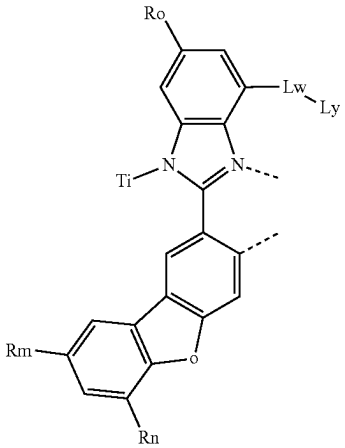
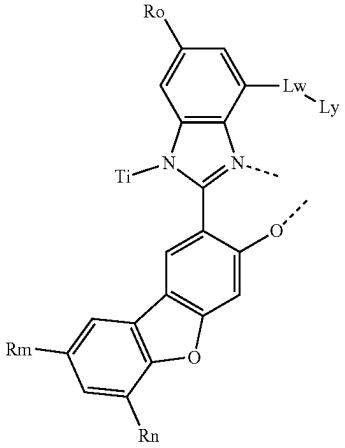
Compound	Structure
$L_{A'}$ 12-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 12-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 12-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 13-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 13-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 13-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 14-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 14-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 14-(L2)(T76)(R468)(R468)(R468) have the structure	

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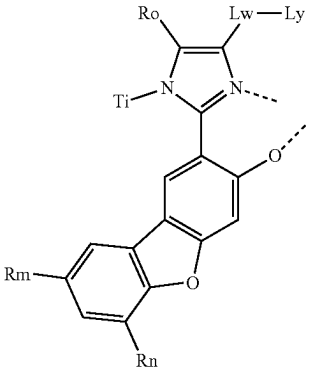
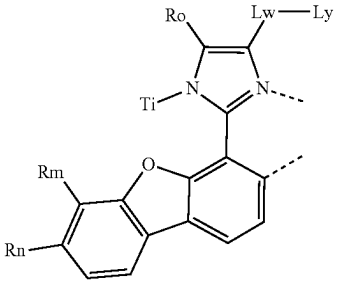
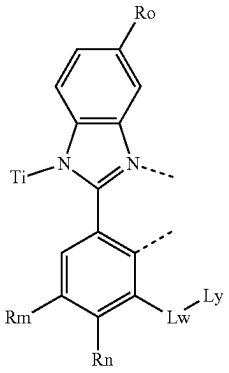
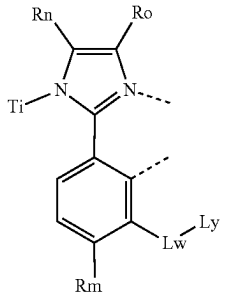
Compound	Structure
$L_{A'}$ 15-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 15-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 15-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 16-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 16-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 16-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 17-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 17-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 17-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 18-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 18-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 18-(L2)(T76)(R468)(R468)(R468) have the structure	

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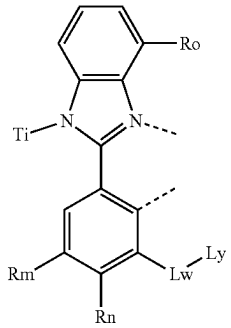
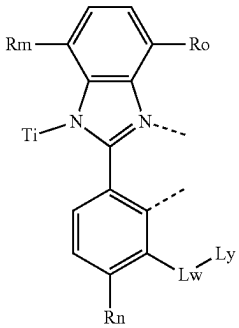
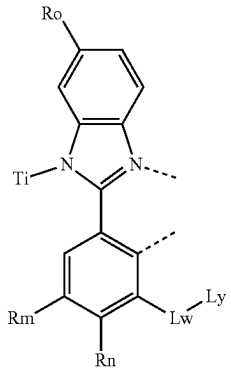
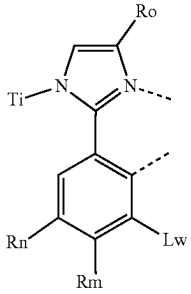
Compound	Structure
$L_{A'}$ 19-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 19-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 19-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 20-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 20-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 20-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 21-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 21-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 21-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 22-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 22-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 22-(L2)(T76)(R468)(R468)(R468) have the structure	

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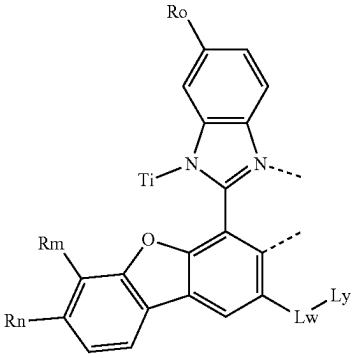
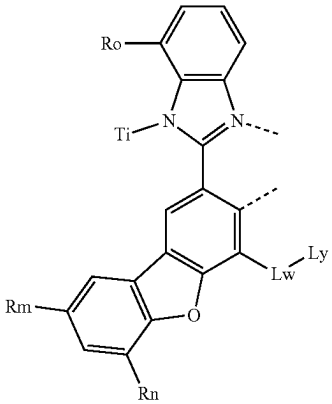
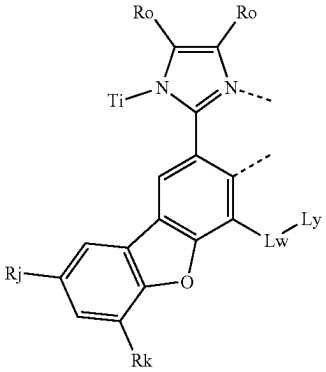
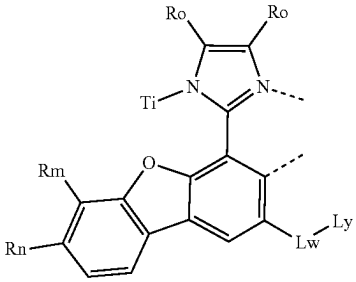
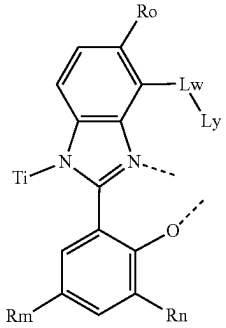
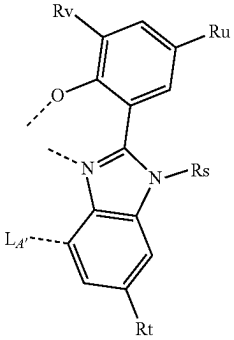
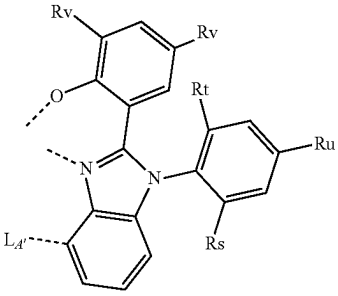
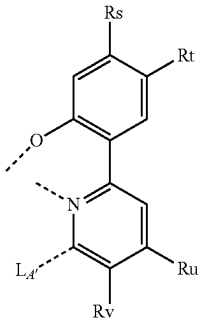
Compound	Structure
$L_{A'}$ 23-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 23-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 23-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 24-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 24-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 24-(L2)(T76)(R468)(R468)(R468) have the structure	
$L_{A'}$ 25-(Lw)(Ti)(Ro) wherein $L_{A'}$ 25-(L1)(T1)(R1) to $L_{A'}$ 25-(L2)(T76)(R468) have the structure	
$L_{A'}$ 26-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 26-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 26-(L2)(T76)(R468)(R468)(R468) have the structure	

-continued

Compound	Structure
$L_{A'}$ 27-(Lw)(Ti)(Rm)(Rn)(Ro) wherein $L_{A'}$ 27-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$ 27-(L2)(T76)(R468)(R468)(R468) have the structure	

wherein L_y is selected from L_{yj}'-(Rs)(Rt)(Ru)(Rv), wherein j' is an integer from 1 to 23, and each Rs, Rt, Ru, and Rv is independently selected from the group consisting of R1 to R468; wherein each of $L_{yl-(R}$1)(R1)(R1)(R1) to L_y23-(R468)(R468)(R468)(R468) is defined in the following LIST 14:

Compound	Structure of compound
L_y1-(Rs)(Rt)(Ru)(Rv), wherein L_y1-(R1)(R1)(R1)(R1) to L_y1-(R468)(R468)(R468)(R468) have the structure	
L_y2-(Rs)(Rt)(Ru)(Rv), wherein L_y2-(R1)(R1)(R1)(R1) to L_y2-(R468)(R468)(R468)(R468) have the structure	
L_y3-(Rs)(Rt)(Ru)(Rv), wherein L_y3-(R1)(R1)(R1)(R1) to L_y3-(R468)(R468)(R468)(R468) have the structure	

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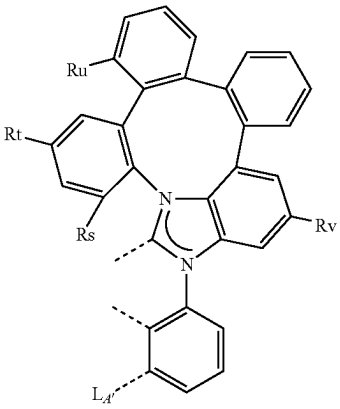
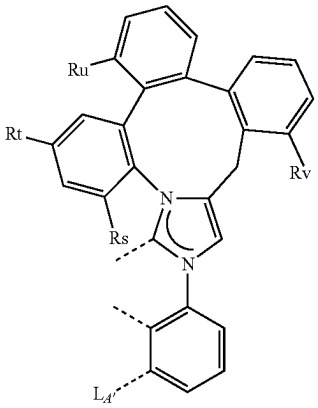
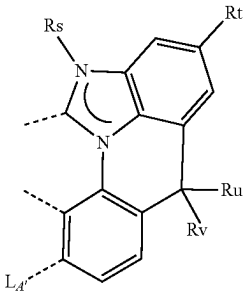
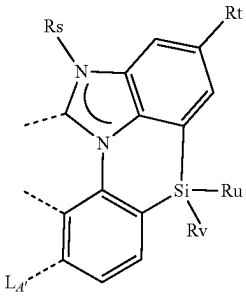
Compound	Structure of compound
L_y4-(Rs)(Rt)(Ru)(Rv), wherein L_y4-(R1)(R1)(R1)(R1) to L_y4-(R468)(R468)(R468)(R468) have the structure	
L_y5-(Rs)(Rt)(Ru)(Rv), wherein L_y5-(R1)(R1)(R1)(R1) to L_y5-(R468)(R468)(R468)(R468) have the structure	
L_y6-(Rs)(Rt)(Ru)(Rv), wherein L_y6-(R1)(R1)(R1)(R1) to L_y6-(R468)(R468)(R468)(R468) have the structure	
L_y7-(Rs)(Rt)(Ru)(Rv), wherein L_y7-(R1)(R1)(R1)(R1) to L_y7-(R468)(R468)(R468)(R468) have the structure	

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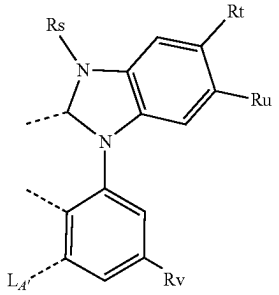
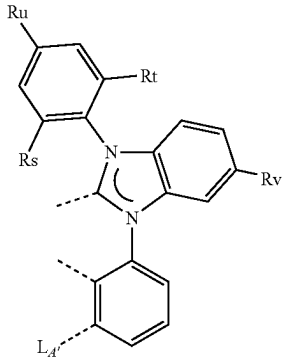
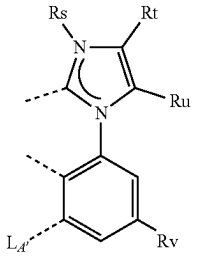
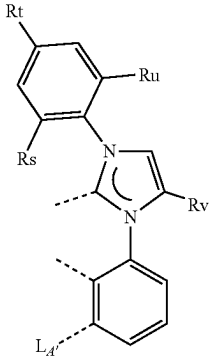
Compound	Structure of compound
L_y8-(Rs)(Rt)(Ru)(Rv), wherein L_y8-(R1)(R1)(R1)(R1) to L_y8-(R468)(R468)(R468)(R468) have the structure	
L_y9-(Rs)(Rt)(Ru)(Rv), wherein L_y9-(R1)(R1)(R1)(R1) to L_y9-(R468)(R468)(R468)(R468) have the structure	
L_y10-(Rs)(Rt)(Ru)(Rv), wherein L_y10-(R1)(R1)(R1)(R1) to L_y10-(R468)(R468)(R468)(R468) have the structure	
L_y11-(Rs)(Rt)(Ru)(Rv), wherein L_y11-(R1)(R1)(R1)(R1) to L_y11-(R468)(R468)(R468)(R468) have the structure	

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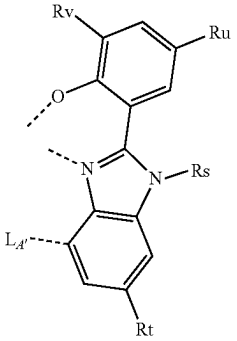
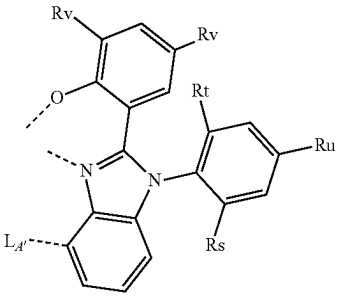
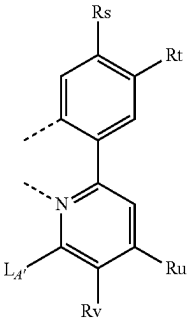
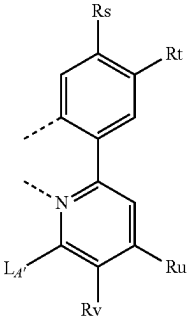
Compound	Structure of compound
L_y12-(Rs)(Rt)(Ru)(Rv), wherein L_y12-(R1)(R1)(R1)(R1) to L_y12-(R468)(R468)(R468)(R468) have the structure	
L_y13-(Rs)(Rt)(Ru)(Rv), wherein L_y13-(R1)(R1)(R1)(R1) to L_y13-(R468)(R468)(R468)(R468) have the structure	
L_y14-(Rs)(Rt)(Ru)(Rv), wherein L_y14-(R1)(R1)(R1)(R1) to L_y14-(R468)(R468)(R468)(R468) have the structure	
L_y15-(Rs)(Rt)(Ru)(Rv), wherein L_y15-(R1)(R1)(R1)(R1) to L_y15-(R468)(R468)(R468)(R468) have the structure	

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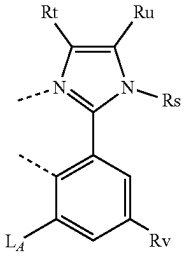
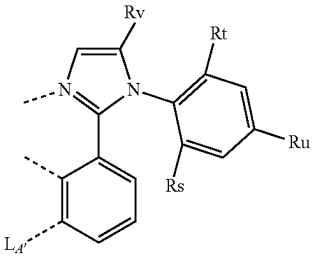
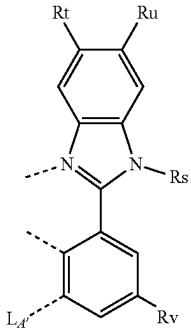
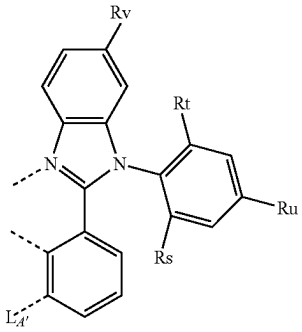
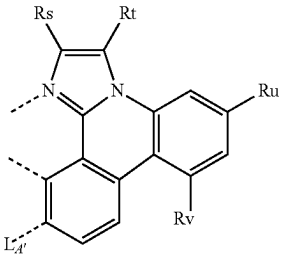
Compound	Structure of compound
L_y16-(Rs)(Rt)(Ru)(Rv), wherein L_y16-(R1)(R1)(R1)(R1) to L_y16-(R468)(R468)(R468)(R468) have the structure	
L_y17-(Rs)(Rt)(Ru)(Rv), wherein L_y17-(R1)(R1)(R1)(R1) to L_y17-(R468)(R468)(R468)(R468) have the structure	
L_y18-(Rs)(Rt)(Ru)(Rv), wherein L_y18-(R1)(R1)(R1)(R1) to L_y18-(R468)(R468)(R468)(R468) have the structure	
L_y19-(Rs)(Rt)(Ru)(Rv), wherein L_y19-(R1)(R1)(R1)(R1) to L_y19-(R468)(R468)(R468)(R468) have the structure	
L_y20-(Rs)(Rt)(Ru)(Rv), wherein L_y20-(R1)(R1)(R1)(R1) to L_y20-(R468)(R468)(R468)(R468) have the structure	

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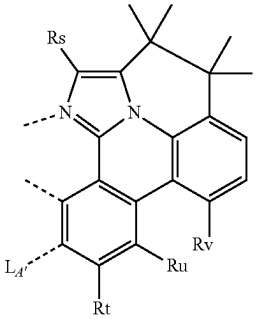
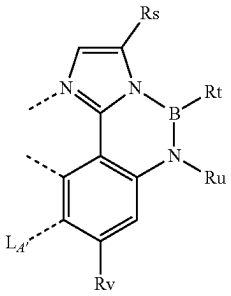
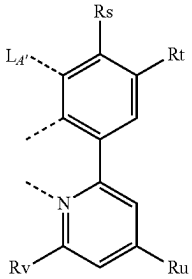
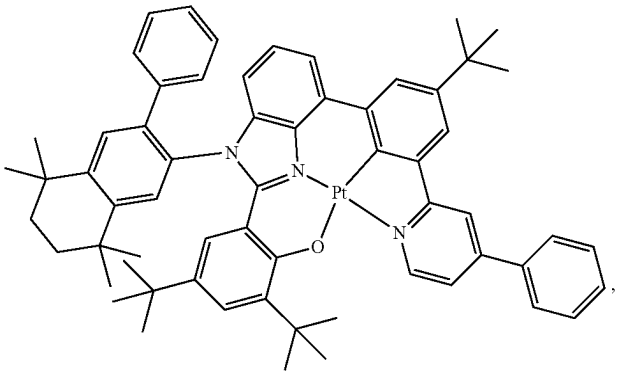
Compound	Structure of compound
L_y21-(Rs)(Rt)(Ru)(Rv), wherein L_y21-(R1)(R1)(R1)(R1) to L_y21-(R468)(R468)(R468)(R468) have the structure	
L_y22-(Rs)(Rt)(Ru)(Rv), wherein L_y22-(R1)(R1)(R1)(R1) to L_y22-(R468)(R468)(R468)(R468) have the structure	
L_y23-(Rs)(Rt)(Ru)(Rv), wherein L_y23-(R1)(R1)(R1)(R1) to L_y23-(R468)(R468)(R468)(R468) have the structure	

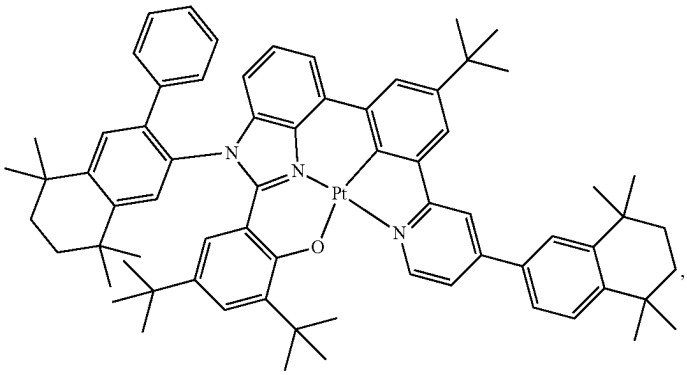
[0270] wherein L1 is a direct bond and L2 is —O—;

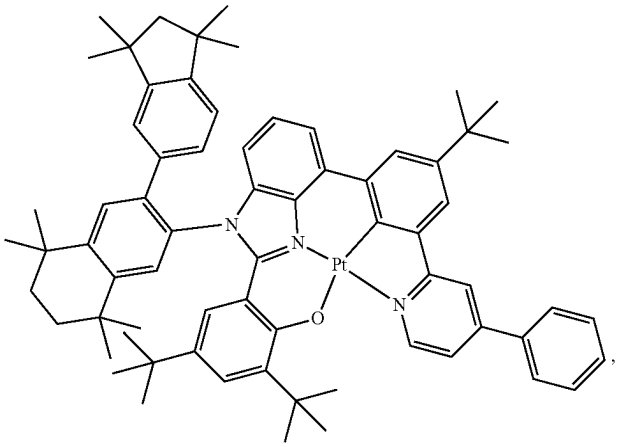
[0271] wherein each of T1 to T76 has the structures defined in LIST 4 defined herein; and

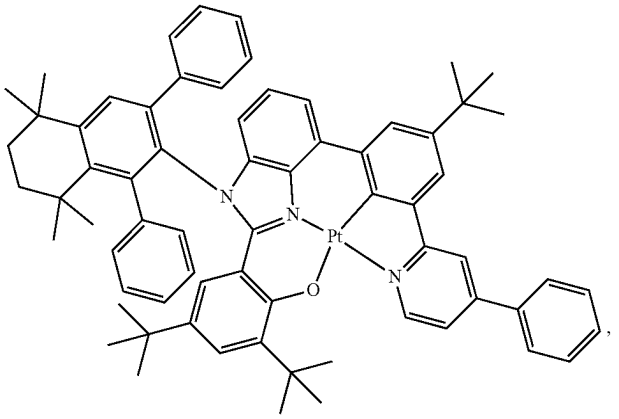
[0272] wherein each of R1 to R468 has the structure defined in LIST 5 defined herein.

[0273] In some embodiments, the compound is selected from the group consisting of the structures of the following LIST 15:









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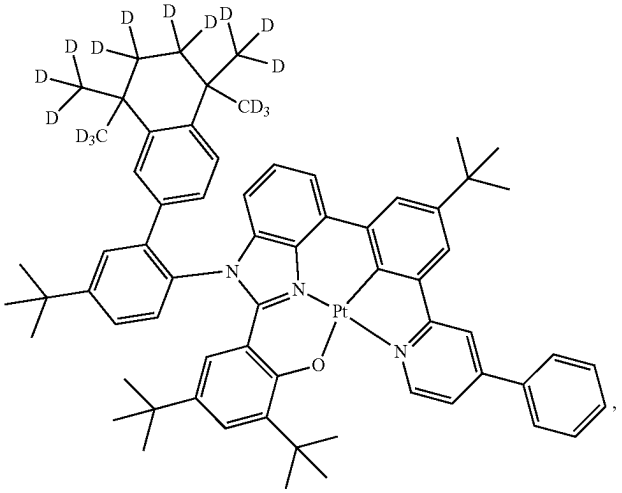

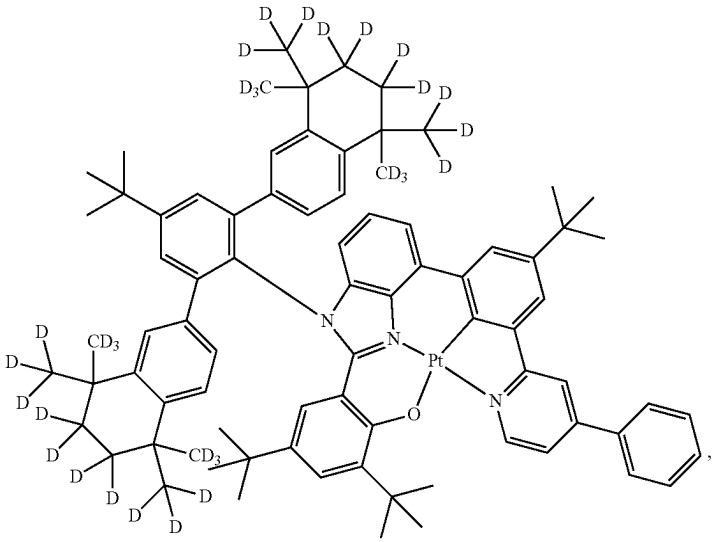

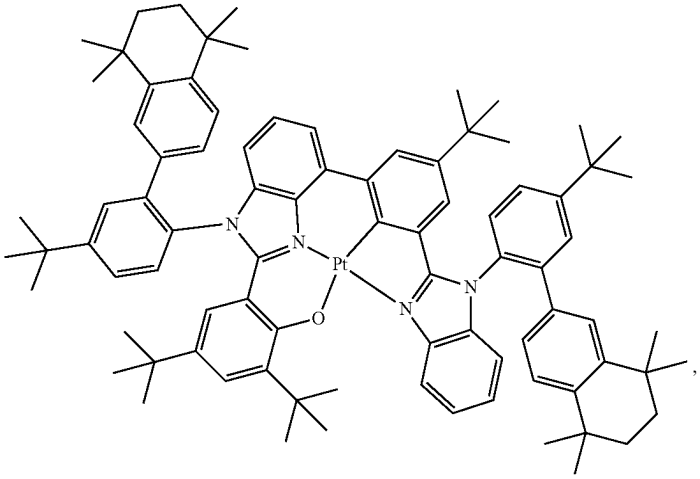

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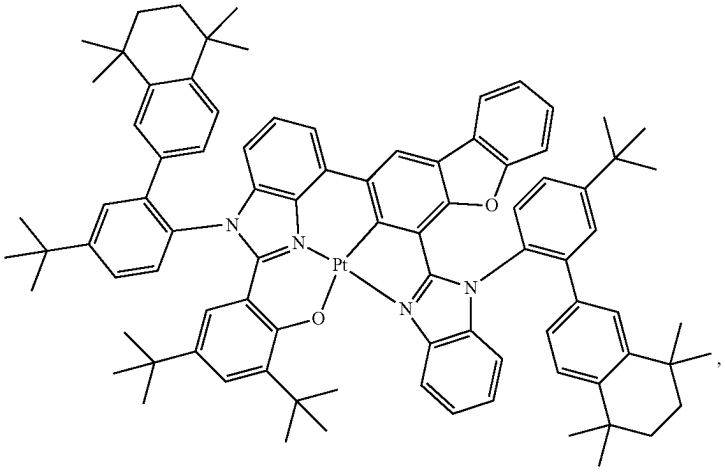

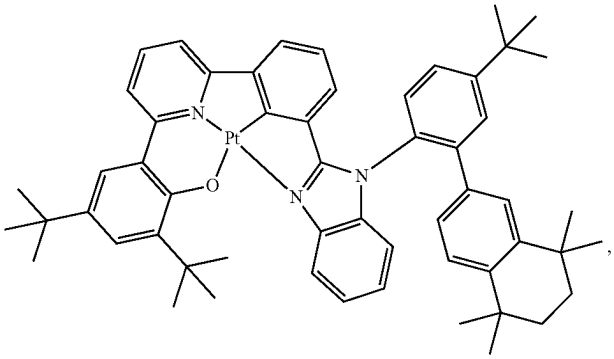

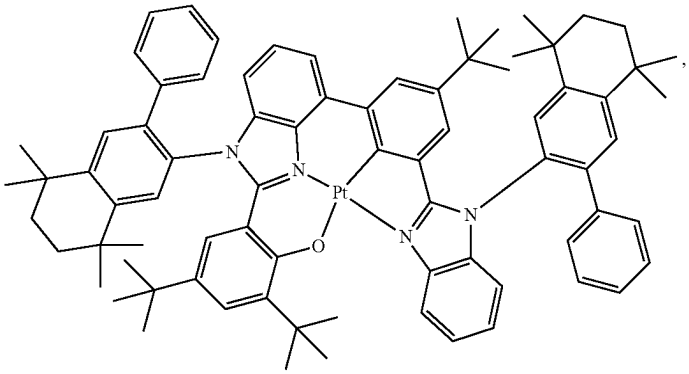

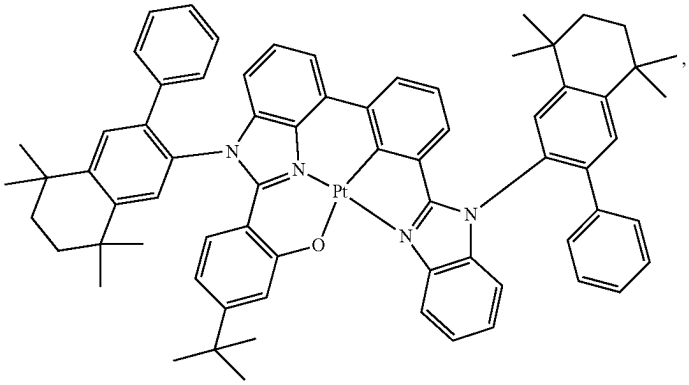

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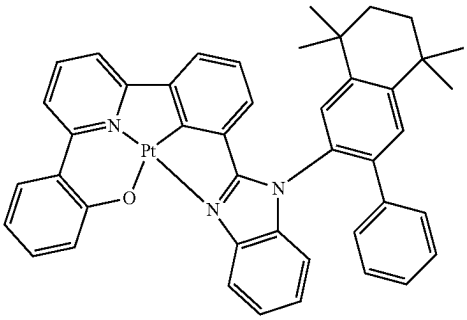

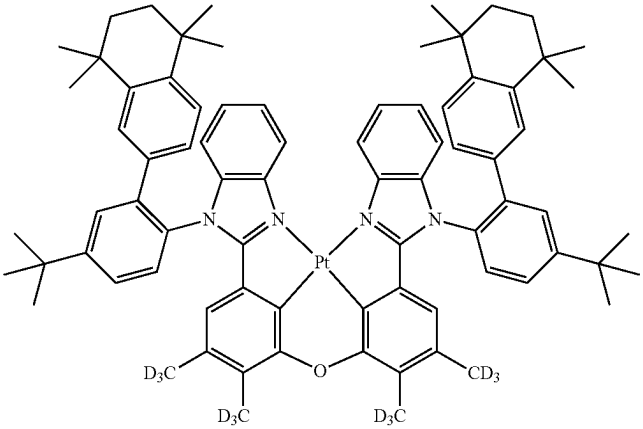

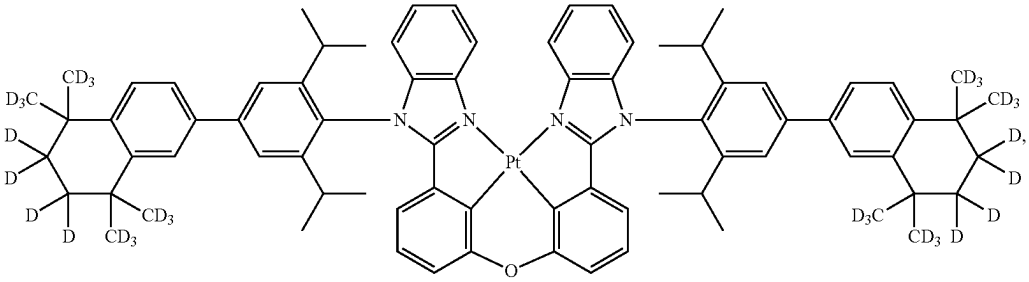

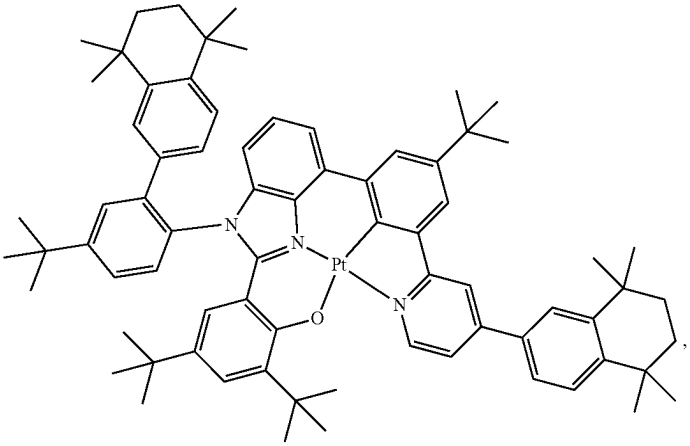

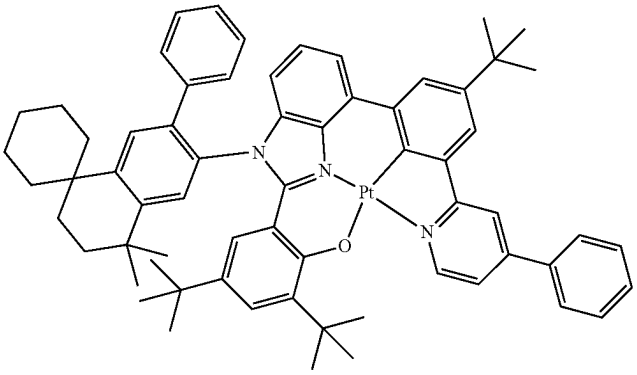

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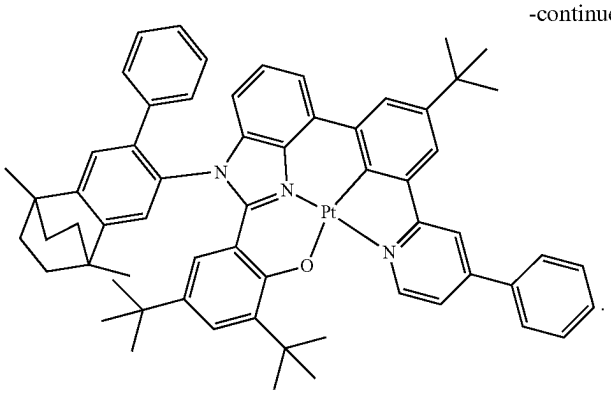


[0274] In some embodiments, the compound having a first ligand L_A comprising a structure of Formula I described herein can be at least 30% deuterated, at least 40% deuterated, at least 50% deuterated, at least 60% deuterated, at least 70% deuterated, at least 80% deuterated, at least 90% deuterated, at least 95% deuterated, at least 99% deuterated, or 100% deuterated. As used herein, percent deuteration has its ordinary meaning and includes the percent of all possible hydrogen atoms in the compound (e.g., positions that are hydrogen or deuterium) that are occupied by deuterium atoms. In some embodiments, carbon atoms comprised the ring coordinated to the metal M are fully or partially deuterated. In some embodiments, carbon atoms comprised by a polycyclic ring system coordinated to the metal M are fully or partially deuterated. In some embodiments, a substituent attached to a monocyclic or fused polycyclic ring system coordinated to the metal M is fully or partially deuterated.

[0275] In some embodiments, the compound of formula I has an emission at room temperature with a full width at half maximum (FWHM) of equal to or less than 50, 45, 40, 35, 30, 25, 20, 15, 10, or 5 nm. Narrower FWHM means better color purity for the OLED display application.

[0276] In some embodiments of heteroleptic compound having the formula of $M(L_A)_p(L_B)_q(L_C)_r$ as defined above, the ligand L_A has a first substituent R^I, where the first substituent R^I has a first atom a-I that is the farthest away from the metal M among all atoms in the ligand L_A. Additionally, the ligand L_B, if present, has a second substituent R^{II}, where the second substituent R^{II} has a first atom a-II that is the farthest away from the metal M among all atoms in the ligand L_B. Furthermore, the ligand L_C, if present, has a third substituent R^{III}, where the third substituent R^{III} has a first atom a-III that is the farthest away from the metal M among all atoms in the ligand L_C.

[0277] In such heteroleptic compounds, vectors V_{D1}, V_{D2}, and V_{D3} can be defined as follows. V_{D1} represents the direction from the metal M to the first atom a-I and the vector V_{D1} has a value D^1 that represents the straight line distance between the metal M and the first atom a-I in the first substituent R^I. V_{D2} represents the direction from the metal M to the first atom a-II and the vector V_{D2} has a value D^2 that represents the straight line distance between the metal M and the first atom a-II in the second substituent R^{II}. V_{D3} represents the direction from the metal M to the first atom a-III and the vector V_{D3} has a value D^3 that represents the straight line distance between the metal M and the first atom a-III in the third substituent R^{III}.

[0278] In such heteroleptic compounds, a sphere having a radius r is defined whose center is the metal M and the radius r is the smallest radius that will allow the sphere to enclose all atoms in the compound that are not part of the substituents R^I, R^{II} and R^{III}; and where at least one of D^1, D^2, and D^3 is greater than the radius r by at least 1.5 Å. In some embodiments, at least one of D^1, D^2, and D^3 is greater than the radius r by at least 2.9, 3.0, 4.3, 4.4, 5.2, 5.9, 7.3, 8.8, 10.3, 13.1, 17.6, or 19.1 Å. In some embodiments, at least two of D^1, D^2, and D^3 is greater than the radius r by at least 1.5, 2.9, 3.0, 4.3, 4.4, 5.2, 5.9, 7.3, 8.8, 10.3, 13.1, 17.6, or 19.1 Å.

[0279] In some embodiments of such heteroleptic compound, the compound has a transition dipole moment axis and angles are defined between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3}, where at least one of the angles between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3} is less than 40°. In some embodiments, at least one of the angles between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3} is less than 30°, 20°, 15°, or 10°. In some embodiments, at least two of the angles between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3} are less than 20°. In some embodiments, at least two of the angles between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3} are less than 15° or 10°.

[0280] In some embodiments, all three angles between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3} are less than 20°. In some embodiments, all three angles between the transition dipole moment axis and the vectors V_{D1}, V_{D2}, and V_{D3} are less than 150 or 10°.

[0281] In some embodiments of such heteroleptic compounds, the compound has a vertical dipole ratio (VDR) of 0.33 or less. In some embodiments of such heteroleptic compounds, the compound has a VDR of 0.30, 0.25, 0.20, or 0.15 or less.

[0282] One of ordinary skill in the art would readily understand the meaning of the terms transition dipole moment axis of a compound and vertical dipole ratio of a compound. Nevertheless, the meaning of these terms can be found in U.S. Pat. No. 10,672,997 whose disclosure is incorporated herein by reference in its entirety. In U.S. Pat. No. 10,672,997, horizontal dipole ratio (HDR) of a compound, rather than VDR, is discussed. However, one skilled in the art readily understands that VDR=1−HDR.

[0283] In some embodiments, the compound can be an emissive dopant. In some embodiments, the compound can produce emissions via phosphorescence, fluorescence, thermally activated delayed fluorescence, triplet-triplet annihilation, or combinations of these processes. In some embodiments, the emissive dopant can be a racemic mixture, or can be enriched in one enantiomer. In some embodiments, the present compounds can have different stereoisomers, such as fac and mer. The current compound relates both to individual isomers and to mixtures of various isomers in any mixing ratio. In some embodiments, the compound can be homoleptic (each ligand is the same). In some embodiments, the compound can be heteroleptic (at least one ligand is different from others). When there are more than one ligand coordinated to a metal, the ligands can all be the same in some embodiments. In some other embodiments, at least one ligand is different from the other ligands. In some embodiments, every ligand can be different from every other ligand. This is also true in embodiments where a ligand being coordinated to a metal can be linked with other ligands being coordinated to that metal to form a tridentate, tetradentate, pentadentate, or hexadentate ligands. Thus, where the coordinating ligands are being linked together, all of the ligands can be the same in some embodiments, and at least one of the ligands being linked can be different from the other ligand(s) in some other embodiments.

[0284] In yet another aspect of the present disclosure, a formulation that comprises the novel compound disclosed herein is described. The formulation can include one or more components selected from the group consisting of a solvent, an emitter, a host, a hole injection material, hole transport material, electron blocking material, hole blocking material, and an electron transport material, disclosed herein.

[0285] The present disclosure encompasses any chemical structure comprising the novel compound of the present disclosure, or a monovalent or polyvalent variant thereof. In other words, the inventive compound, or a monovalent or polyvalent variant thereof, can be a part of a larger chemical structure. Such chemical structure can be selected from the group consisting of a monomer, a polymer, a macromolecule, and a supramolecule (also known as supermolecule). As used herein, a "monovalent variant of a compound" refers to a moiety that is identical to the compound except that one hydrogen has been removed and replaced with a bond to the rest of the chemical structure. As used herein, a "polyvalent variant of a compound" refers to a moiety that is identical to the compound except that more than one hydrogen has been removed and replaced with a bond or bonds to the rest of the chemical structure. In the instance of a supramolecule, the inventive compound can also be incorporated into the supramolecule complex without covalent bonds. As used in this context, the description that a structure A comprises a moiety B means that the structure A includes the structure of moiety B not including the H or D atoms that can be attached to the moiety B. This is because at least one H or D on a given moiety structure has to be replaced to become a substituent so that the moiety B can be part of the structure A, and one or more of the H or D on a given moiety B structure can be further substituted once it becomes a part of structure A.

C. The OLEDs and the Devices of the Present Disclosure

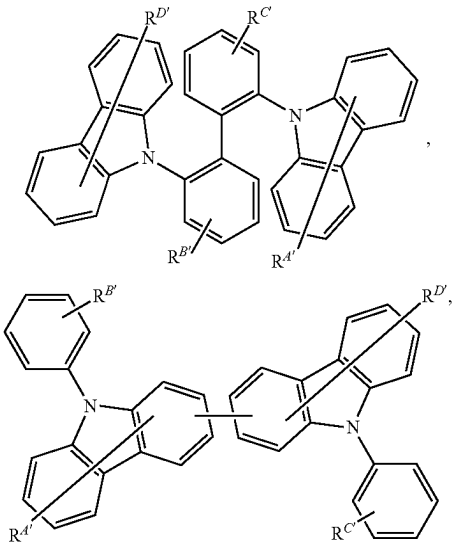
[0286] In another aspect, the present disclosure also provides an OLED device comprising a first organic layer that contains a compound as disclosed in the above compounds section of the present disclosure.

[0287] In some embodiments, the OLED comprises: an anode; a cathode; and an organic layer disposed between the anode and the cathode, where the organic layer comprises a compound having a first ligand L_A comprising a structure of Formula I defined herein.

[0288] In some embodiments, the organic layer is selected from the group consisting of HIL, HTL, EBL, EML, HBL, ETL, and EIL. In some embodiments, the organic layer may be an emissive layer and the compound as described herein may be an emissive dopant or a non-emissive dopant.

[0289] In some embodiments, the organic layer may further comprise a host, wherein host comprises at least one chemical group selected from the group consisting of triphenylene, carbazole, indolocarbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, 5λ^2-benzo[d]benzo[4,5]imidazo[3,2-a]imidazole, 5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene, azaborinine, oxaborinine, dihydroacridine, xanthene, dihydrobenzoazasiline, dibenzooxasiline, phenoxazine, phenoxathiine, phenothiazine, dihydrophenazine, fluorene, naphthalene, anthracene, phenanthrene, phenanthroline, benzoquinoline, quinoline, isoquinoline, quinazoline, pyrimidine, pyrazine, pyridine, triazine, boryl, silyl, aza-triphenylene, aza-carbazole, aza-indolocarbazole, aza-dibenzothiophene, aza-dibenzofuran, aza-dibenzoselenophene, aza-5λ^2-benzo[d]benzo[4,5]imidazo[3,2-a]imidazole, and aza-(5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene).

[0290] In some embodiments, the host can be selected from the group consisting of the structures of the following HOST Group 1:



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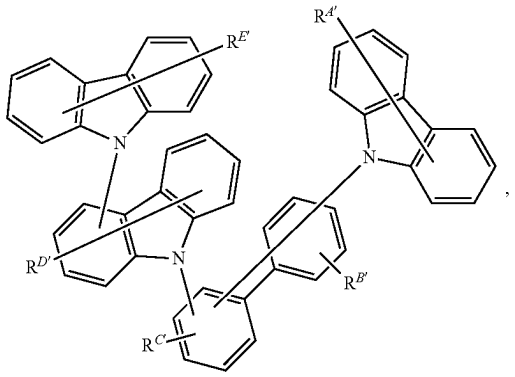

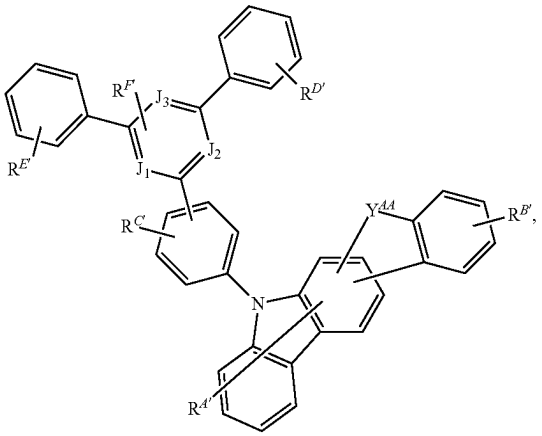

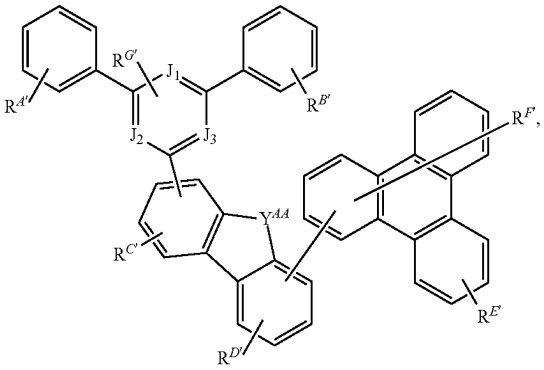

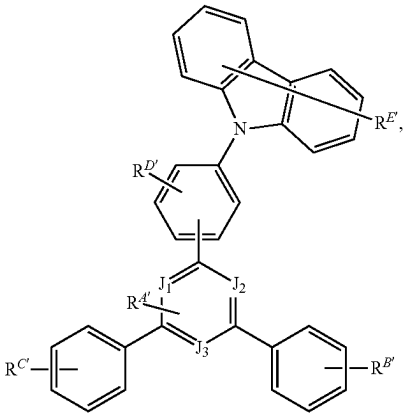

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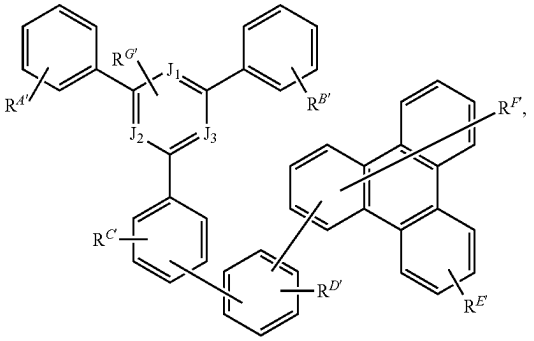

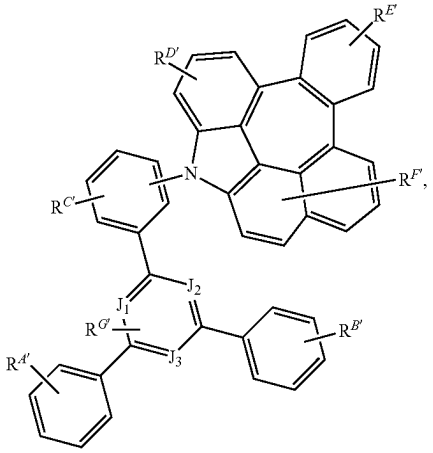

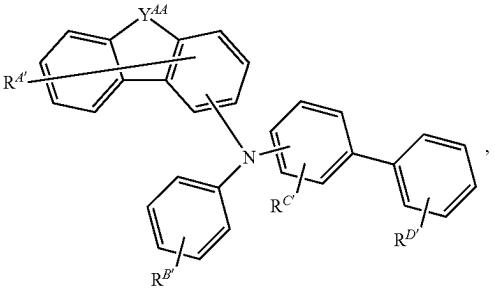

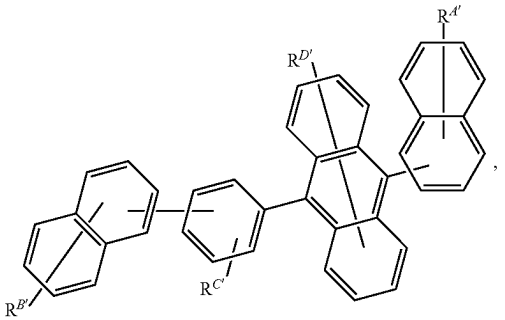

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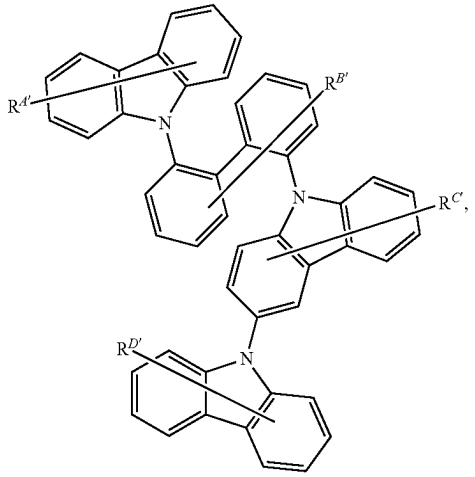

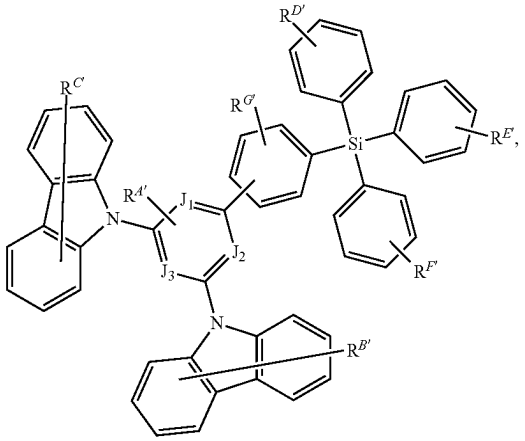

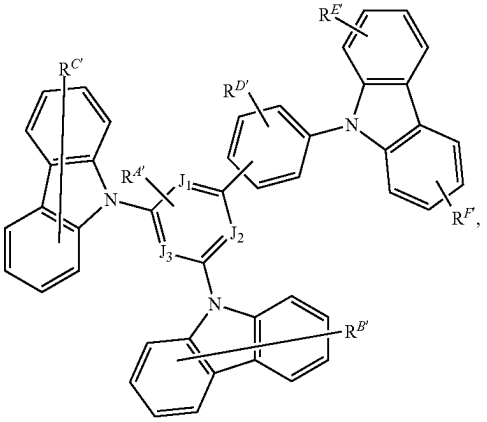

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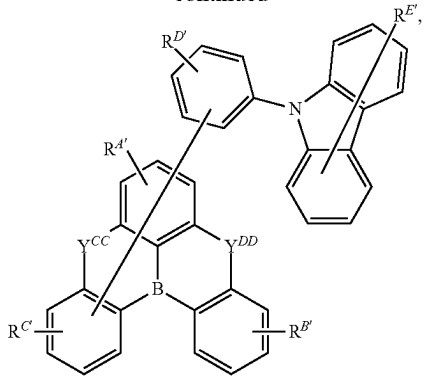

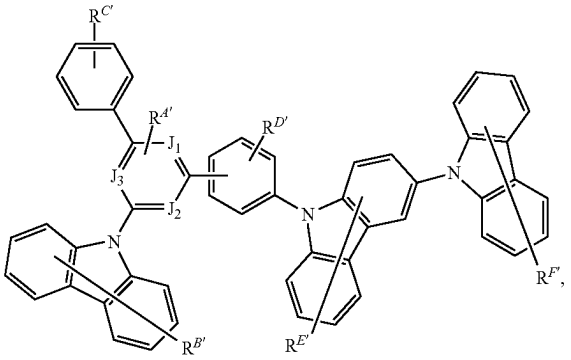

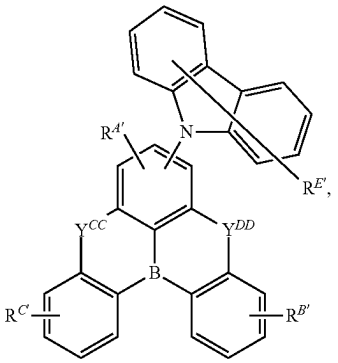

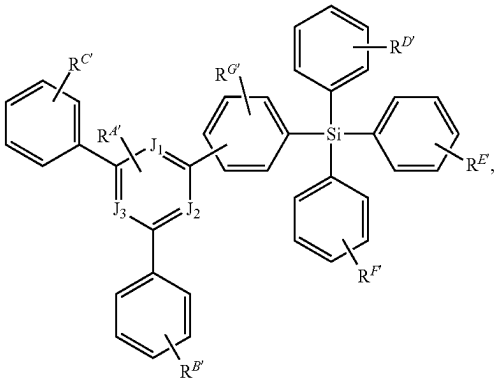

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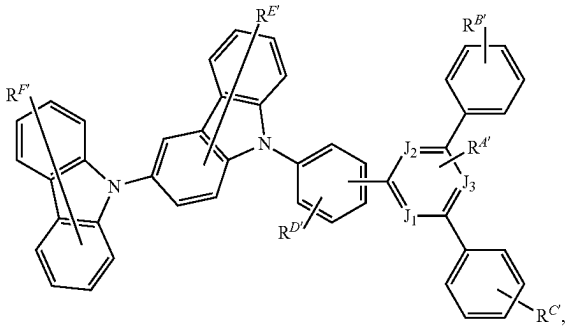

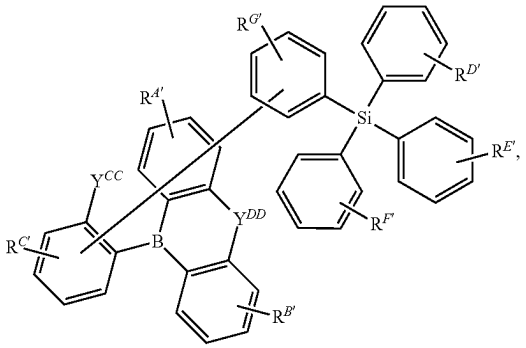

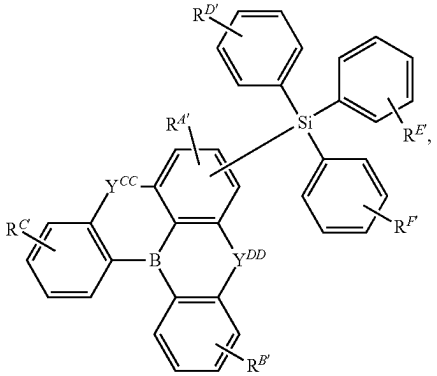

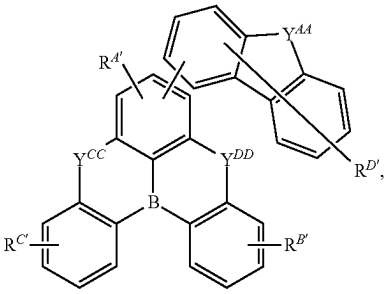

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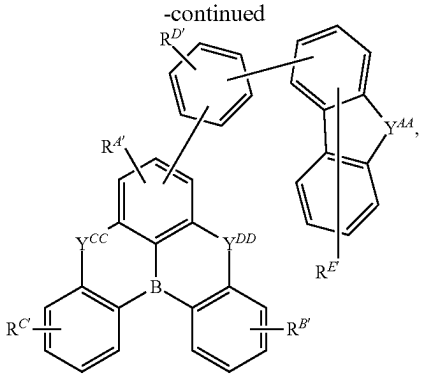

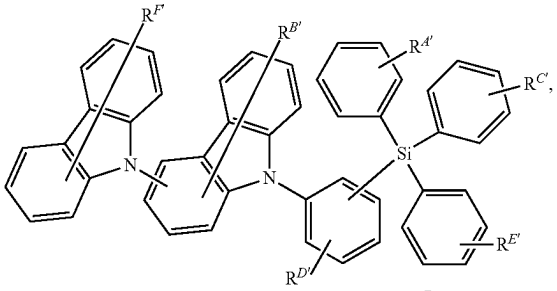

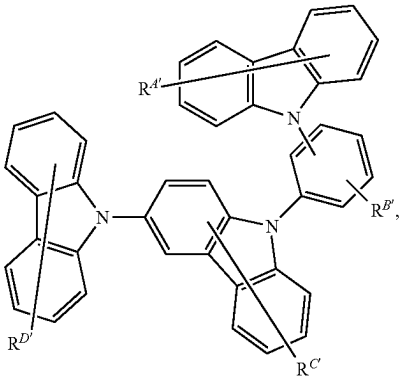

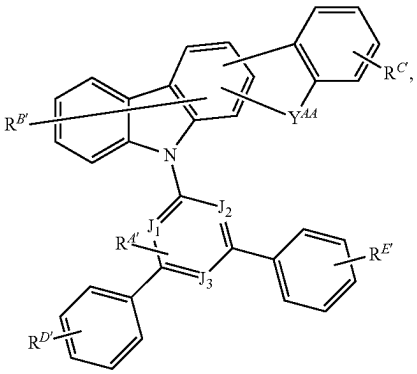

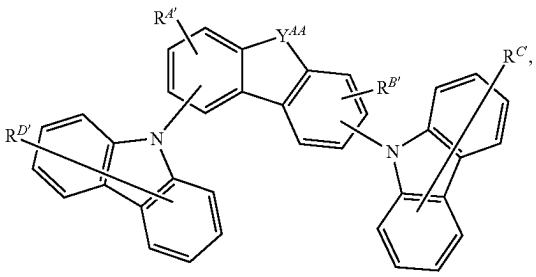

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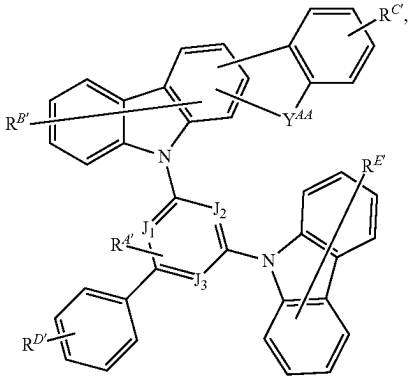

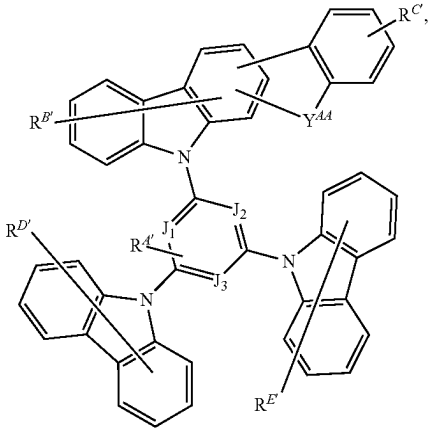

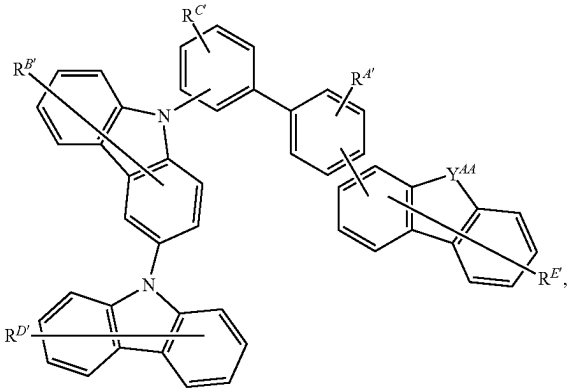

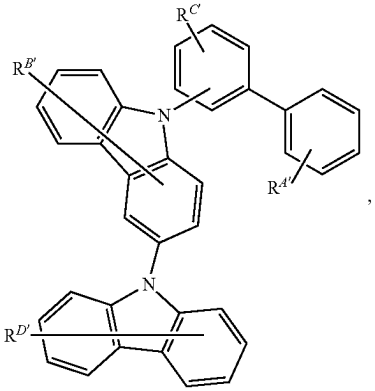

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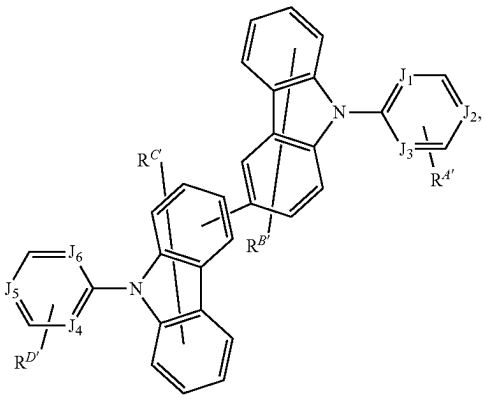

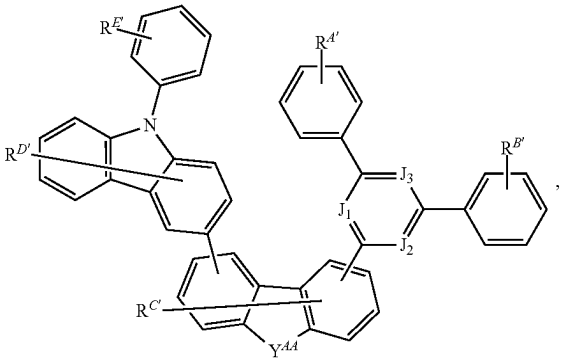

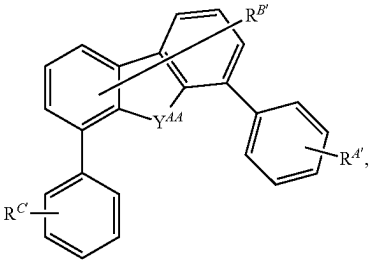

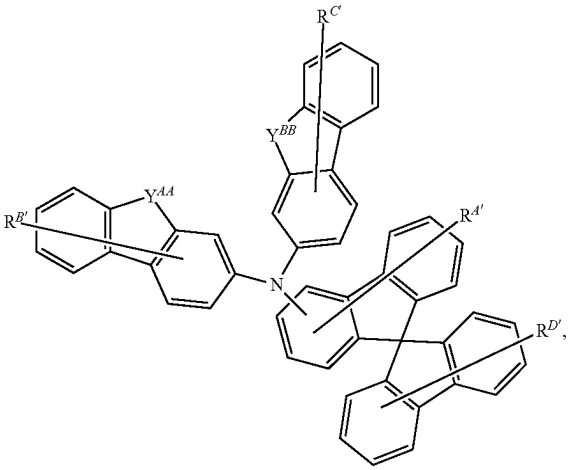

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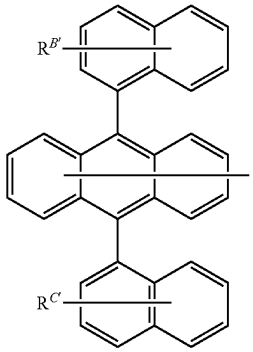

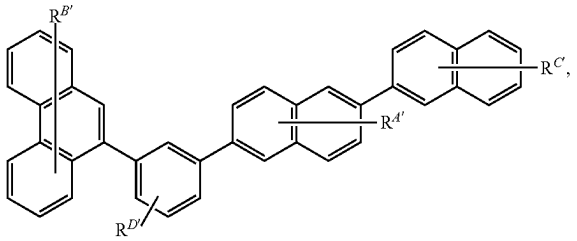

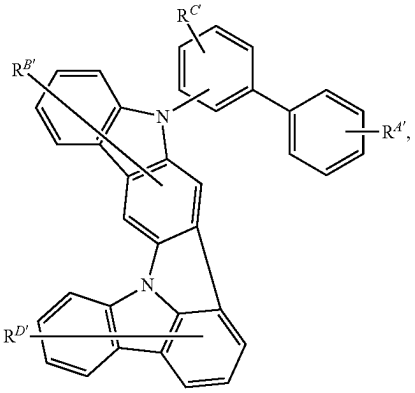

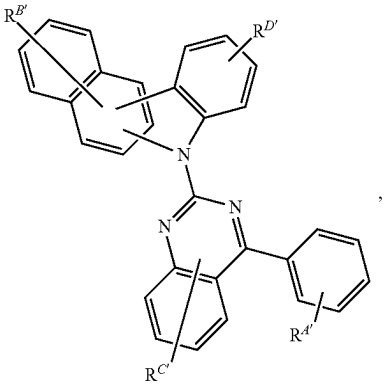

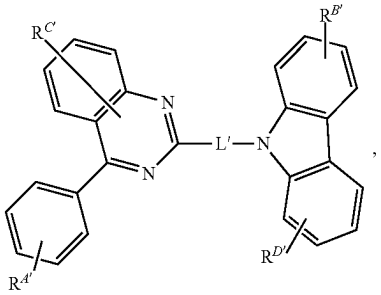

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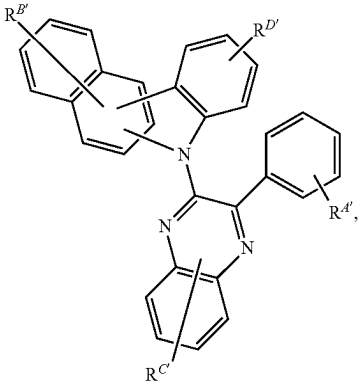

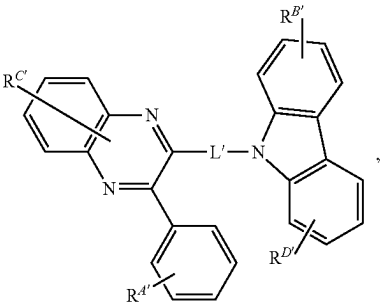

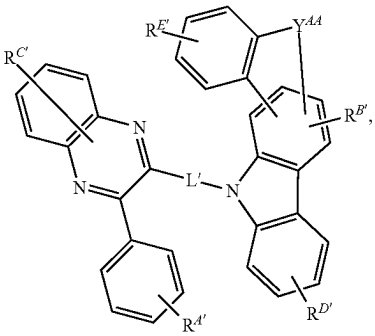

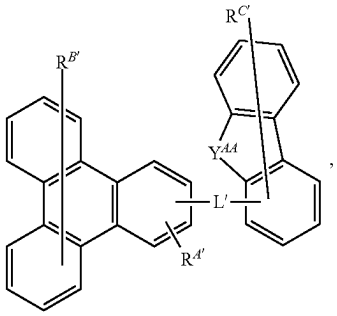

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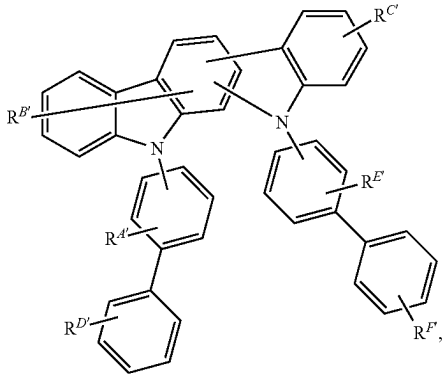

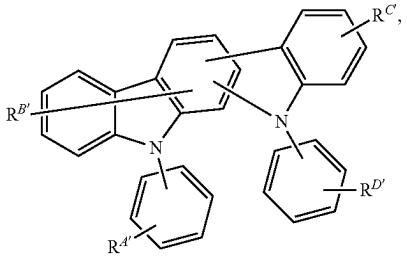

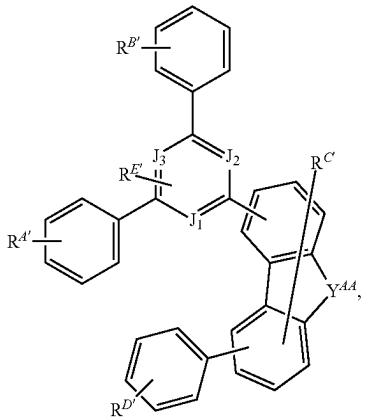

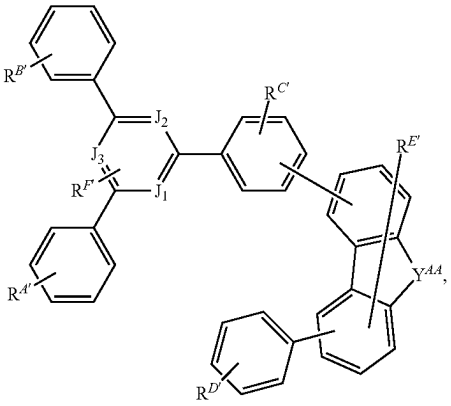

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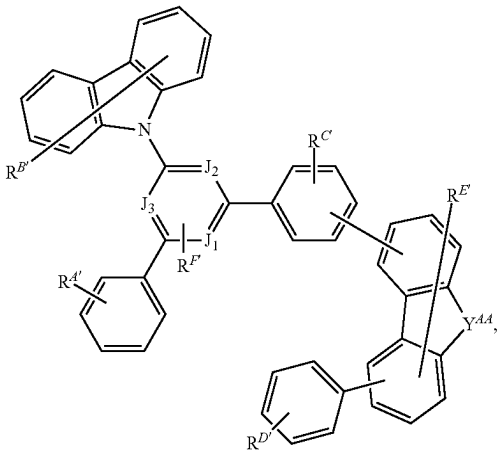

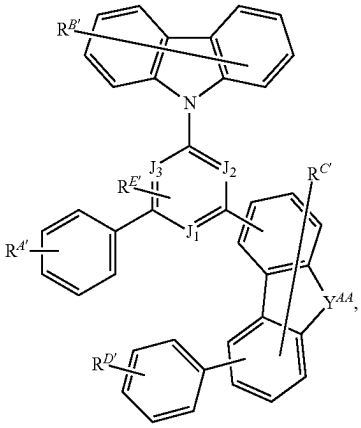

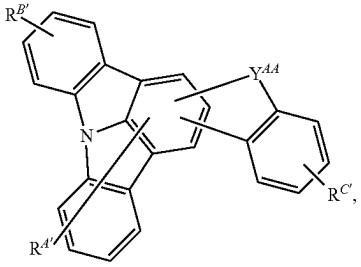

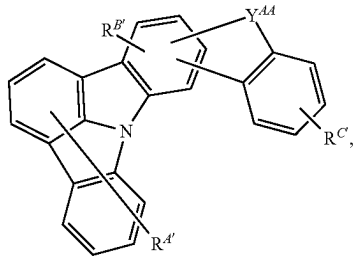

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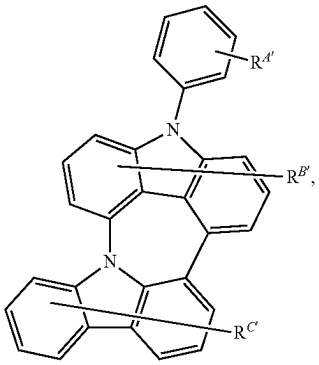

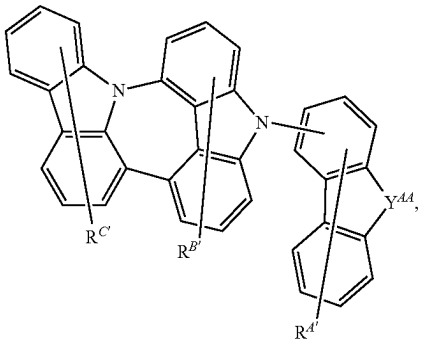

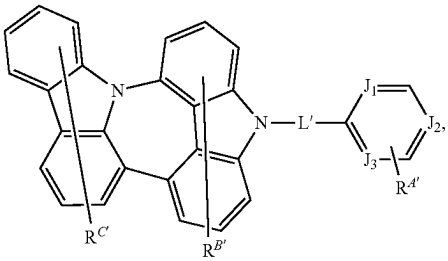

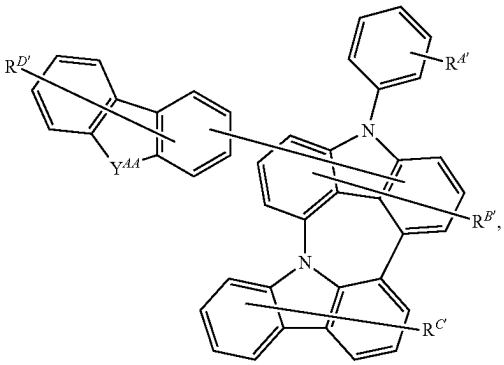

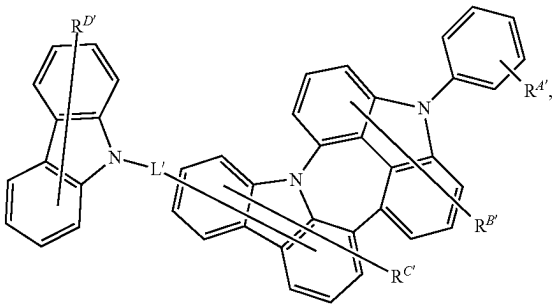

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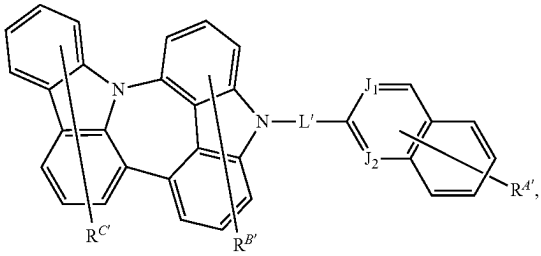

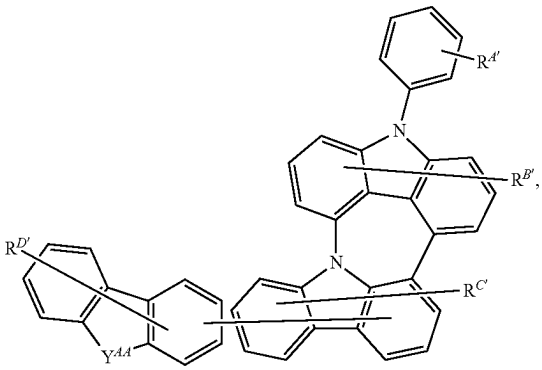

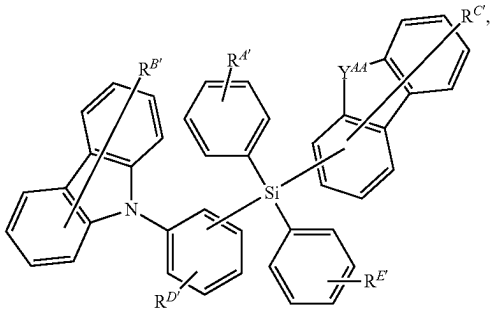

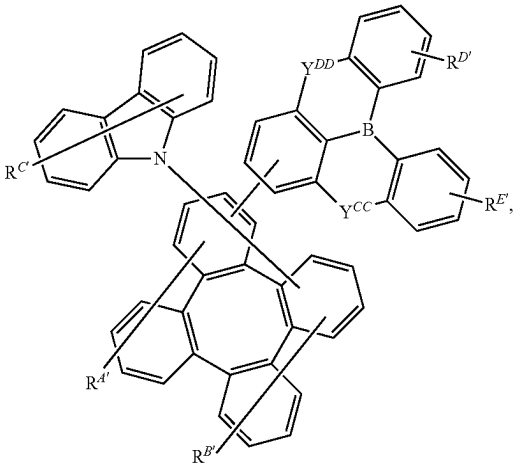

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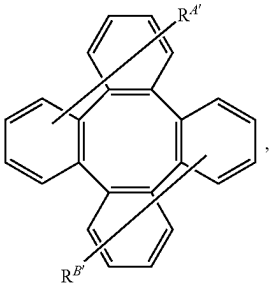

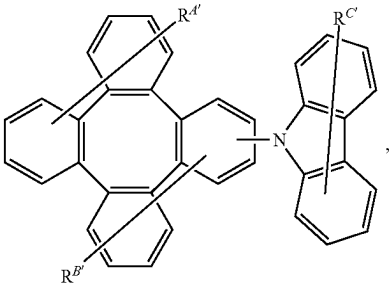

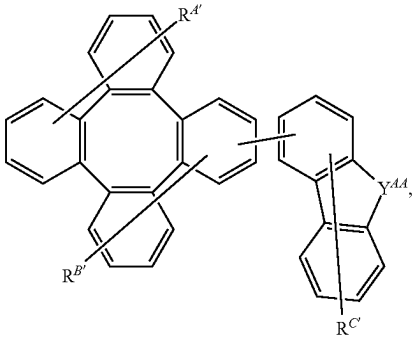

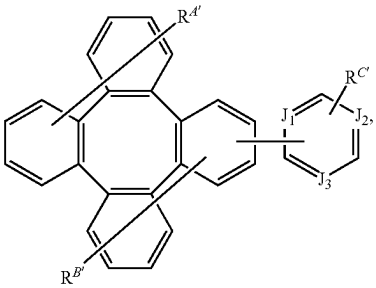

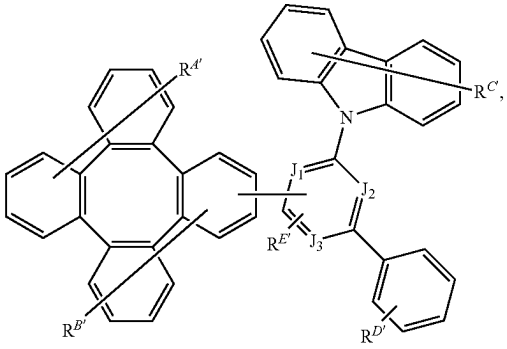

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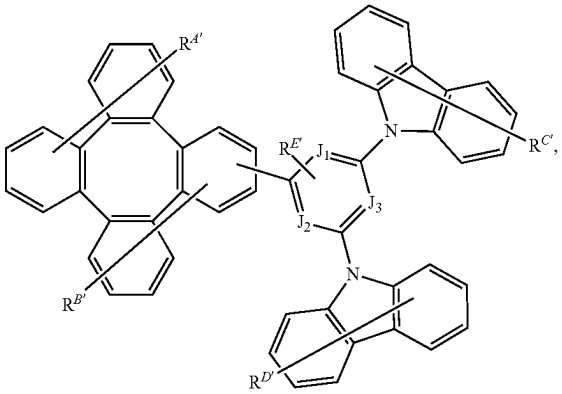

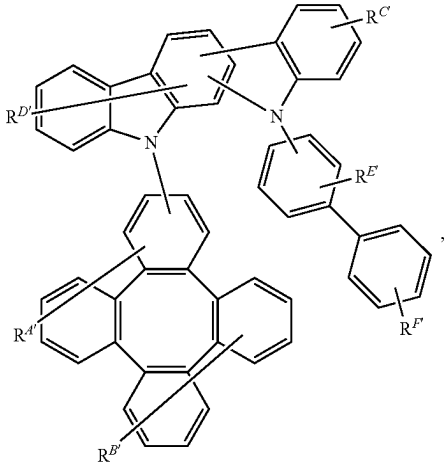

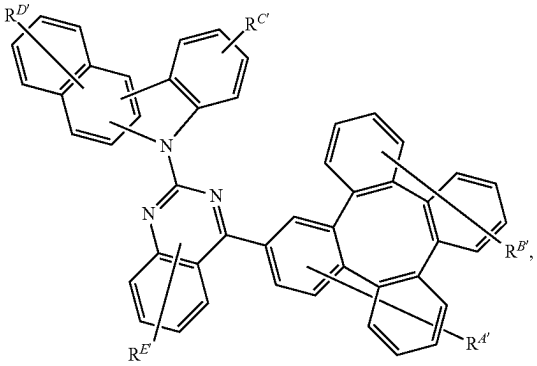

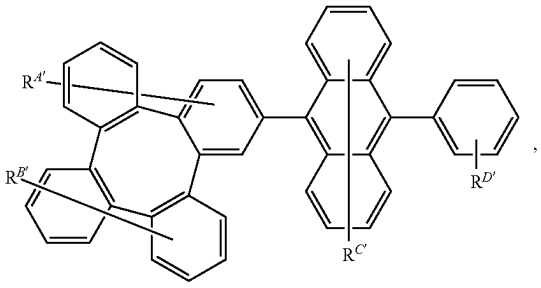

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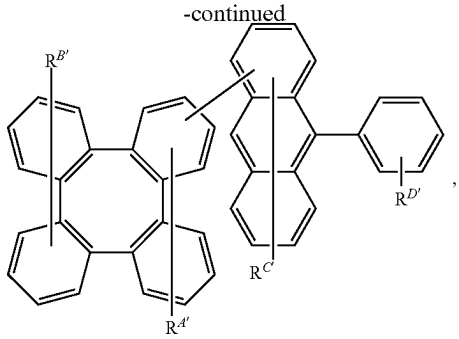
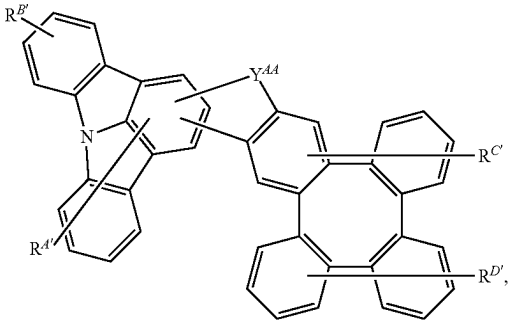
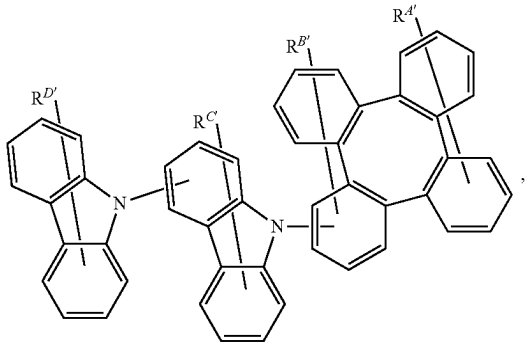




and



[0291] wherein:

[0292] each of J_1 to J_6 is independently C or N;

[0293] L' is a direct bond or an organic linker;

[0294] each Y^{AA}, Y^{BB}, Y^{CC}, and Y^{DD} is independently selected from the group consisting of absent a bond, direct bond, O, S, Se, CRR', SiRR', GeRR', NR, BR, BRR';

[0295] each of $R^{A'}$, $R^{B'}$, $R^{C'}$, $R^{D'}$, $R^{E'}$, $R^{F'}$, and $R^{G'}$ independently represents mono, up to the maximum substitutions, or no substitutions;

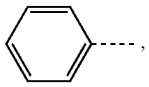
[0296] each R, R', $R^{A'}$, $R^{B'}$, $R^{C'}$, $R^{D'}$, $R^{E'}$, $R^{F'}$, and $R^{G'}$ is independently a hydrogen or a substituent selected from the group consisting of the General Substituents as defined herein; any two substituents can be joined or fused to form a ring;

[0297] and where possible, each unsubstituted aromatic carbon atom can be replaced with one or more N to form an aza-substituted ring.

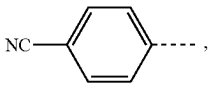
[0298] In some embodiments at least one of J_1 to J_3 is N. In some embodiments at least two of J_1 to J_3 are N. In some embodiments, all three of J_1 to J_3 are N. In some embodiments, each Y^{CC} and Y^{DD} is independently O, S, or SiRR', or more preferably O or S. In some embodiments, at least one unsubstituted aromatic carbon atom is replaced with N to form an aza-ring.

[0299] In some embodiments, the host is selected from the group consisting of EG1-MG1-EG1 to EG53-MG27-EG53 with a formula of EGa-MGb-EGc, or EG1-EG1 to EG53-EG53 with a formula of EGa-EGc when MGb is absent, wherein a is an integer from 1 to 53, b is an integer from 1 to 27, c is an integer from 1 to 53. The structure of EG1 to EG53 is shown below:

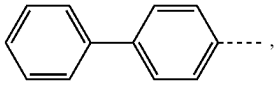
EG1



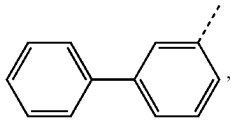
EG2



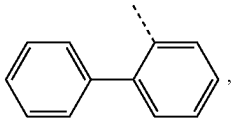
EG3



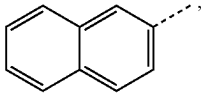
EG4



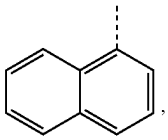
EG5



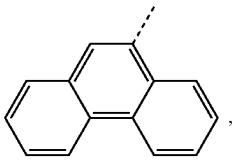
EG6



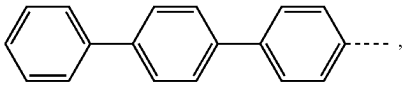
EG7



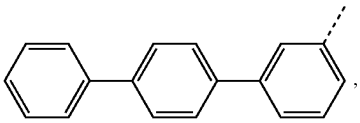
EG8



EG9



EG10



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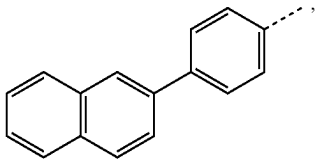
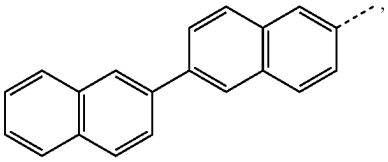
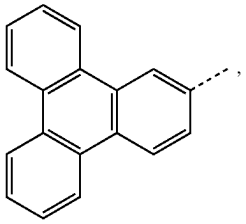
EG11



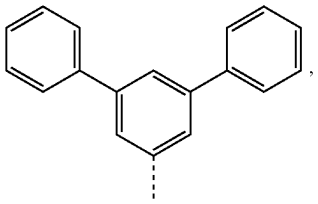
EG12



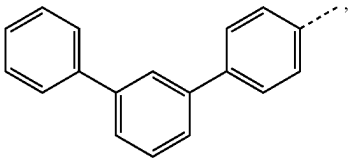
EG13



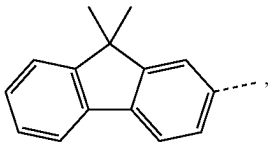
EG14



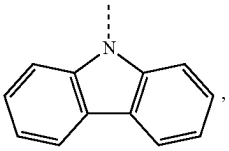
EG15



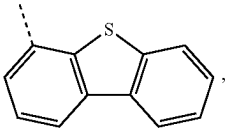
EG16



EG17



EG18



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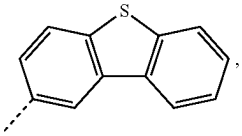

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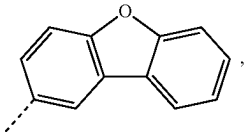

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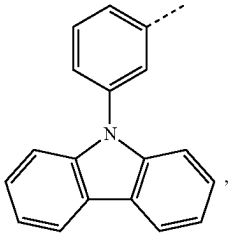

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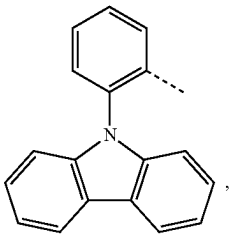

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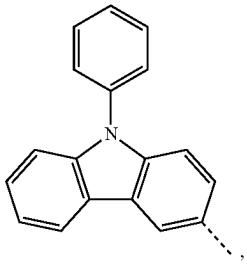

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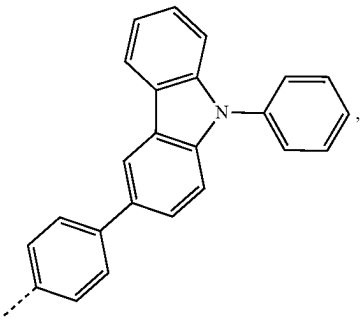

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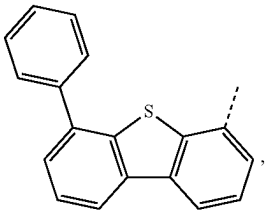

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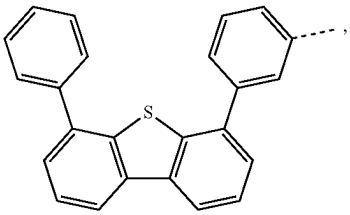

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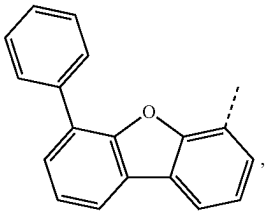

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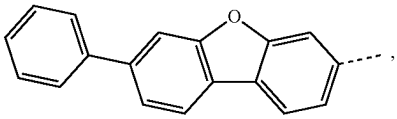

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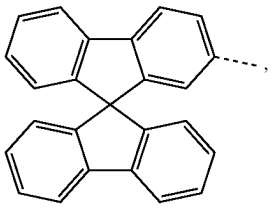

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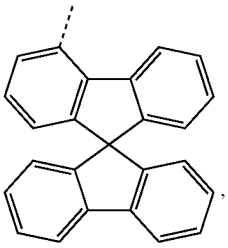

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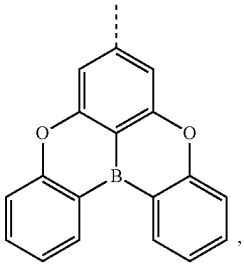

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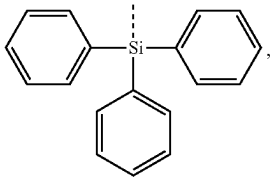

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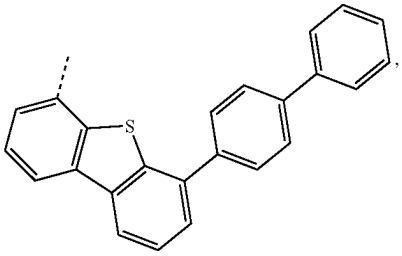

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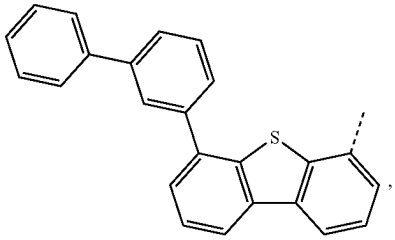

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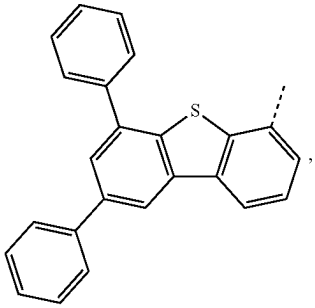

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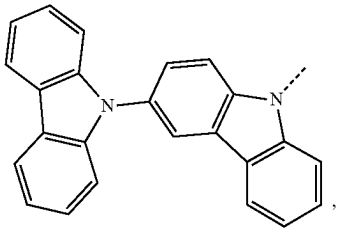

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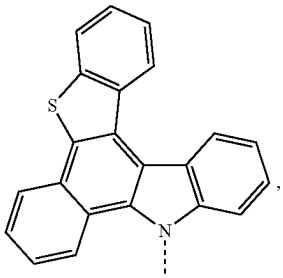

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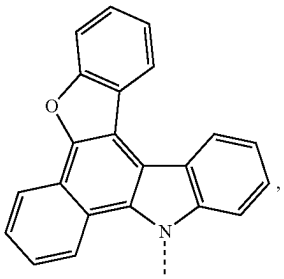

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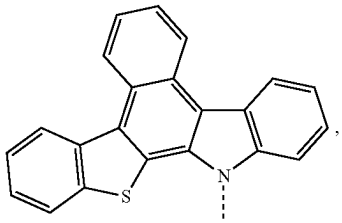

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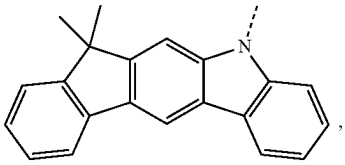

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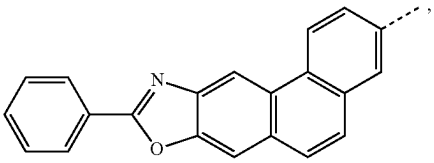

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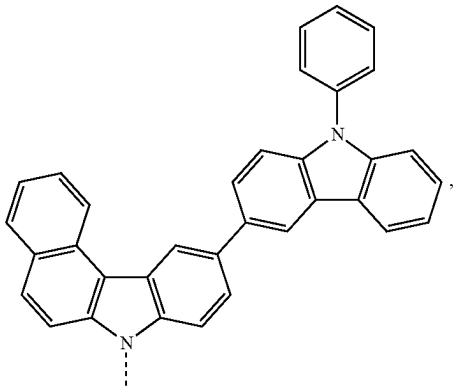

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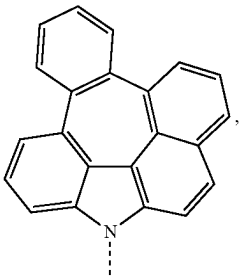

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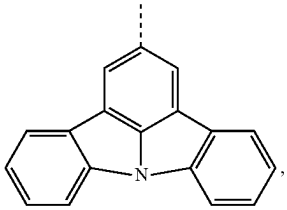

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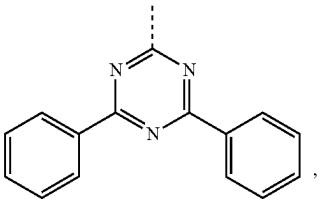

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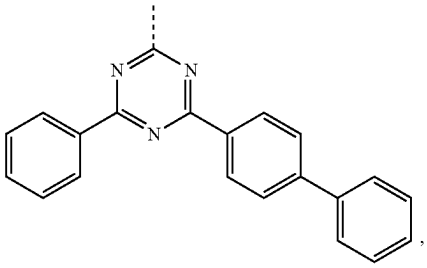

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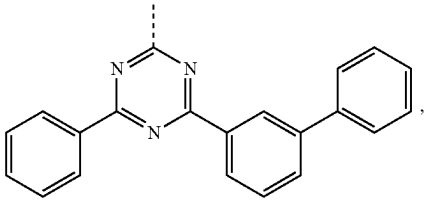

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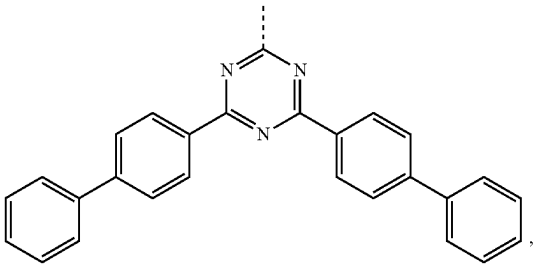

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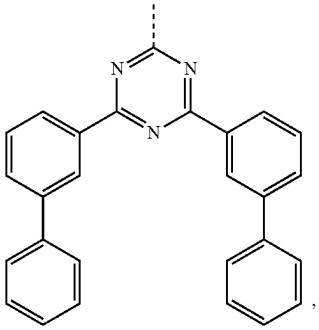

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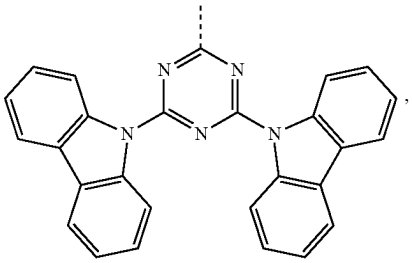

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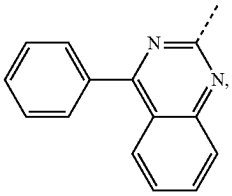

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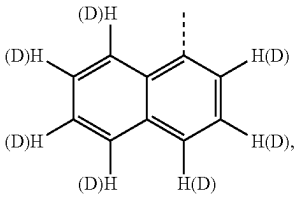

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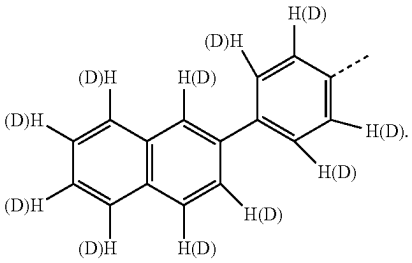
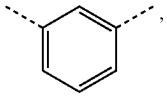


[0300] The structures of MG1 to MG27 are shown below:

MG1



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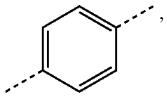

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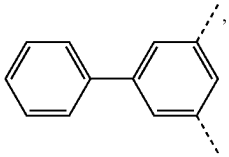

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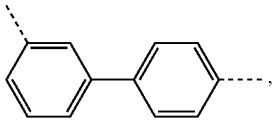
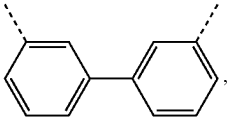
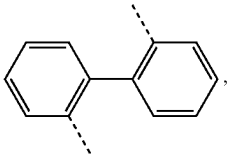
MG4



MG5



MG6



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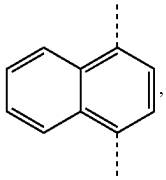

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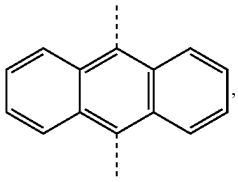

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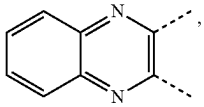

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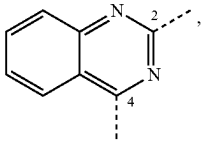

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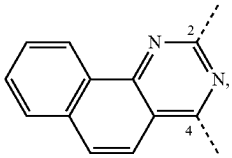
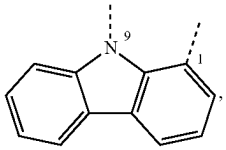


MG12



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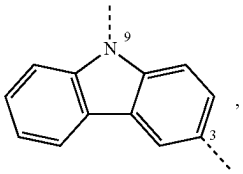
MG13



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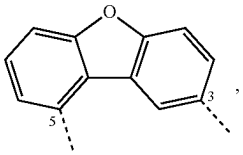

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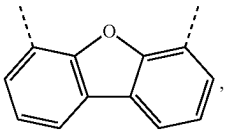

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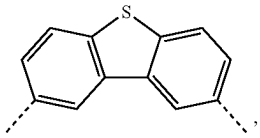

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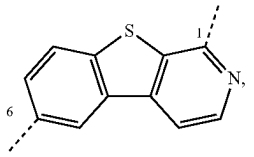

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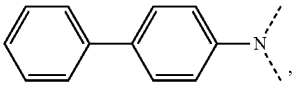

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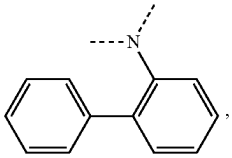
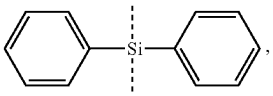
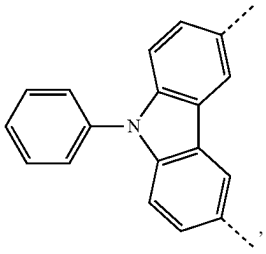


MG20

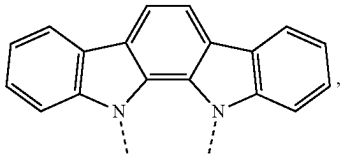


MG21

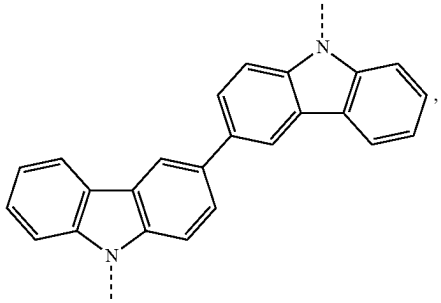


-continued

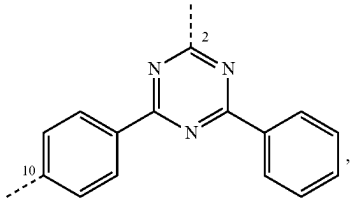
MG22



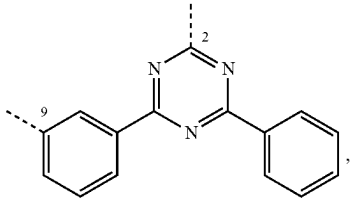
MG23



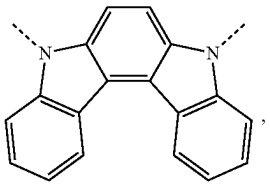
MG24



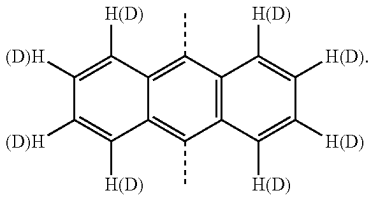
MG25



MG26



MG27



In the MGb structures shown above, the two bonding positions in the asymmetric structures MG10, MG11, MG12, MG13, MG14, MG17, MG24, and MG25 are labeled with numbers for identification purposes.

[0301] In some embodiments, the host can be any of the aza-substituted variants thereof, fully or partially deuterated variants thereof, and combinations thereof. In some embodiments, the host has formula EGa-MGb-Egc and is selected from the group consisting of h1 to h112 defined in the following HOST Group 2 list, where each of MGb, EGa, and EGc are defined as follows:

h	MGb	EGa	EGc
h1	MG1	EG3	EG36
h2	MG1	EG8	EG12
h3	MG1	EG13	EG14
h4	MG1	EG13	EG18
h5	MG1	EG13	EG25
h6	MG1	EG13	EG36
h7	MG1	EG22	EG36
h8	MG1	EG25	EG46
h9	MG1	EG27	EG46
h10	MG1	EG27	EG48
h11	MG1	EG32	EG50
h12	MG1	EG35	EG46
h13	MG1	EG36	EG45
h14	MG1	EG36	EG49
h15	MG1	EG40	EG45
h16	MG2	EG3	EG36
h17	MG2	EG25	EG31
h18	MG2	EG31	EG33
h19	MG2	EG36	EG45
h20	MG2	EG36	EG46
h21	MG3	EG4	EG36
h22	MG3	EG34	EG45
h23	MG4	EG13	EG17
h24	MG5	EG13	EG45
h25	MG5	EG17	EG36
h26	MG5	EG18	EG36
h27	MG6	EG17	EG17
h28	MG7	EG43	EG45
h29	MG8	EG1	EG28
h30	MG8	EG6	EG7
h31	MG8	EG7	EG7
h32	MG8	EG7	EG11
h33	MG9	EG1	EG43
h34	MG10	4-EG1	2-EG37
h35	MG10	4-EG1	2-EG38
h36	MG10	EG1	EG42
h37	MG11	4-EG1	2-EG39
h38	MG12	1-EG17	9-EG31
h39	MG13	3-EG17	9-EG4
h40	MG13	3-EG17	9-EG13
h41	MG13	3-EG17	9-EG31
h42	MG13	3-EG17	9-EG45
h43	MG13	3-EG17	9-EG46
h44	MG13	3-EG17	9-EG48
h45	MG13	3-EG17	9-EG49
h46	MG13	3-EG32	9-EG31
h47	MG13	3-EG44	9-EG3
h48	MG14	3-EG13	5-EG45
h49	MG14	3-EG23	5-EG45
h50	MG15	EG3	EG48
h51	MG15	EG17	EG31
h52	MG15	EG31	EG36
h53	MG16	EG17	EG17
h54	MG17	EG17	EG17
h55	MG18	EG16	EG24
h56	MG18	EG16	EG30
h57	MG18	EG20	EG41
h58	MG19	EG16	EG29
h59	MG20	EG1	EG31
h60	MG20	EG17	EG18
h61	MG21	EG23	EG23
h62	MG22	EG1	EG45
h63	MG22	EG1	EG46
h64	MG22	EG3	EG46
h65	MG22	EG4	EG46
h66	MG22	EG4	EG47
h67	MG22	EG9	EG45
h68	MG23	EG1	EG3
h69	MG23	EG1	EG6
h70	MG23	EG1	EG14
h71	MG23	EG1	EG18
h72	MG23	EG1	EG19
h73	MG23	EG1	EG23
h74	MG23	EG1	EG51
h75	MG23	EG2	EG18
h76	MG23	EG3	EG3

-continued

h	MGb	EGa	EGc
h77	MG23	EG3	EG4
h78	MG23	EG3	EG5
h79	MG23	EG4	EG4
h80	MG23	EG4	EG5
h81	MG24	2-EG1	10-EG33
h82	MG24	2-EG4	10-EG36
h83	MG24	2-EG21	10-EG36
h84	MG24	2-EG23	10-EG36
h85	MG25	2-EG1	9-EG33
h86	MG25	2-EG3	9-EG36
h87	MG25	2-EG4	9-EG36
h88	MG25	2-EG17	9-EG27
h89	MG25	2-EG17	9-EG36
h90	MG25	2-EG21	9-EG36
h91	MG25	2-EG23	9-EG27
h92	MG25	2-EG23	9-EG36
h93	MG26	EG1	EG9
h94	MG26	EG1	EG10
h95	MG26	EG1	EG21
h96	MG26	EG1	EG23
h97	MG26	EG1	EG26
h98	MG26	EG3	EG3
h99	MG26	EG3	EG9
h100	MG26	EG3	EG23
h101	MG26	EG3	EG26
h102	MG26	EG4	EG10
h103	MG26	EG5	EG10
h104	MG26	EG6	EG10
h105	MG26	EG10	EG10
h106	MG26	EG10	EG14
h107	MG26	EG10	EG15
h108	MG27	EG52	EG53
h109	—	EG13	EG18
h110	—	EG17	EG31
h111	—	EG17	EG50
h112	—	EG40	EG45

In the table above, the EGa and EGc structures that are bonded to one of the asymmetric structures MG10, MG11, MG12, MG13, MG14, MG17, MG24, and MG25, are noted with a numeric prefix identifying their bonding position in the MGb structure.

[0302] In some embodiments, the organic layer may further comprise a host, wherein the host comprises a metal complex.

[0303] In some embodiments, the emissive layer can comprise two hosts, a first host and a second host. In some embodiments, the first host is a hole transporting host, and the second host is an electron transporting host. In some embodiments, the first host is a hole transporting host, and the second host is a bipolar host. In some embodiments, the first host is an electron transporting host, and the second host is a bipolar host. In some embodiments, the first host and the second host can form an exciplex. In some embodiments, the emissive layer can comprise a third host. In some embodiments, the third host is selected from the group consisting of an insulating host (wide band gap host), a hole transporting host, and an electron transporting host. In some embodiments, the third host forms an exciplex with one of the first host and the second host, or with both the first host and the second host. In some embodiments, the emissive layer can comprise a fourth host. In some embodiments, the fourth host is selected from the group consisting of an insulating host (wide band gap host), a hole transporting host, and an electron transporting host. In some embodiments, the fourth host forms an exciplex with one of the first host, the second host, and the third host, with two of the first host, the second

host, and the third host, or with each of the first host, the second host, and the third host. In some embodiments, the electron transporting host has a LUMO less than −2.4 eV, less than −2.5 eV, less than −2.6 eV, or less than −2.7 eV. In some embodiments, the hole transporting host has a HOMO higher than −5.6 eV, higher than −5.5 eV, higher than −5.4 eV, or higher than −5.35 eV. The HOMO and LUMO values can be determined using solution electrochemistry. Solution cyclic voltammetry and differential pulsed voltammetry can be performed using a CH Instruments model 6201B potentiostat using anhydrous dimethylformamide (DMF) solvent and tetrabutylammonium hexafluorophosphate as the supporting electrolyte. Glassy carbon, platinum wire, and silver wire were used as the working, counter and reference electrodes, respectively. Electrochemical potentials can be referenced to an internal ferrocene-ferroconium redox couple (Fc/Fc+) by measuring the peak potential differences from differential pulsed voltammetry. The corresponding highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) energies can be determined by referencing the cationic and anionic redox potentials to ferrocene (4.8 eV vs. vacuum) according to literature ((a) Fink, R.; Heischkel, Y.; Thelakkat, M.; Schmidt, H. W. *Chem. Mater.* 1998, 10, 3620-3625. (b) Pommerehne, J.; Vestweber, H.; Guss, W; Mahrt, R. F.; Bassler, H.; Porsch, M.; Daub, *J. Adv. Mater* 1995, 7, 551).

[0304] In some embodiments, the compound as described herein may be a sensitizer or a component of a sensitizer; wherein the device may further comprise an acceptor that receives the energy from the sensitizer. In some embodiments, the acceptor is an emitter in the device. In some embodiments, the acceptor may be a fluorescent material. In some embodiments, the compound described herein can be used as a phosphorescent sensitizer in an OLED where one or multiple layers in the OLED contain an acceptor in the form of one or more non-delayed fluorescent and/or delayed fluorescence material. In some embodiments, the compound described herein can be used as one component of an exciplex to be used as a sensitizer. As a phosphorescent sensitizer, the compound must be capable of energy transfer to the acceptor and the acceptor will emit the energy or further transfer energy to a final emitter. The acceptor concentrations can range from 0.001% to 99.9%. The acceptor could be in either the same layer as the phosphorescent sensitizer or in one or more different layers. In some embodiments, the acceptor is a thermally activated delayed fluorescence (TADF) material. In some embodiments, the acceptor is a non-delayed fluorescent material. In some embodiments, the emission can arise from any or all of the sensitizer, acceptor, and final emitter. In some embodiments, the acceptor has an emission at room temperature with a full width at half maximum (FWHM) of equal to or less than 50, 45, 40, 35, 30, 25, 20, 15, 10, or 5 nm. Narrower FWHM means better color purity for the OLED display application.

[0305] As used herein, phosphorescence generally refers to emission of a photon with a change in electron spin quantum number, i.e., the initial and final states of the emission have different electron spin quantum numbers, such as from T1 to S0 state. Most of the Ir and Pt complexes currently used in OLED are phosphorescent emitters. In some embodiments, if an exciplex formation involves a triplet emitter, such exciplex can also emit phosphorescent light. On the other hand, fluorescent emitters generally refer to emission of a photon without a change in electron spin quantum number, such as from S1 to S0 state, or from D1 to D0 state. Fluorescent emitters can be delayed fluorescent or non-delayed fluorescent emitters. Depending on the spin state, fluorescent emitter can be a singlet emitter or a doublet emitter, or other multiplet emitter. It is believed that the internal quantum efficiency (IQE) of fluorescent OLEDs can exceed the 25% spin statistics limit through delayed fluorescence. There are two types of delayed fluorescence, i.e. P-type and E-type delayed fluorescence. P-type delayed fluorescence is generated from triplet-triplet annihilation (TTA). On the other hand, E-type delayed fluorescence does not rely on the collision of two triplets, but rather on the thermal population between the triplet states and the singlet excited states. Thermal energy can activate the transition from the triplet state back to the singlet state. This type of delayed fluorescence is also known as TADF. E-type delayed fluorescence characteristics can be found in an exciplex system or in a single compound. Without being bound by theory, it is believed that TADF emissions require a compound or an exciplex having a small singlet-triplet energy gap (ΔE_{S-T}) less than or equal to 400, 350, 300, 250, 200, 150, 100, or 50 meV. There are two major types of TADF emitters, one is called donor-acceptor type TADF, the other one is called multiple resonance (MR) TADF. Often, single compound donor-acceptor TADF compounds are constructed by connecting an electron donor moiety such as amino- or carbazole-derivatives and an electron acceptor moiety such as N-containing six-membered aromatic rings or cyano-substituted aromatic rings. Donor-acceptor exciplexes can be formed between a hole transporting compound and an electron transporting compound. Examples of MR-TADF materials include highly conjugated fused ring systems. In some embodiments, MR-TADF materials comprises boron, carbon, and nitrogen atoms. Such materials may comprise other atoms, such as oxygen, as well. In some embodiments, the reverse intersystem crossing time from T1 to Si of the delayed fluorescent emission at 293K is less than or equal to 10 microseconds. In some embodiments, such time can be greater than 10 microseconds and less than 100 microseconds.

[0306] In some embodiments, the OLED may comprise an additional compound selected from the group consisting of a non-delayed fluorescence material, a delayed fluorescence material, a phosphorescent material, and combination thereof.

[0307] In some embodiments, the inventive compound described herein is a phosphorescent material.

[0308] In some embodiments, the phosphorescent material is an emitter which emits light within the OLED. In some embodiments, the phosphorescent material does not emit light within the OLED. In some embodiments, the phosphorescent material energy transfers its excited state to another material within the OLED. In some embodiments, the phosphorescent material participates in charge transport within the OLED. In some embodiments, the phosphorescent material is a sensitizer or a component of a sensitizer, and the OLED further comprises an acceptor. In some embodiments, the phosphorescent material forms an exciplex with another material within the OLED, for example a host material, an emitter material.

[0309] In some embodiments, the non-delayed fluorescence material or the delayed fluorescence material is an emitter which emits light within the OLED. In some embodiments, the non-delayed fluorescence material or the

delayed fluorescence material does not emit light within the OLED. In some embodiments, the non-delayed fluorescence material or the delayed fluorescence material energy transfers its excited state to another material within the OLED. In some embodiments, the non-delayed fluorescence material or the delayed fluorescence material participates in charge transport within the OLED. In some embodiments, the non-delayed fluorescence material or the delayed fluorescence material is an acceptor, and the OLED further comprises a sensitizer.

[0310] In some embodiments of the OLED, the delayed fluorescence material comprises at least one donor group and at least one acceptor group. In some embodiments, the delayed fluorescence material is a metal complex. In some embodiments, the delayed fluorescence material is a non-metal complex. In some embodiments, the delayed fluorescence material is a Pt, Pd, Zn, Cu, Ag, or Au complex (some of them are also called metal-assisted (MA) TADF). In some embodiments, the metal-assisted delayed fluorescence material comprises a metal-carbene bond. In some embodiments, the non-delayed fluorescence material or delayed fluorescence material comprises at least one chemical group selected from the group consisting of aryl-amine, aryloxy, arylthio, triphenylene, carbazole, indolocarbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, 5λ^2-benzo[d]benzo[4,5]imidazo[3,2-a]imidazole, 5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene, 5λ^2,9λ^2-diaza-13b-boranaphtho[2,3,4-de]anthracene, 5-oxa-9λ^2-aza-13b-boranaphtho[3,2,1-de]anthracene, azaborinine, oxaborinine, dihydroacridine, xanthene, dihydrobenzoazasiline, dibenzooxasiline, phenoxazine, phenoxathiine, phenothiazine, dihydrophenazine, fluorene, naphthalene, anthracene, phenanthrene, phenanthroline, benzoquinoline, quinoline, isoquinoline, quinazoline, pyrimidine, pyrazine, pyridine, triazine, boryl, amino, silyl, aza-variants thereof, and combinations thereof. In some embodiments, non-delayed the fluorescence material or delayed fluorescence material comprises a tri(aryl/heteroaryl)borane with one or more pairs of the substituents from the aryl/heteroaryl being joined to form a ring. In some embodiments, the fluorescence material comprises at least one chemical group selected from the group consisting of naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene.

[0311] In yet another aspect, the OLED of the present disclosure may also comprise an emissive region containing a compound or a formulation of the compound as disclosed in the above compounds section of the present disclosure. In some embodiments, the emissive region can comprise a compound or a formulation of the compound having a first ligand L_A comprising a structure of Formula I defined herein. In some embodiments, the emissive region consists of one or more organic layers, wherein at least one of the one or more organic layers has a minimum thickness selected from the group consisting of 350, 400, 450, 500, 550, 600, 650 and 700 Å. In some embodiments, the at least one of the one or more organic layers are formed from an Emissive System that has a figure of merit (FOM) value equal to or larger than the number selected from the group consisting of 2.50, 2.55, 2.60, 2.65, 2.70, 2.75, 2.80, 2.85, 2.90, 2.95, 3.00, 5.00, 10.0, 15.0, and 20.0. The definition of FOM is available in U.S. patent Application Publication No. 2023/0292605, and its entire contents are incorporated herein by reference. In some embodiments, the at least one of the one or more organic layers comprises a compound or a formulation of the compound as disclosed in Sections A and D of the present disclosure.

[0312] In some embodiments, the OLED or the emissive region comprising the inventive compound disclosed herein can be incorporated into a full-color pixel arrangement of a device. The full-color pixel arrangement of such a device comprises at least one pixel, wherein the at least one pixel comprises a first subpixel and a second subpixel. The first subpixel includes a first OLED comprising a first emissive region. The second subpixel includes a second OLED comprising a second emissive region. In some embodiments, the first and/or second OLED, the first and/or second emissive region can be the same or different and each can independently have the various device characteristics and the various embodiments of the inventive compounds included therein, and various combinations and subcombinations of the various device characteristics and the various embodiments of the inventive compounds included therein, as disclosed herein.

[0313] In some embodiments, the first emissive region is configured to emit a light having a peak wavelength λ_{max1}; the second emissive region is configured to emit a light having a peak wavelength λ_{max2}. In some embodiments, the difference between the peak wavelengths λ_{max1} and λ_{max2} is at least 4 nm but within the same color. For example, a light blue and a deep blue light as described above. In some embodiments, a first emissive region is configured to emit a light having a peak wavelength λ_{max1} in one region of the visible spectrum of 400-500 nm, 500-600 nm, 600-700 nm; and a second emissive region is configured to emit light having a peak wavelength λ_{max2} in one of the remaining regions of the visible spectrum of 400-500 nm, 500-600 nm, 600-700 nm. In some embodiments, the first emissive region comprises a first number of emissive layers that are deposited one over the other if more than one; and the second emissive region comprises a second number of emissive layers that is deposited one over the other if more than one; and the first number is different from the second number. In some embodiments, both the first emissive region and the second emissive region comprise a phosphorescent material, which may be the same or different. In some embodiments, the first emissive region comprises a phosphorescent material, while the second emissive region comprises a fluorescent material. In some embodiments, both the first emissive region and the second emissive region comprise a fluorescent material, which may be the same or different.

[0314] In some embodiments, the at least one pixel of the OLED or emissive regions includes a total of N subpixels; wherein the N subpixels comprises the first subpixel and the second subpixel; wherein each of the N subpixels comprises an emissive region; wherein the total number of the emissive regions within the at least one pixel is equal to or less than N−1. In some embodiments, the second emissive region is exactly the same as the first emissive region; and each subpixel of the at least one pixel comprises the same one emissive region as the first emissive region. In some embodiments, the full-color pixel arrangements can have a plurality of pixels comprising a first pixel region and a second pixel region; wherein at least one display characteristic in the first pixel region is different from the corresponding display characteristic of the second pixel region, and

wherein the at least one display characteristic is selected from the group consisting of resolution, cavity mode, color, outcoupling, and color filter.

[0315] In some embodiments, the OLED is a stacked OLED comprising one or more charge generation layers (CGLs). In some embodiments, the OLED comprises a first electrode, a first emissive region disposed over the first electrode, a first CGL disposed over the first emissive region, a second emissive region disposed over the first CGL, and a second electrode disposed over the second emissive region. In some embodiments, the first and/or the second emissive regions can have the various device characteristics as described above for the pixelated device. In some embodiments, the stacked OLED is configured to emit white color. In some embodiments, one or more of the emissive regions in a pixelated or in a stacked OLED comprises a sensitizer and an acceptor with the various sensitizing device characteristics and the various embodiments of the inventive compounds disclosed herein. For example, the first emissive region is comprised in a sensitizing device, while the second emissive region is not comprised in a sensitizing device; in some instances, both the first and the second emissive regions are comprised in sensitizing devices.

[0316] In some embodiments, the OLED can emit light having at least 1%, 5%, 10, 30%, 50%, 70%, 80%, 90%, 95%, 99%, or 100% from the plasmonic mode. In some embodiments, at least one of the anode, the cathode, or a new layer disposed over the organic emissive layer functions as an enhancement layer. The enhancement layer comprises a plasmonic material exhibiting surface plasmon resonance that non-radiatively couples to the emitter material and transfers excited state energy from the emitter material to non-radiative mode of surface plasmon polariton. In some embodiments, the enhancement layer is provided no more than a threshold distance away from the organic emissive layer, wherein the emitter material has a total non-radiative decay rate constant and a total radiative decay rate constant due to the presence of the enhancement layer. A threshold distance is where the total non-radiative decay rate constant is equal to the total radiative decay rate constant. Another threshold distance is the distance at which the total radiative decay rate constant divided by the sum of the total non-radiative decay rate constant and total radiative decay rate constant is equal to the photoluminescent yield of the emissive material without the enhancement layer present.

[0317] In some embodiments, the OLED further comprises an outcoupling layer. In some embodiments, the outcoupling layer is disposed over the enhancement layer on a side opposite the organic emissive layer The outcoupling layer scatters the energy from the surface plasmon polaritons. In some embodiments this energy is scattered as photons to free space. In other embodiments, the energy is scattered from the surface plasmon mode into other modes of the device such as but not limited to the organic waveguide mode, the substrate mode, or another waveguiding mode. In some embodiments, one or more intervening layer can be disposed between the enhancement layer and the outcoupling layer. The examples for intervening layer(s) can be dielectric materials, including organic, inorganic, perovskites, oxides, and may include stacks and/or mixtures of these materials.

[0318] The enhancement layer modifies the effective properties of the medium in which the emitter material resides resulting in any or all of the following: a decreased rate of emission, a modification of emission line-shape, a change in emission intensity with angle, a change in the stability of the emitter material, a change in the efficiency of the OLED, and a reduced efficiency roll-off of the OLED device. Placement of the enhancement layer on the cathode side, anode side, or on both sides, or the enhancement layer itself being as the CGL, results in OLED devices which take advantage of any of the above-mentioned effects. In addition to the specific functional layers mentioned herein and illustrated in the various OLED examples shown in the figures, the OLEDs according to the present disclosure may include any of the other functional layers often found in OLEDs.

[0319] In some embodiments, the enhancement layer can be comprised of plasmonic materials, optically active metamaterials, or hyperbolic metamaterials. In some embodiments, the plasmonic material includes at least one metal. In such embodiments the metal may include at least one of Ag, Al, Au, Ir, Pt, Ni, Cu, W, Ta, Fe, Cr, Mg, Ga, Rh, Ti, Ru, Pd, In, Bi, or Ca, alloys or mixtures of these materials, and stacks of these materials. In some embodiments, the enhancement layer is provided as a planar layer. In other embodiments, the enhancement layer has wavelength-sized features that are arranged periodically, quasi-periodically, or randomly, or sub-wavelength-sized features that are arranged periodically, quasi-periodically, or randomly.

[0320] In some embodiments, the outcoupling layer has wavelength-sized or sub-wavelength sized features that are arranged periodically, quasi-periodically, or randomly. In some embodiments, the outcoupling layer may be composed of a plurality of nanoparticles. In some embodiments, the outcoupling layer is composed of a plurality of nanoparticles disposed over a material. In these embodiments the outcoupling layer may be tunable by at least one of: varying a size of the plurality of nanoparticles, varying a shape of the plurality of nanoparticles, changing a material of the plurality of nanoparticles, adjusting a thickness of the material, changing the refractive index of the material, adding an additional layer disposed on the plurality of nanoparticles, varying a thickness of the enhancement layer, or varying the material of the enhancement layer. The plurality of nanoparticles of the device may be formed from at least one of metal, dielectric material, semiconductor materials, an alloy of metal, a mixture of dielectric materials, a stack or layering of one or more materials, and/or a core of one type of material and that is coated with a shell of a different type of material. In some embodiments, the outcoupling layer is composed of at least metal nanoparticles wherein the metal is selected from the group consisting of Ag, Al, Au, Ir, Pt, Ni, Cu, W, Ta, Fe, Cr, Mg, Ga, Rh, Ti, Ru, Pd, In, Bi, and Ca, alloys or mixtures of these materials, and stacks of these materials. In some embodiments the outcoupling layer is formed by lithography.

[0321] In some embodiments of a plasmonic device, the emitter, and/or host compounds used in the emissive layer has a vertical dipole ratio (VDR) of 0.33 or more. In some such embodiments, the emitter, and/or host compounds have a VDR of 0.40, 0.50, 0.60, 0.70, or more.

[0322] In yet another aspect, the present disclosure also provides a consumer product comprising an organic light-emitting device (OLED) having an anode; a cathode; and an organic layer disposed between the anode and the cathode, wherein the organic layer may comprise a compound or a

formulation of the compound as disclosed in the above compounds section of the present disclosure.

[0323] In some embodiments, the consumer product comprises an OLED having an anode; a cathode; and an organic layer disposed between the anode and the cathode, wherein the organic layer may comprise a compound having a first ligand L_A comprising a structure of Formula I defined herein.

[0324] 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, and 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 as an excimer or an exciplex. Non-radiative mechanisms, such as thermal relaxation, may also occur, but are generally considered undesirable.

[0325] 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 (HIL) **120**, a hole transport layer (HTL) **125**, an electron blocking layer (EBL) **130**, an emissive layer (EML) **135**, a hole blocking layer (HBL) **140**, an electron transport layer (ETL) **145**, an electron injection layer (EIL) **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.

[0326] 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 F_4-TCNQ at a molar ratio of 50:1, as disclosed in U.S. Patent Application Publication No. 2003/0230980, which is incorporated by reference in its entirety. Examples of emissive and host materials are disclosed in U.S. Pat. No. 6,303,238 to Thompson et al., which is incorporated by reference in its entirety. An example of an n-doped electron transport layer is BPhen doped with Li at a molar ratio of 1:1, as disclosed in U.S. Patent Application Publication No. 2003/0230980, which is incorporated by reference in its entirety. U.S. Pat. Nos. 5,703,436 and 5,707,745, which are incorporated by reference in their entireties, disclose examples of cathodes including compound cathodes having a thin layer of metal such as Mg:Ag with an overlying transparent, electrically-conductive, sputter-deposited ITO layer. The theory and use of blocking layers is described in more detail in U.S. Pat. No. 6,097,147 and U.S. Patent Application Publication No. 2003/0230980, which are incorporated by reference in their entireties. Examples of injection layers are provided in U.S. Patent Application Publication No. 2004/0174116, which is incorporated by reference in its entirety. A description of protective layers may be found in U.S. Patent Application Publication No. 2004/0174116, which is incorporated by reference in its entirety.

[0327] 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**.

[0328] 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 present disclosure 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**.

[0329] 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 outcoupling, 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.

[0330] 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, also referred to as organic vapor jet deposition (OVJD)), 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, sputtering, chemical vapor deposition, atomic layer deposition, and electron beam deposition. Preferred patterning methods include deposition through a mask, photolithography, and cold welding such as described in U.S. Pat. Nos. 6,294,398 and 6,468,819, which are incorporated by reference in their entireties, and patterning associated with some of the deposition methods such as ink-jet and organic vapor jet printing (OVJP). Other methods may also be used. The materials to be deposited may be modified to make them compatible with a particular deposition method. For example, substituents such as alkyl and aryl groups, branched or unbranched, and preferably containing at least 3 carbons, may be used in small molecules to enhance their ability to undergo solution processing. Substituents having 20 carbons or more may be used, and 3-20 carbons are 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.

[0331] Devices fabricated in accordance with embodiments of the present disclosure 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 plurality of alternative layers of polymeric material and non-polymeric material; organic material and inorganic material; or a mixture of a polymeric material and a non-polymeric material as one example 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.

[0332] Devices fabricated in accordance with embodiments of the present disclosure can be incorporated into a wide variety of electronic component modules (or units) that can be incorporated into a variety of electronic products or intermediate components. Examples of such electronic products or intermediate components include display screens, lighting devices such as discrete light source devices or lighting panels, etc. that can be utilized by the end-user product manufacturers. Such electronic component modules can optionally include the driving electronics and/or power source(s). Devices fabricated in accordance with embodiments of the present disclosure can be incorporated into a wide variety of consumer products that have one or more of the electronic component modules (or units) incorporated therein. A consumer product comprising an OLED that includes the compound of the present disclosure in the organic layer in the OLED is disclosed. Such consumer products would include any kind of products that include one or more light source(s) and/or one or more of some type of visual displays. Some examples of such consumer products include flat panel displays, curved displays, computer monitors, medical monitors, televisions, billboards, lights for interior or exterior illumination and/or signaling, heads-up displays, fully or partially transparent displays, flexible displays, rollable displays, foldable displays, stretchable displays, laser printers, telephones, mobile phones, tablets, phablets, personal digital assistants (PDAs), wearable devices, laptop computers, digital cameras, camcorders, viewfinders, micro-displays (displays that are less than 2 inches diagonal), 3-D displays, virtual reality or augmented reality displays, vehicles, video walls comprising multiple displays tiled together, theater or stadium screen, a light therapy device, and a sign. Various control mechanisms may be used to control devices fabricated in accordance with the present disclosure, 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° C.), but could be used outside this temperature range, for example, from −40 degree C. to +80° C.

[0333] 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.

[0334] 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.

[0335] In some embodiments, the OLED has one or more characteristics selected from the group consisting of being flexible, being rollable, being foldable, being stretchable, and being curved. In some embodiments, the OLED is transparent or semi-transparent. In some embodiments, the OLED further comprises a layer comprising carbon nanotubes. In some embodiments, the OLED further comprises one or more quantum dots. Such quantum dots can be in the emissive layer, or in other functional layers, such as a down conversion layer.

[0336] In some embodiments, the OLED comprises a RGB pixel arrangement or white plus color filter pixel arrangement. In some embodiments, the OLED is a mobile device, a handheld device, or a wearable device. In some embodiments, the OLED is a display panel having less than 10 inch diagonal or 50 square inch area. In some embodiments, the OLED is a display panel having at least 10 inch diagonal or 50 square inch area. In some embodiments, the OLED is a lighting panel.

D. Other Materials Used in the OLED

[0337] The materials described herein are as various examples useful for a particular layer in an OLED. They may also be used in combination with a wide variety of other materials present in the device. For example, emissive dopants disclosed herein may be used by themselves in the EML, or in conjunction with a wide variety of other emitters,

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 and the devices disclosed herein, and one of skill in the art can readily consult the literature to identify other materials that may be useful in combination.

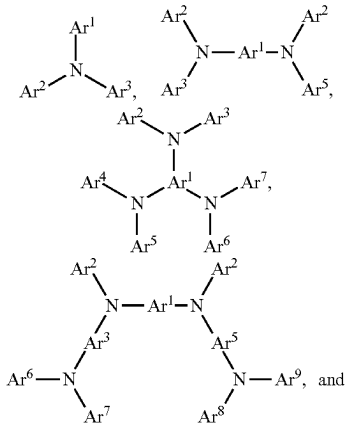
a) Conductivity Dopants:

[0338] A charge transport layer can be doped with conductivity dopants to substantially alter its density of charge carriers, which will in turn alter its conductivity. The conductivity is increased by generating charge carriers in the matrix material, and depending on the type of dopant, a change in the Fermi level of the semiconductor may also be achieved. Hole-transporting layer can be doped by p-type conductivity dopants and n-type conductivity dopants are used in the electron-transporting layer. In some embodiments, conductivity dopants comprise at least one chemical moiety selected from the group consisting of cyano, fluorinated aryl or heteroaryl, fluorinated alkyl or cycloalkyl, alkylene, heteroaryl, amide, benzodithiophene, and highly conjugated heteroaryl groups extended by non-ring double bonds.

b) HIL/HTL:

[0339] A hole injecting/transporting material to be used in the present disclosure is not particularly limited, and any compound may be used as long as the compound is typically used as a hole injecting/transporting material. Examples of the material include, but are not limited to: a phthalocyanine or porphyrin derivative; an aromatic amine derivative; an indolocarbazole derivative; a polymer containing fluorohydrocarbon; a polymer with conductivity dopants; a conducting polymer, such as PEDOT/PSS; a self-assembly monomer derived from compounds such as phosphonic acid and silane derivatives; a metal oxide derivative, such as MoO_x; a p-type semiconducting organic compound, such as 1,4,5,8,9,12-Hexaazatriphenylenehexacarbonitrile; a metal complex, and a cross-linkable compounds.

[0340] Examples of aromatic amine derivatives used in HIL or HTL include, but not limit to the following general structures:



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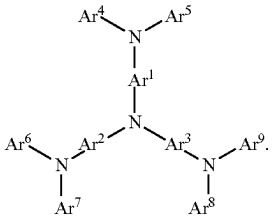
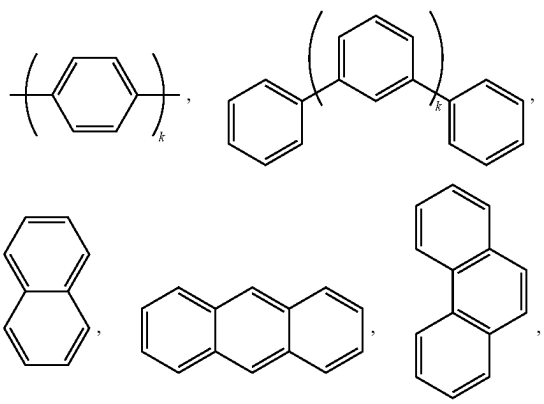


[0341] Each of Ar^1 to Ar^9 is selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene; the group consisting of aromatic heterocyclic compounds such as 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, benzofuropyridine, furodipyridine, benzothienopyridine, thienodipyridine, benzoselenophenopyridine, and selenophenodipyridine; and the group consisting of 2 to 10 cyclic structural units which are groups of the same type or different types selected from the aromatic hydrocarbon cyclic group and the aromatic heterocyclic group and are bonded to each other directly or via at least one of oxygen atom, nitrogen atom, sulfur atom, silicon atom, phosphorus atom, boron atom, chain structural unit and the aliphatic cyclic group. Each of Ar^1 to Ar^9 may be unsubstituted or may be substituted by a general substituent as described above, any two substituents can be joined or fused into a ring.

[0342] In some embodiments, each Ar^1 to Ar^9 independently comprises a moiety selected from the group consisting of:



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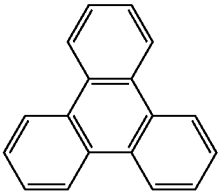
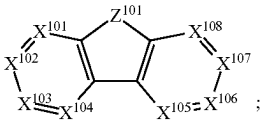


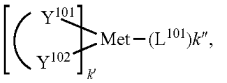
, and



;

wherein k is an integer from 1 to 20; X^{101} to X^{108} is C or N; Z^{101} is C, N, O, or S.

[0343] Examples of metal complexes used in HIL or HTL include, but are not limited to the following general formula:



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

[0344] In some embodiments, (Y^{101}-Y^{102}) is a 2-phenylpyridine or 2-phenylimidazole derivative. In some embodiments, (Y^{101}-Y^{102}) is a carbene ligand. In some embodiments, Met is selected from Ir, Pt, Pd, Os, Cu, and Zn. In some embodiments, the metal complex has a smallest oxidation potential in solution vs. Fc^{+}/Fc couple less than about 0.6 V.

[0345] In some embodiments, the HIL/HTL material is selected from the group consisting of phthalocyanine and porphryin compounds, starburst triarylamines, CF_x fluorohydrocarbon polymer, conducting polymers (e.g., PEDOT:PSS, polyaniline, polypthiophene), phosphonic acid and sliane SAMs, triarylamine or polythiophene polymers with conductivity dopants, Organic compounds with conductive inorganic compounds (such as molybdenum and tungsten oxides), n-type semiconducting organic complexes, metal organometallic complexes, cross-linkable compounds, polythiophene based polymers and copolymers, triarylamines, triaylamine with spirofluorene core, arylamine carbazole compounds, triarylamine with (di)benzothiophene/(di)benzofuran, indolocarbazoles, isoindole compounds, and metal carbene complexes.

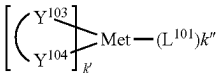
c) EBL:

[0346] An electron blocking layer (EBL) may be used to reduce the number of electrons and/or excitons that leave the emissive layer. The presence of such a blocking layer in a device may result in substantially higher efficiencies, and/or longer lifetime, as compared to a similar device lacking a blocking layer. Also, a blocking layer may be used to confine emission to a desired region of an OLED. In some embodiments, the EBL material has a higher LUMO (closer to the vacuum level) and/or higher triplet energy than one or more emitters closest to the EBL interface. In some embodiments, the compound used in EBL contains at least one carbazole group and/or at least one arylamine group. In some embodiments the HOMO level of the compound used in the EBL is shallower than the HOMO level of one or more of the hosts in the EML. In some embodiments, the compound used in EBL contains the same molecule or the same functional groups used as one of the hosts described herein.

d) Hosts:

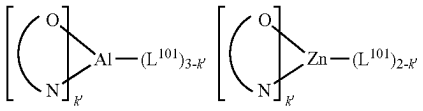
[0347] The light emitting layer of the organic EL device of the present disclosure preferably contains at least a light emitting material as the dopant, and a host material. Examples of the host material are not particularly limited, and any metal complexes or organic compounds may be used as long as the host won't fully quench the emission of the dopant.

[0348] Examples of metal complexes used as host are preferred to have the following general formula:



wherein Met is a metal; (Y^{103}-Y^{104}) is a bidentate ligand, the coordinating atoms of Y^{103} and Y^{104} are independently selected from C, N, O, P, and S; L^{101} is an another ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached to the metal; and k'+k" is the maximum number of ligands that may be attached to the metal.

[0349] In some embodiments, the metal complexes are:



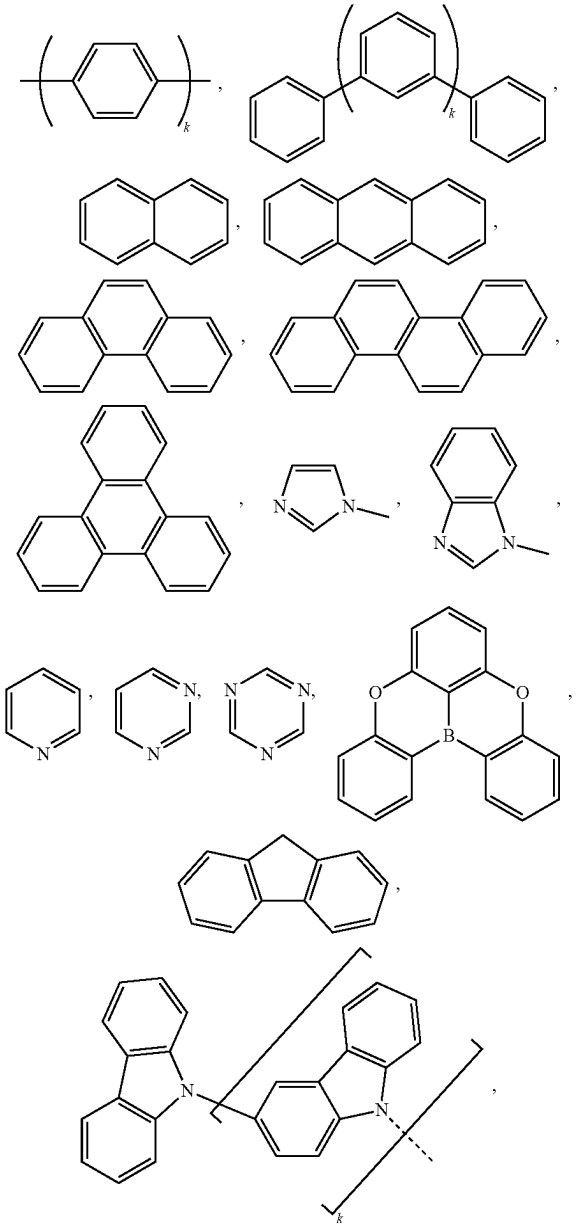
wherein (O—N) is a bidentate ligand, having metal coordinated to atoms O and N.

[0350] In some embodiments, Met is selected from Ir and Pt. In a further embodiment, (Y^{103}-Y^{104}) is a carbene ligand.

[0351] In some embodiments, the host compound contains at least one of the following groups selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, tetraphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene; the group consisting of aromatic heterocyclic compounds such as dibenzothiophene, dibenzofuran, dibenzoselenophene, furan, thiophene, benzofuran, benzothiophene, benzoselenophene, carbazole, indolocarbazole, pyridylindole, 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, aza-dibenzothiophene, aza-dibenzofuran, aza-dibenzoselenophene, aza-carbazole, aza-indolocarbazole, aza-triphenylene, aza-tetraphenylene, 5λ^2-benzo[d]benzo[4,5]imidazo[3,2-a]

imidazole, 5,9-dioxa-13b-boranaphtho[3,2,1-de]anthracene; and the group consisting of 2 to 10 cyclic structural units which are groups of the same type or different types selected from the aromatic hydrocarbon cyclic group and the aromatic heterocyclic group and are bonded to each other directly or via at least one of oxygen atom, nitrogen atom, sulfur atom, silicon atom, phosphorus atom, boron atom, chain structural unit and the aliphatic cyclic group. Each option within each group may be unsubstituted or may be substituted by the General Substituents as described herein or may be further fused.

[0352] In some embodiments, the host compound comprises at least one of the moieties selected from the group consisting of:



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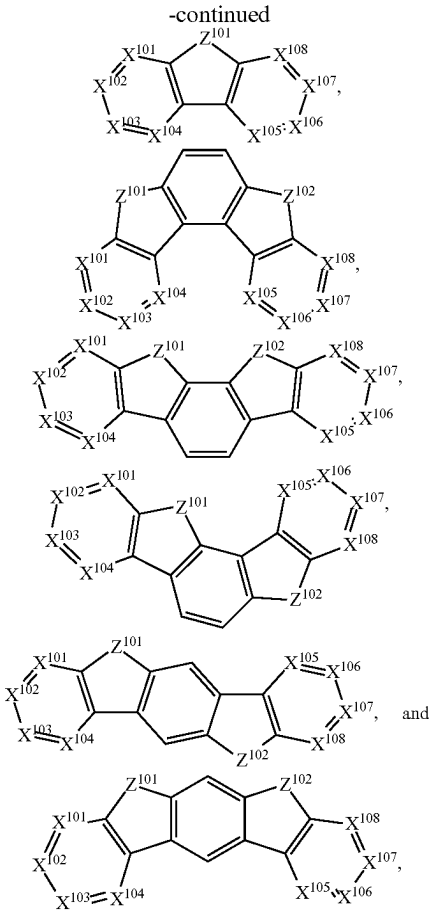


wherein k is an integer from 0 to 20 or 1 to 20. X^{101} to X^{108} are independently selected from C or N. Z^{101} and Z^{102} are independently selected from C, N, O, or S.

[0353] In some embodiments, the host material is selected from the group consisting of arylcarbazoles, metal 8-hydroxyquinolates, (e.g., alq3, balq), metal phenoxybenzothiazole compounds, conjugated oligomers and polymers (e.g., polyfluorene), aromatic fused rings, zinc complexes, chrysene based compounds, aryltriphenylene compounds, poly-fused heteroaryl compounds, donor acceptor type molecules, dibenzofuran/dibenzothiophene compounds, polymers (e.g., pvk), spirofluorene compounds, spirofluorene-carbazole compounds, indolocabazoles, 5-member ring electron deficient heterocycles (e.g., triazole, oxadiazole), tetraphenylene complexes, metal phenoxypyridine compounds, metal coordination complexes (e.g., Zn, Al with N^N ligands), dibenzothiophene/dibenzofuran-carbazole compounds, silicon/germanium aryl compounds, aryl benzoyl esters, carbazole linked by non-conjugated groups, aza-carbazole/dibenzofuran/dibenzothiophene compounds, and high triplet metal organometallic complexes (e.g., metal-carbene complexes).

e) Emitter Materials in EML:

[0354] One or more emitter materials may be used in conjunction with the compound or device of the present disclosure. The emitter material can be emissive or non-emissive in the current device as described herein. Examples

of the emitter materials are not particularly limited, and any compounds may be used as long as the compounds are capable of producing emissions in a regular OLED device. Examples of suitable emitter materials include, but are not limited to, compounds which are capable of producing emissions via phosphorescence, non-delayed fluorescence, delayed fluorescence, especially the thermally activated delayed fluorescence, i.e., TADF (also referred to as E-type delayed fluorescence), triplet-triplet annihilation, or combinations of these processes.

[0355] In some embodiments, the emitter material has the formula of $M(L^1)_x(L^2)_y(L^3)_z$;

[0356] wherein L^1, L^2, and L^3 can be the same or different;

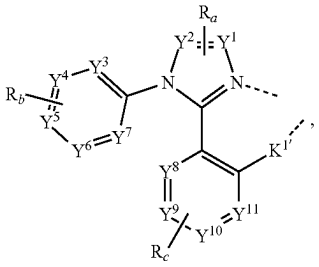
[0357] wherein x is 1, 2, or 3;

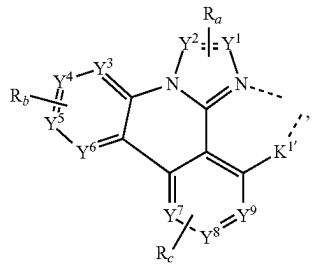
[0358] wherein y is 0, 1, or 2;

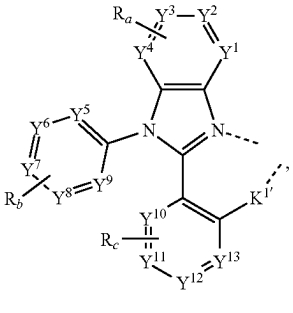
[0359] wherein z is 0, 1, or 2;

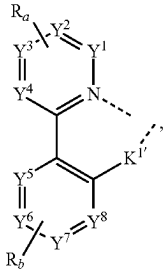
[0360] wherein x+y+z is the oxidation state of the metal M;

[0361] wherein L^1 is selected from the group consisting of the structures of LIGAND LIST:









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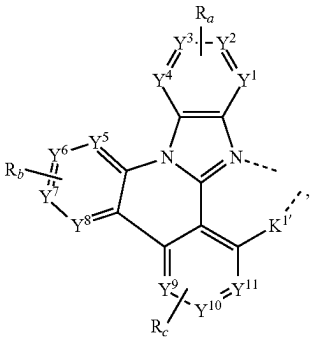

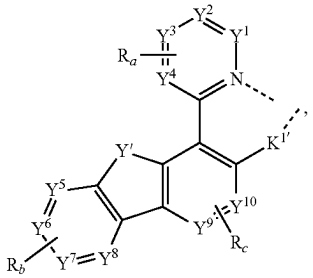

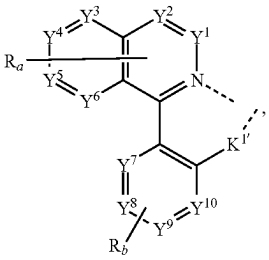

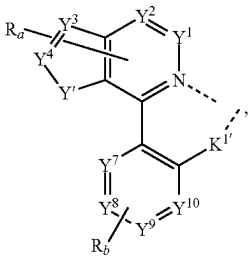

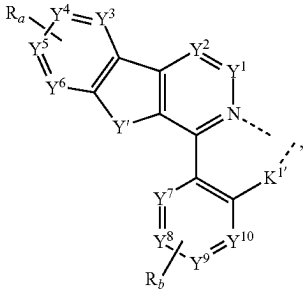

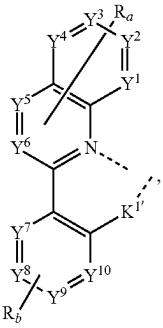

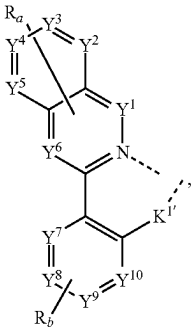

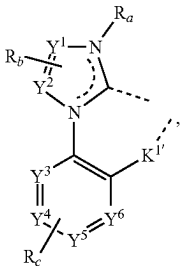

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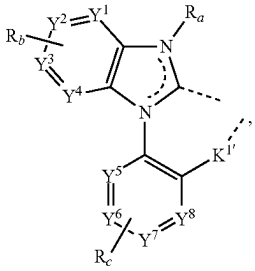

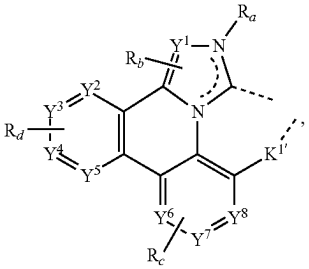

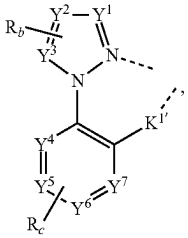

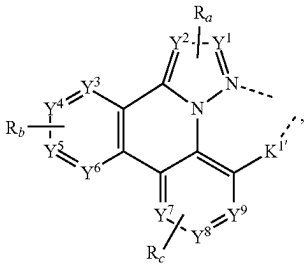

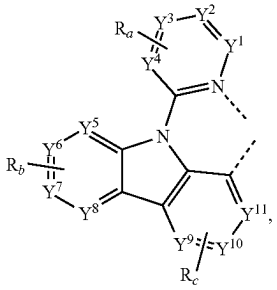

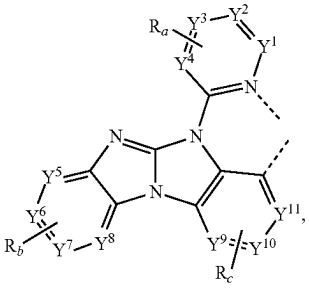

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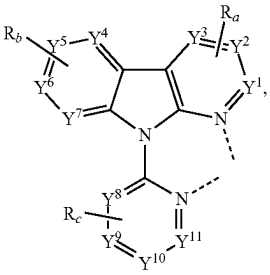

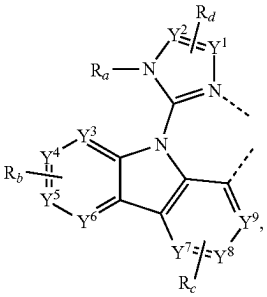

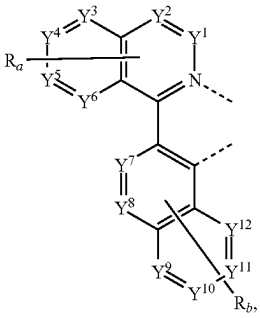

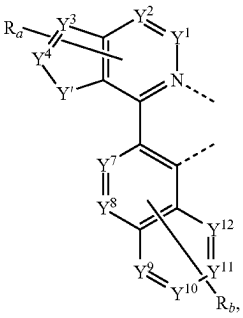

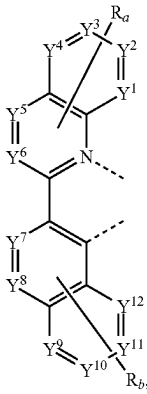

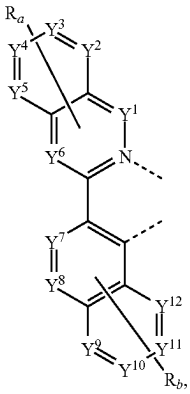

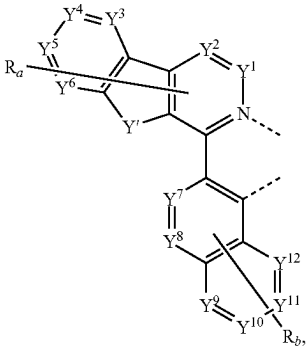

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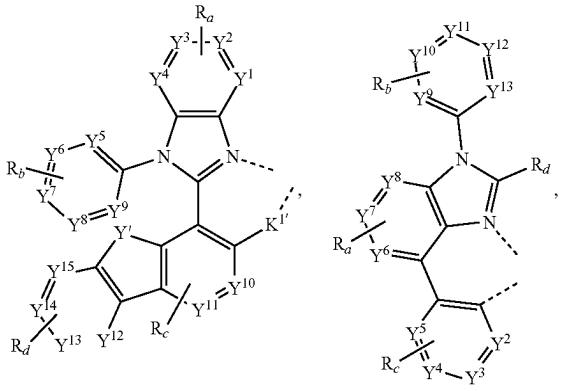

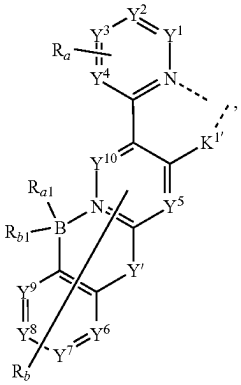

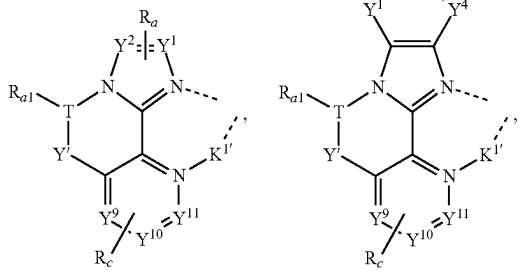

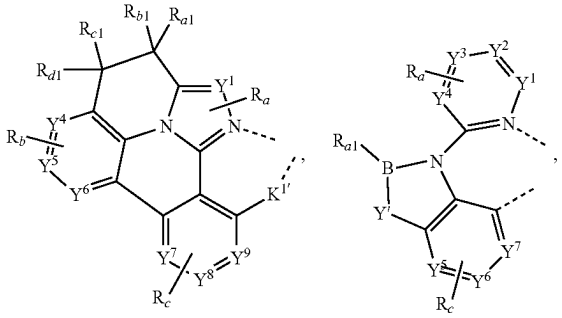

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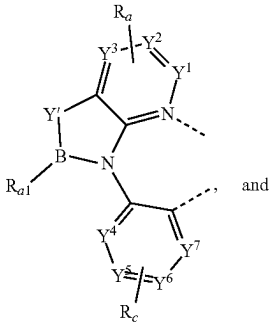
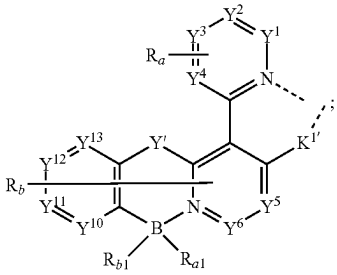
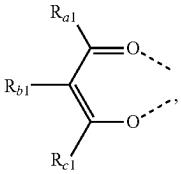


and



wherein each L^2 and L^3 are independently selected from the group consisting of



and the structures of LIGAND LIST; wherein:

[0362] M is selected from the group consisting of Ir, Rh, Re, Ru, Os, Pt, Pd, Zn, Au, Ag, and Cu;

[0363] T is selected from the group consisting of B, A1, Ga, and In;

[0364] $K^{1'}$ is a direct bond or is selected from the group consisting of NR_e, PR_e, O, S, and Se;

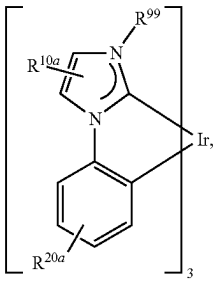
[0365] each Y^1 to Y^{15} are independently selected from the group consisting of carbon and nitrogen;

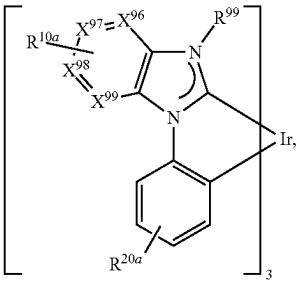
[0366] Y' is selected from the group consisting of BR_e, NR_e, PR_e, O, S, Se, C═O, S═O, SO_2, CR_eR_f, SiR_eR_f, and GeR_eR_f;

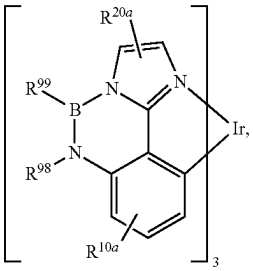
[0367] each R_a, R_b, R_c, and R_d can independently represent from mono to the maximum possible number of substitutions, or no substitution;

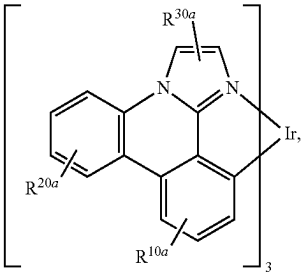
[0368] each R_{a1}, R_{b1}, R_{c1}, R_{d1}, R_a, R_b, R_c, R_d, R_e, and R_f is independently a hydrogen or a substituent selected from the group consisting of the General Substituents as defined herein; and wherein any two substituents can be fused or joined to form a ring or form a multidentate ligand.

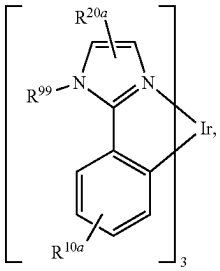
[0369] In some embodiments, the emitter material is selected from the group consisting of the following Dopant Group 1:

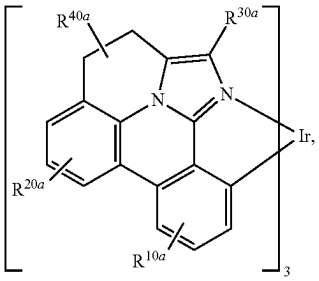


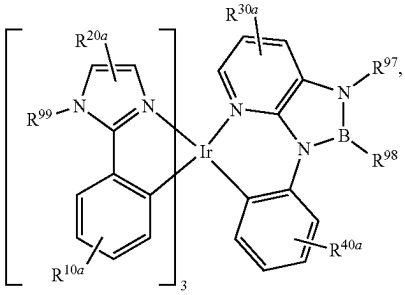












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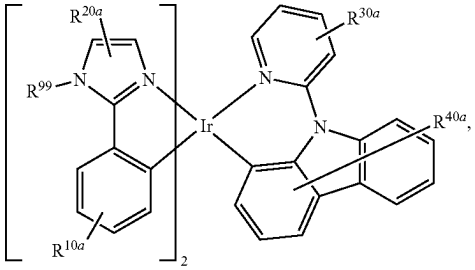

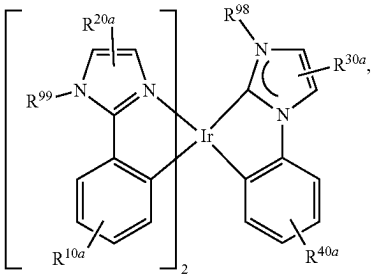

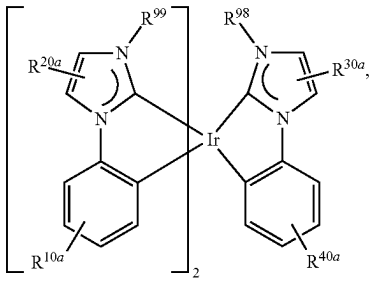

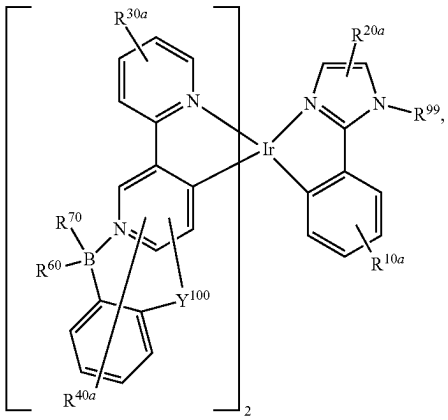

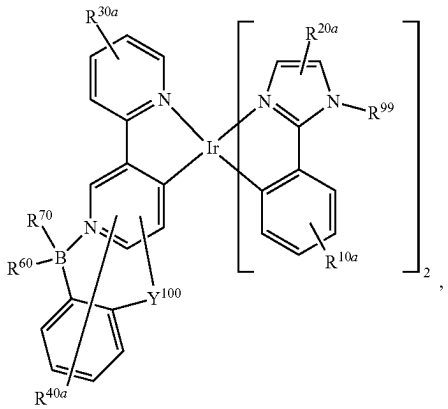

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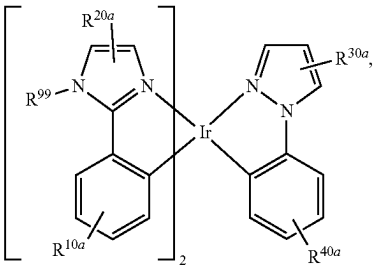

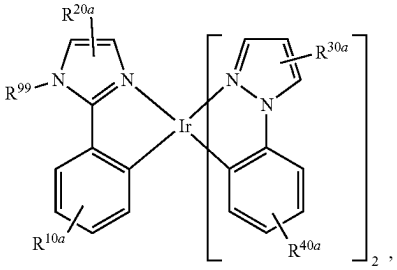

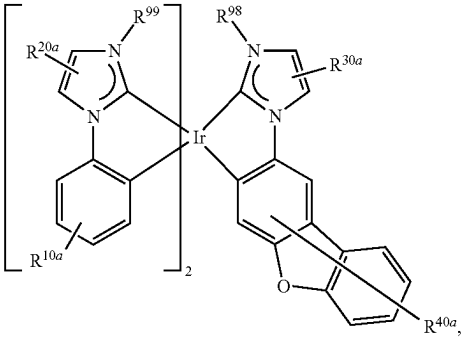

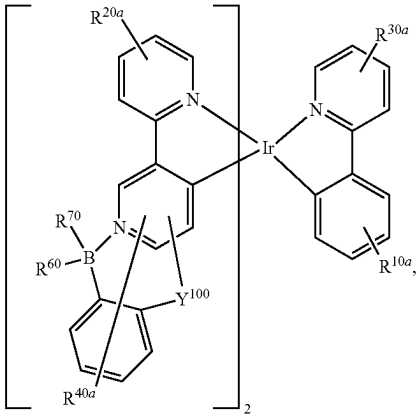

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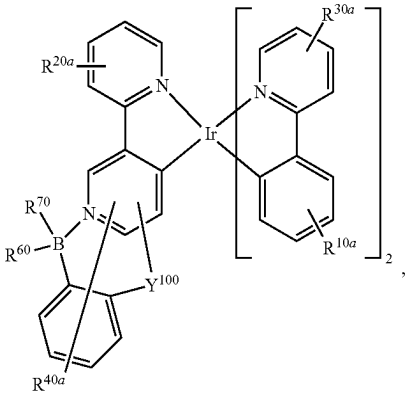

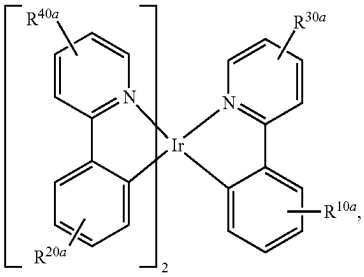

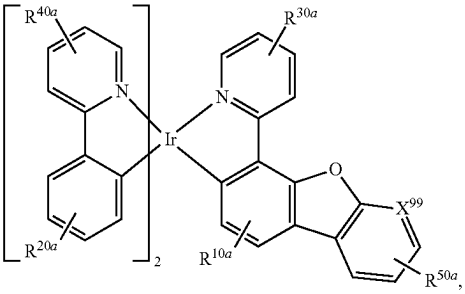

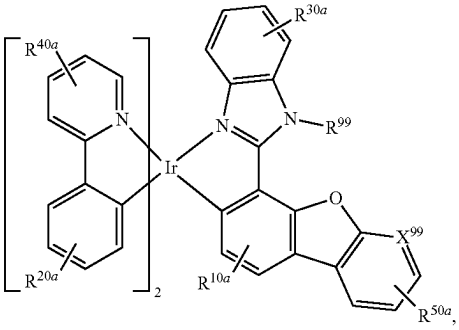

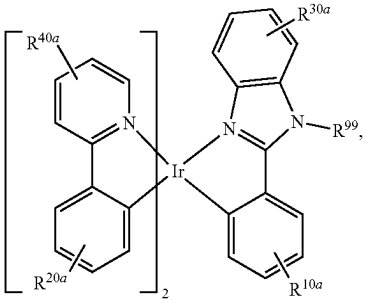

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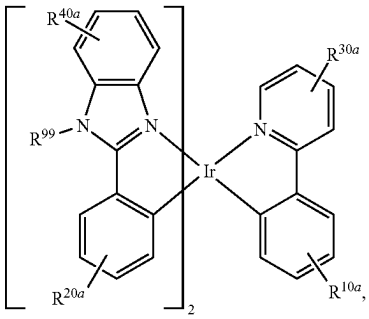

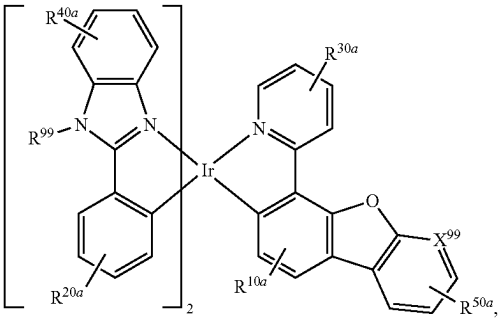

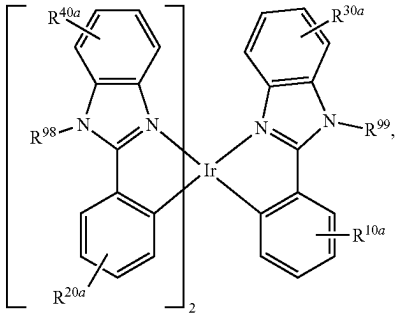

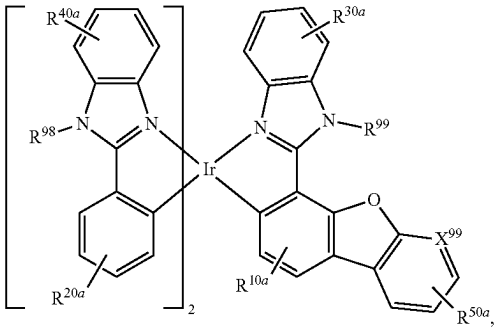

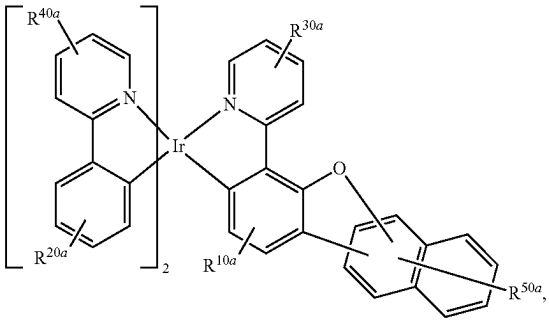

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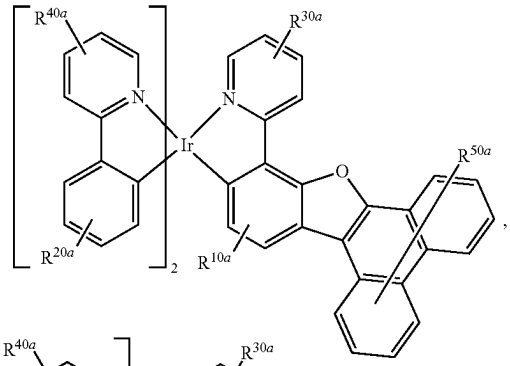

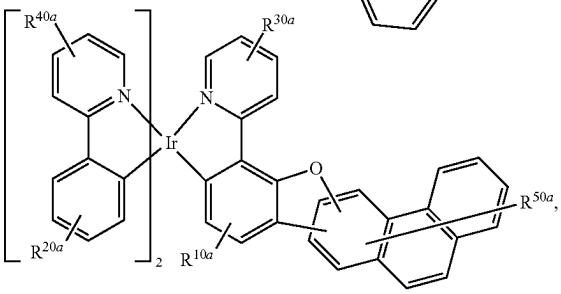

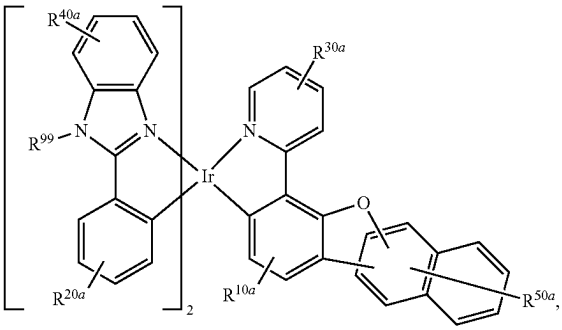

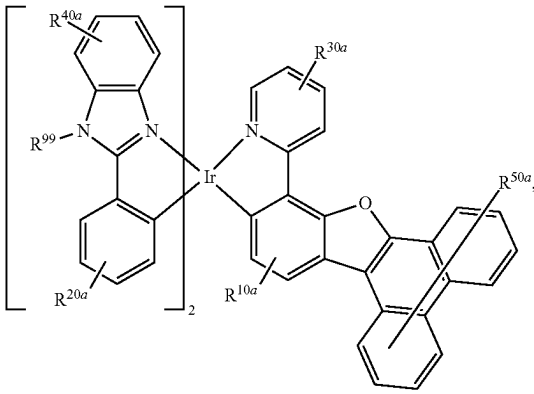

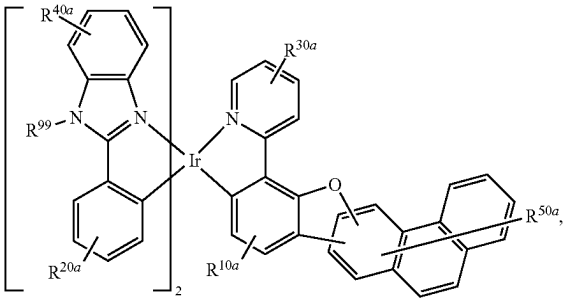

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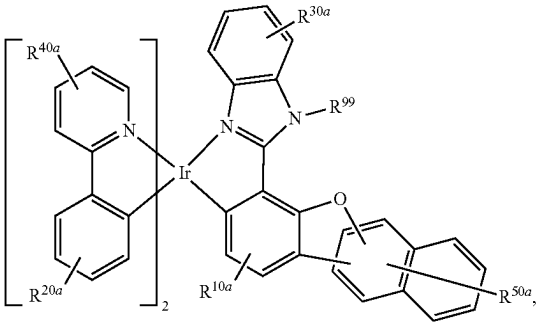

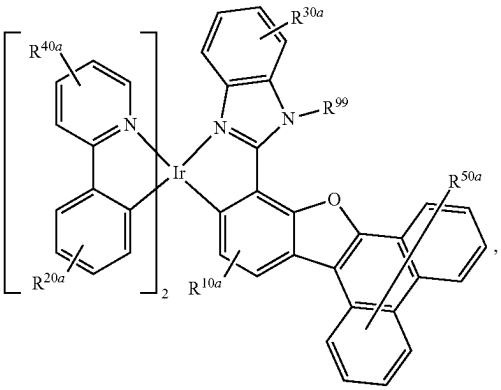

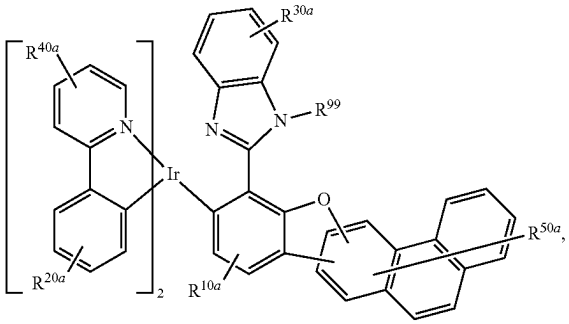

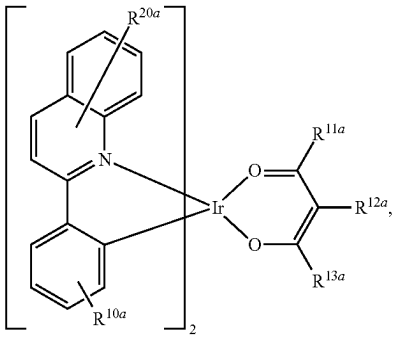

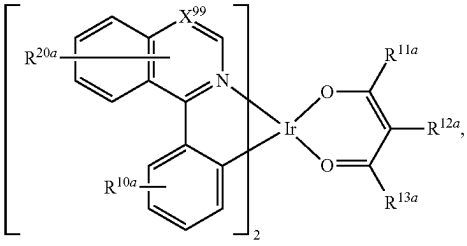

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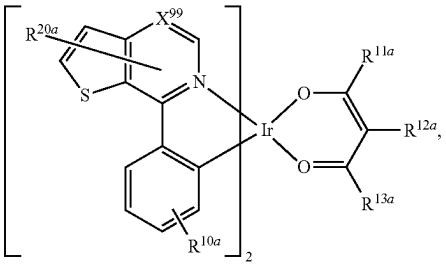

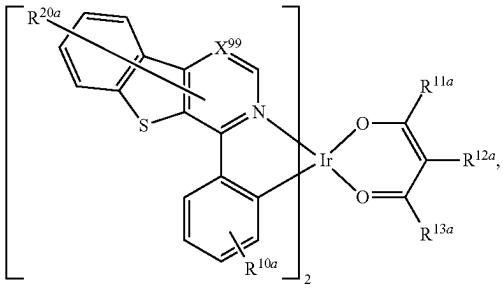

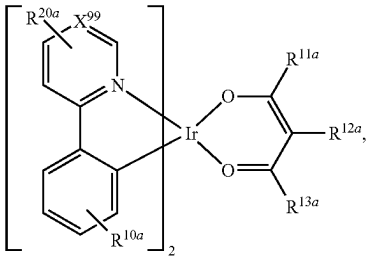

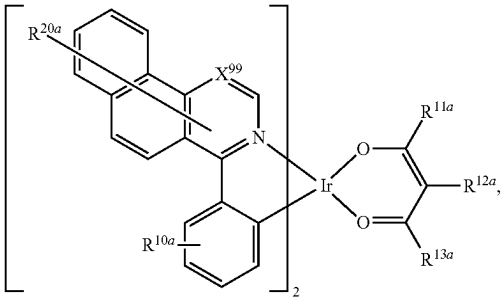

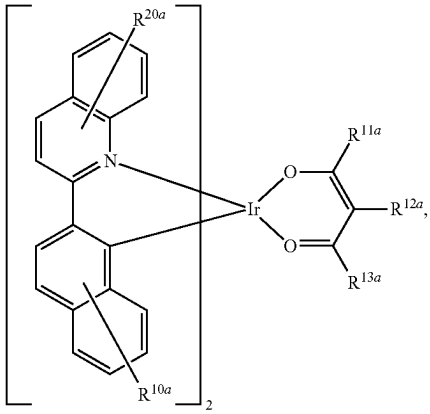

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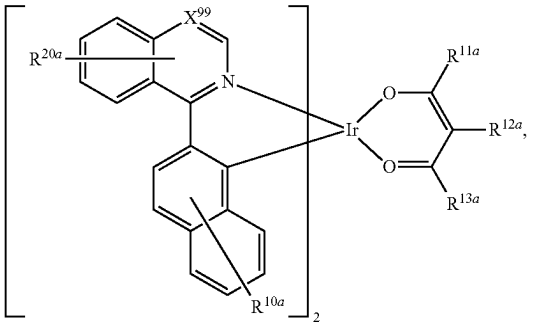

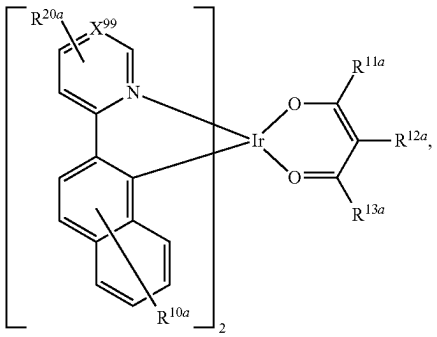

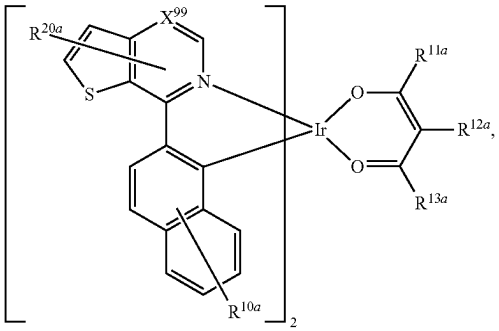

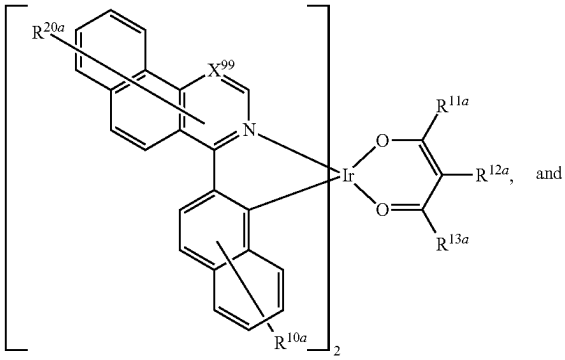

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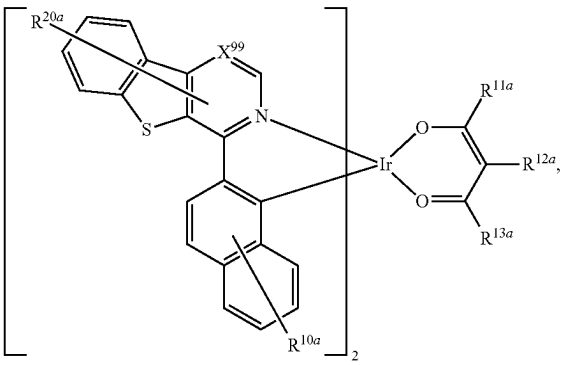


[0370] wherein

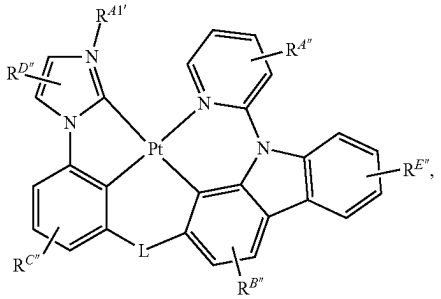
[0371] each of X^{96} to X^{99} is independently C or N;

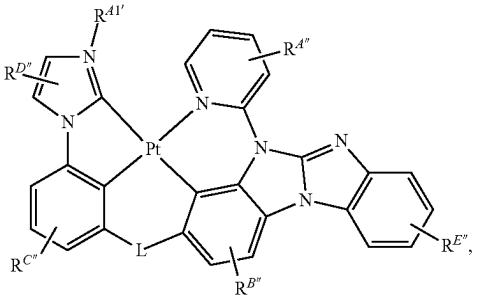
[0372] each Y^{100} is independently selected from the group consisting of a NR", O, S, and Se;

[0373] each of R^{10a}, R^{20a}, R^{30a}, R^{40a}, and R^{50a} independently represents mono substitution, up to the maximum substitutions, or no substitution;

[0374] each of R, R', R", R^{10a}, R^{11a}, R^{12a}, R^{13a}, R^{20a}, R^{30a}, R^{40a}, R^{50a}, R^{60}, R^{70}, R^{97}, R^{98}, and R^{99} is independently a hydrogen or a substituent selected from the group consisting of the General Substituents as defined herein; any two substituents can be joined or fused to form a ring.

[0375] In some embodiments, the emitter material is selected from the group consisting of the following Dopant Group 2:





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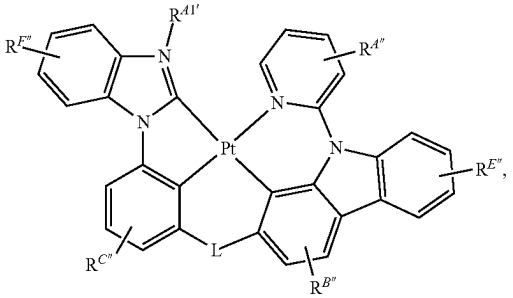

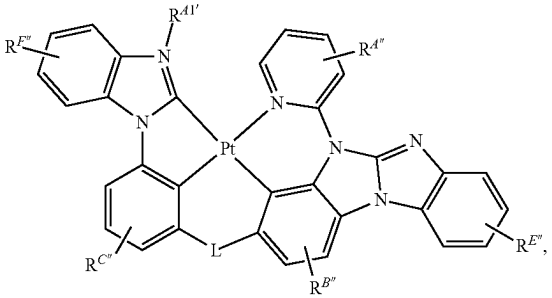

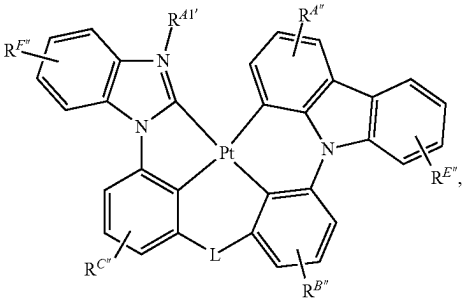

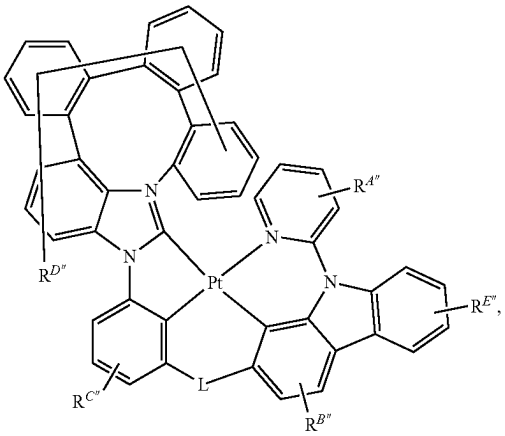

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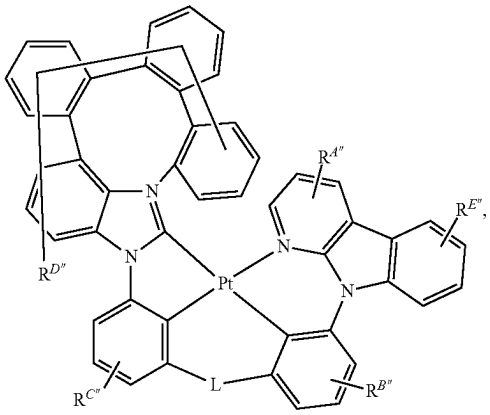

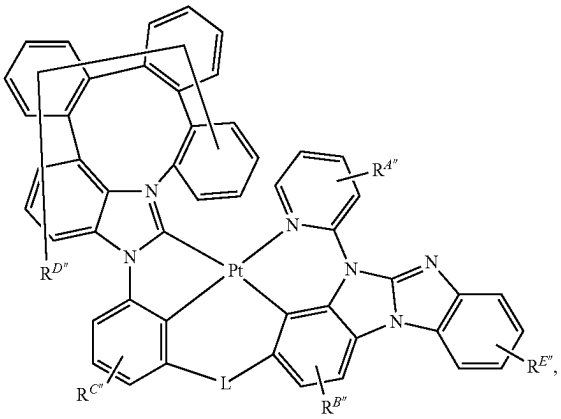

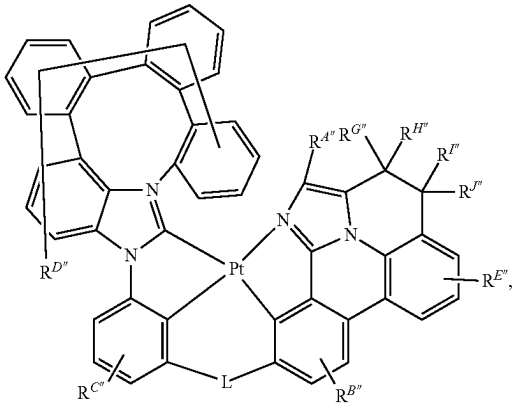

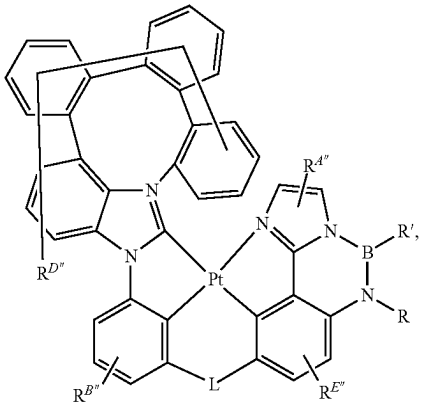

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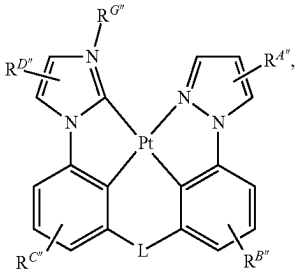

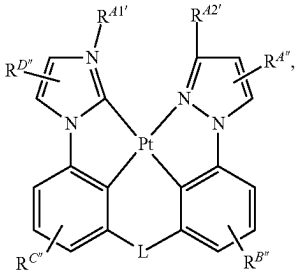

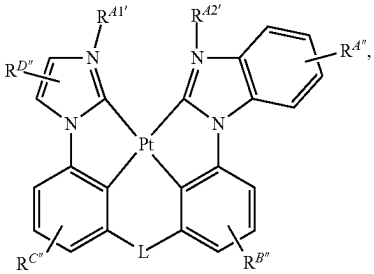

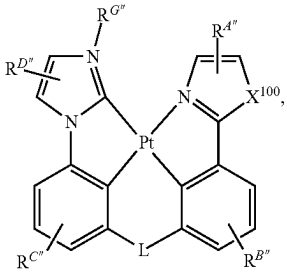

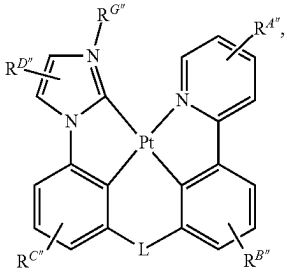

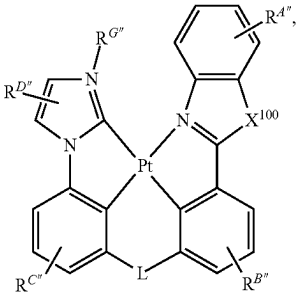

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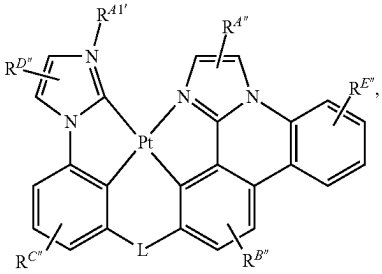

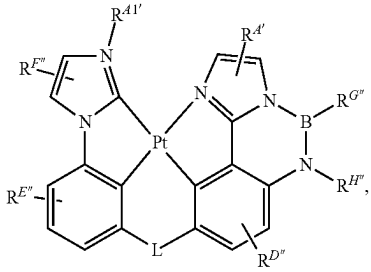

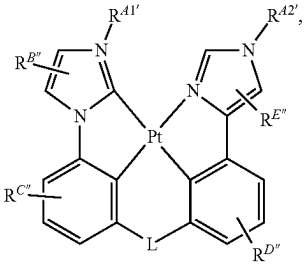

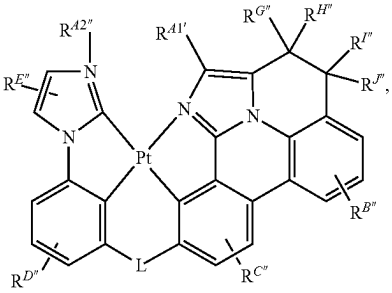

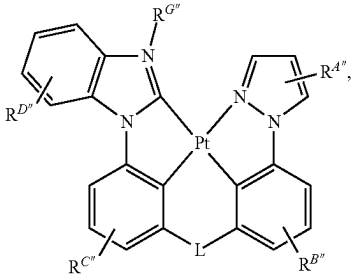

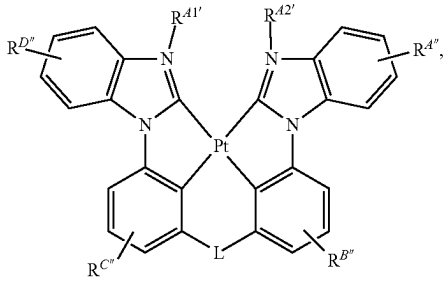

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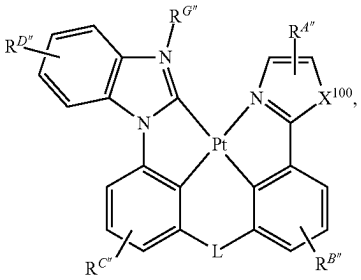

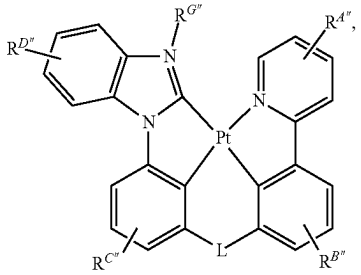

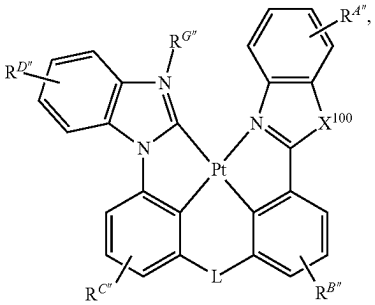

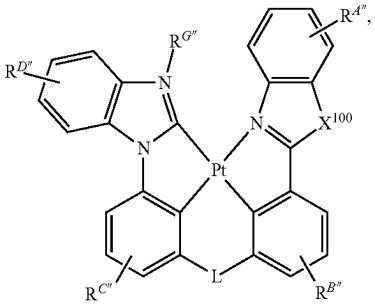

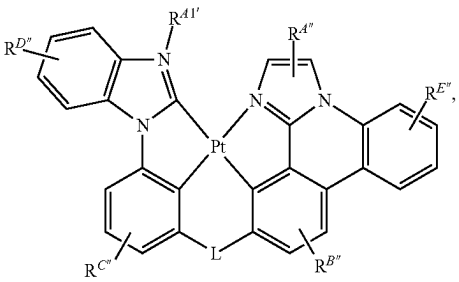

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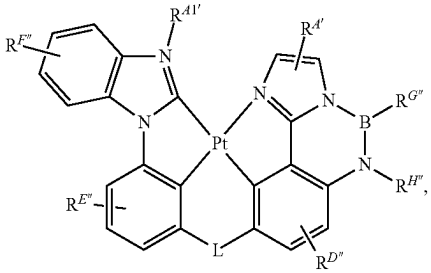

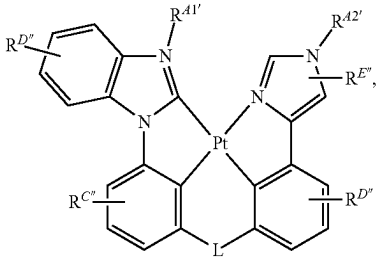

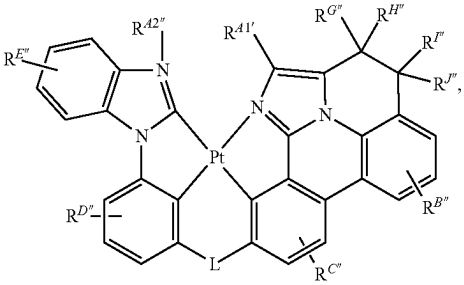

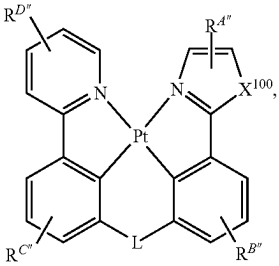

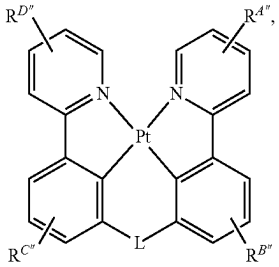

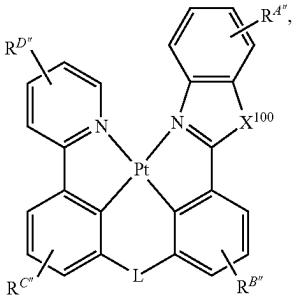

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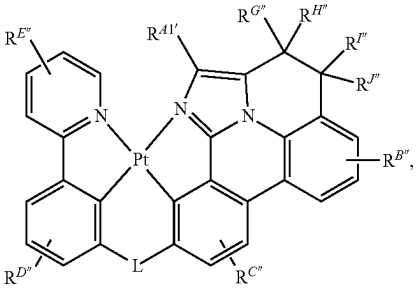

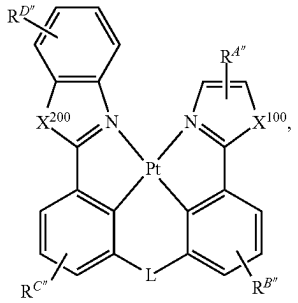

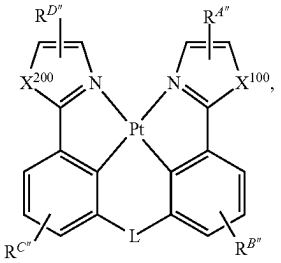

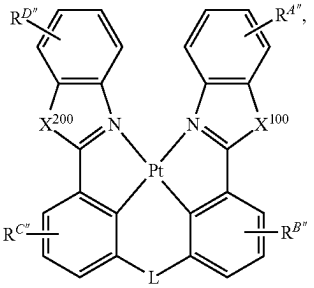

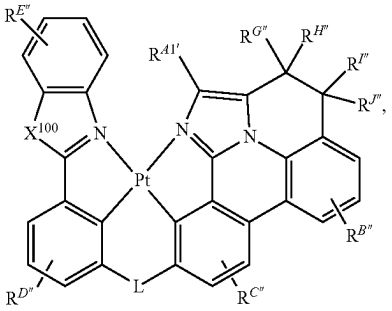

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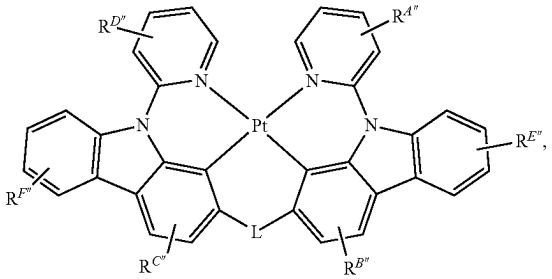

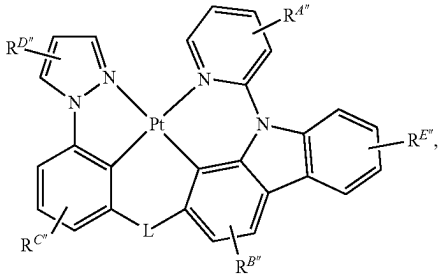

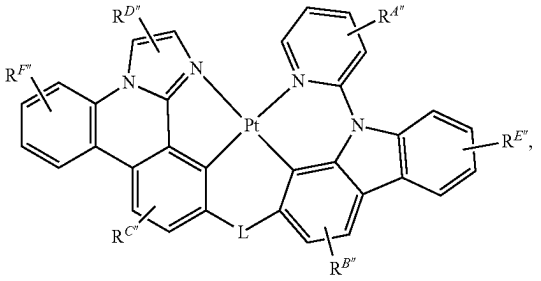

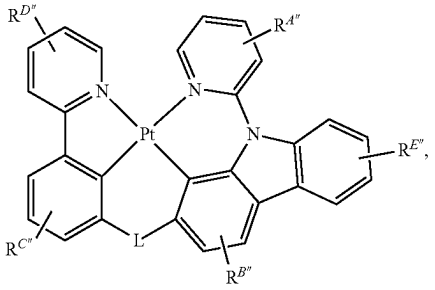

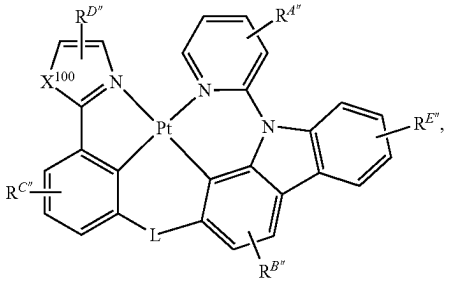

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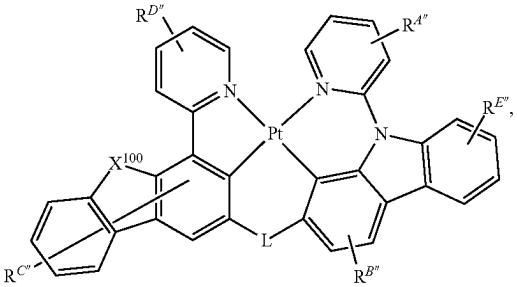

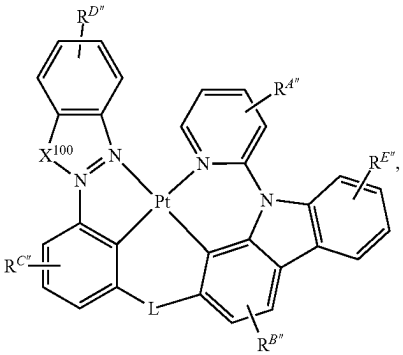

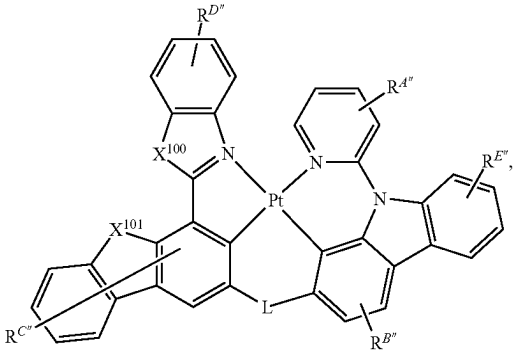

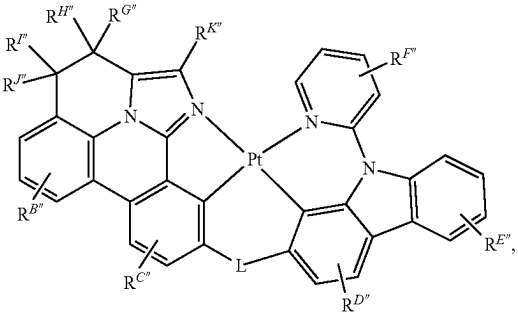

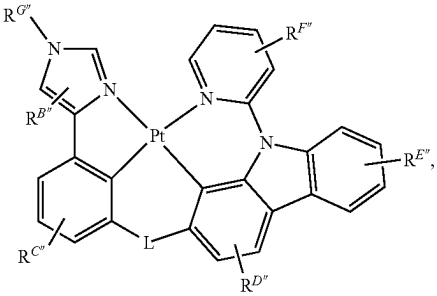

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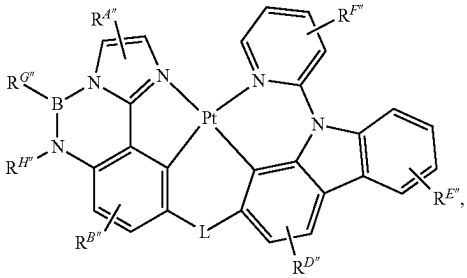

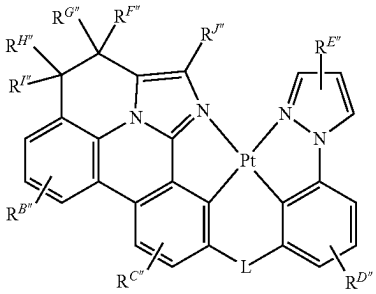

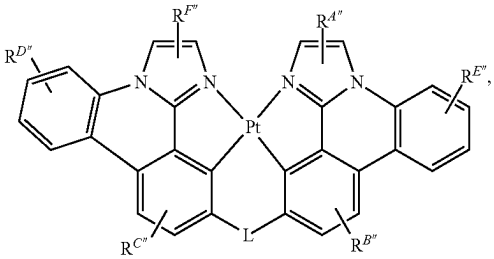

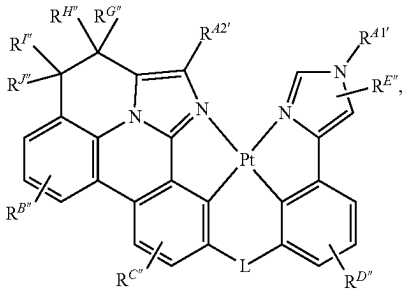

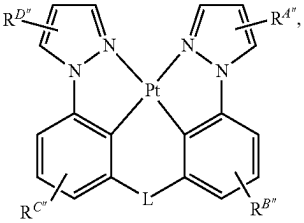

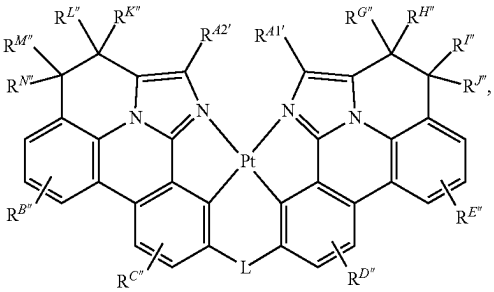

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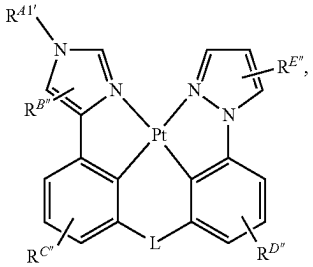

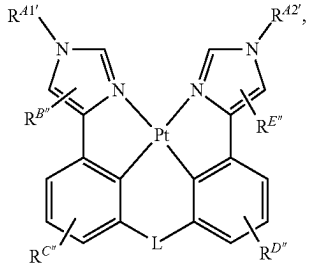

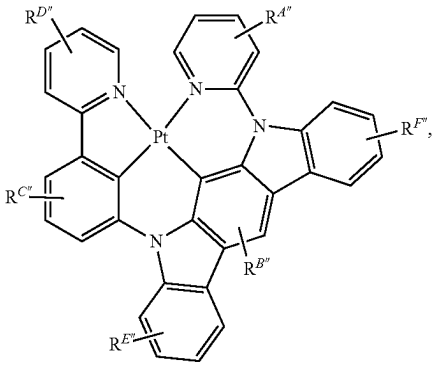

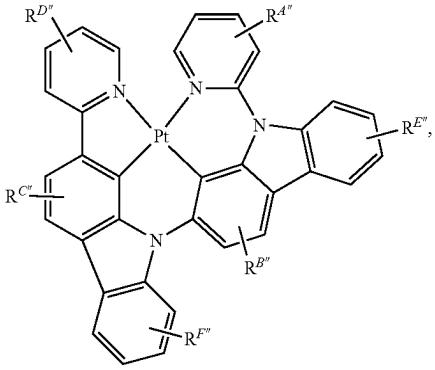

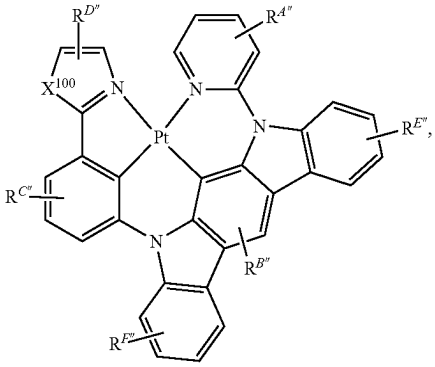

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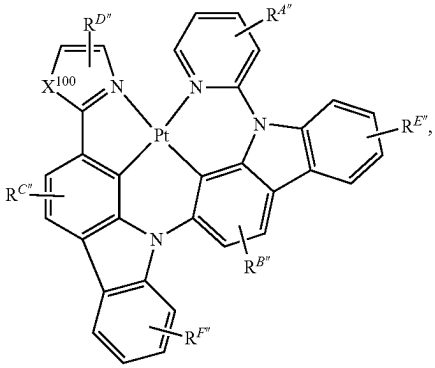

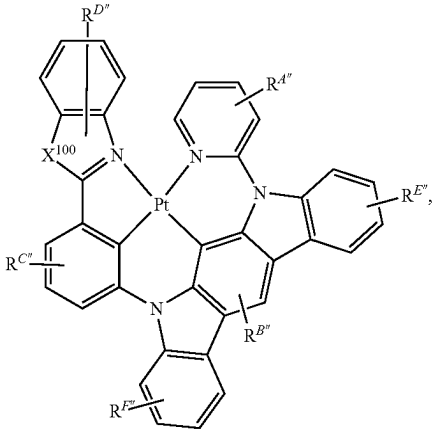

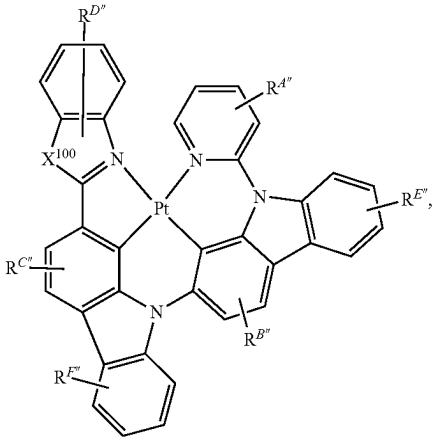

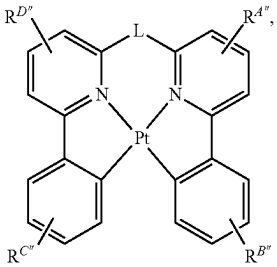

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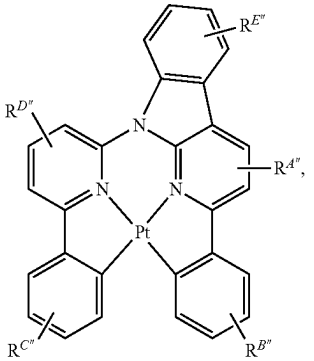

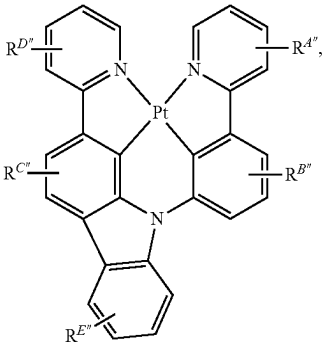

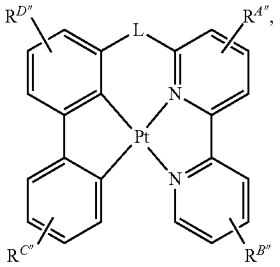

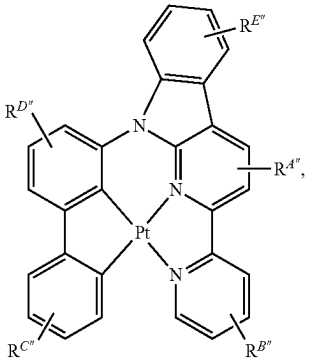

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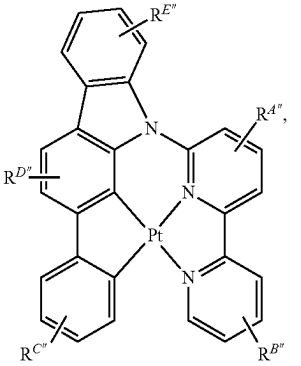

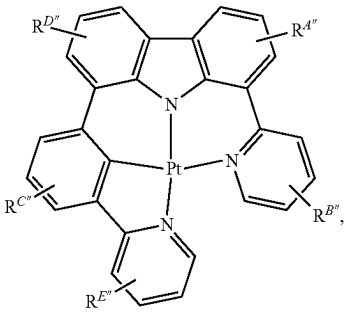

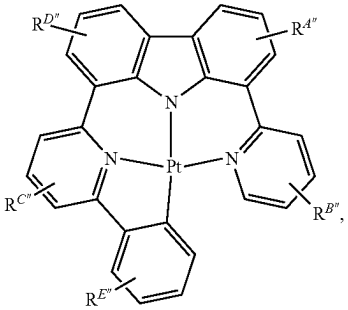

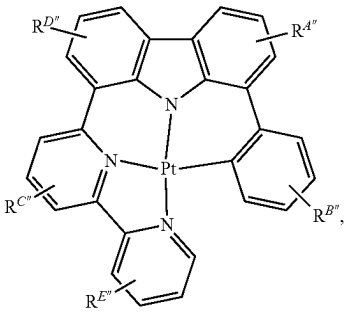

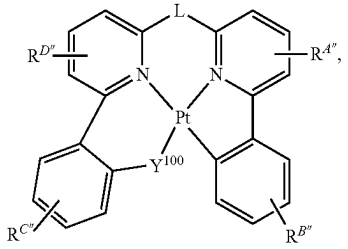

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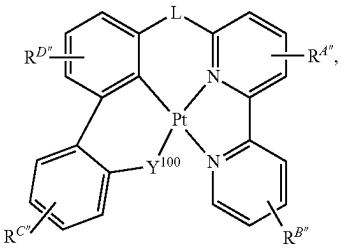

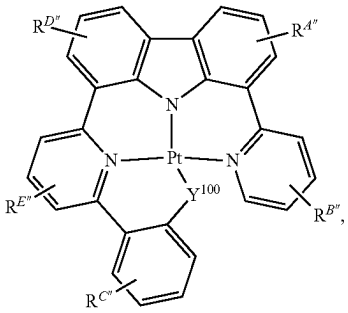

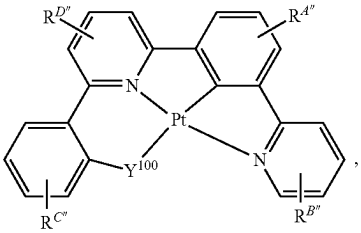

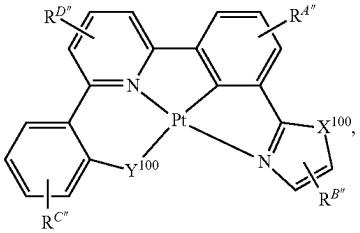

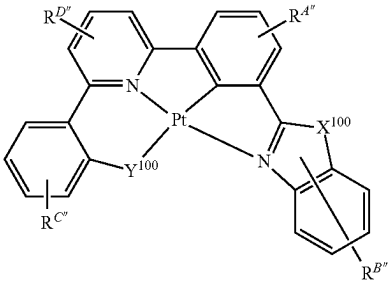

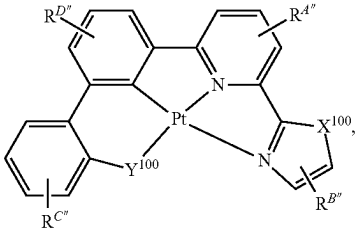

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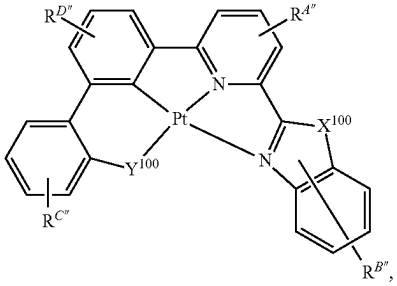

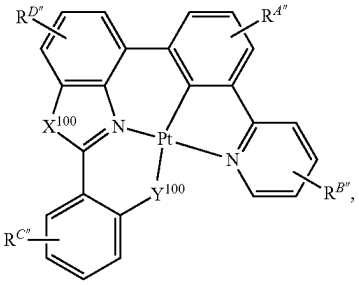

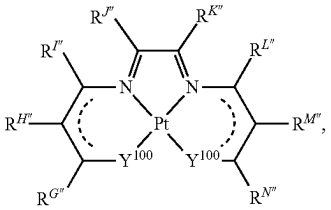

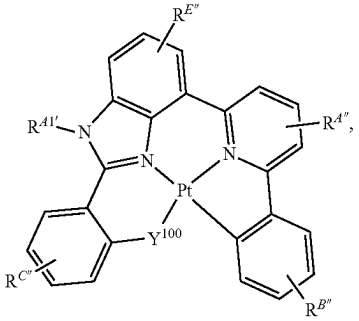

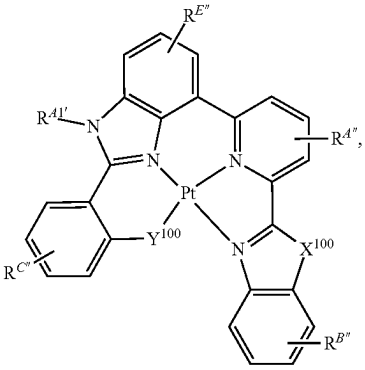

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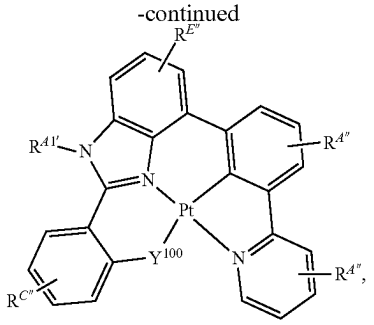


[0376] wherein:

[0377] each Y^{100} is independently selected from the group consisting of a NR", O, S, and Se;

[0378] L is independently selected from the group consisting of a direct bond, BR", BR"R'", NR", PR", O, S, Se, C═O, C═S, C═Se, C═NR", C═CR"R'", S═O, SO_2, CR", CR"R'", SiR"R'", GeR"R'", alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof;

[0379] X^{100} and X^{200} for each occurrence is selected from the group consisting of O, S, Se, NR", and CR"R'";

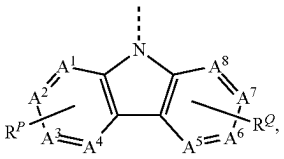
[0380] each R^{A}", R^{B}", R^{C}", R^{D}", R^{E}", and R^{F}" independently represents mono-, up to the maximum substitutions, or no substitutions;

[0381] each of R, R', R", R'", R^{A1}', R^{A2}', R^{A}", R^{B}", R^{C}", R^{D}", R^{E}", R^{F}", R^{G}", R^{H}", R^{I}", R^{J}", R^{K}", R^{L}", R^{M}", and R^{N}" is independently a hydrogen or a substituent selected from the group consisting of the General Substituents as defined herein; and any two substituents can be joined or fused to form a ring.

[0382] In some embodiments of the above Dopant Groups 1 and 2, each unsubstituted aromatic carbon atom can be replaced with N to form an aza-ring. In some embodiments, the maximum number of N atom in one ring is 1 or 2. In some embodiments of the above Dopant Groups 2, Pt atom in each formula can be replaced by Pd atom.

[0383] In some embodiments of the OLED, the delayed fluorescence material comprises at least one donor group and at least one acceptor group. In some embodiments, the delayed fluorescence material is a metal complex. In some embodiments, the delayed fluorescence material is a non-metal complex. In some embodiments, the delayed fluorescence material is a Zn, Cu, Ag, or Au complex.

[0384] In some embodiments of the OLED, the delayed fluorescence material has the formula of $M(L^5)(L^6)$, wherein M is Cu, Ag, or Au, L^5 and L^6 are different, and L^5 and L^6 are independently selected from the group consisting of:



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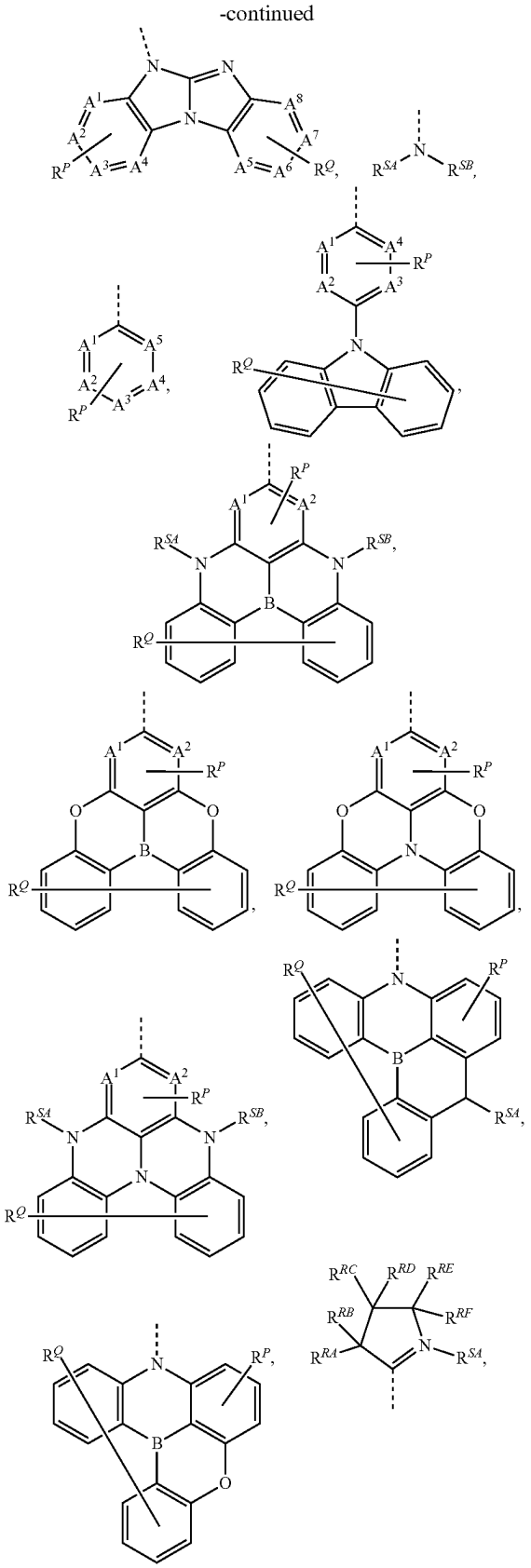

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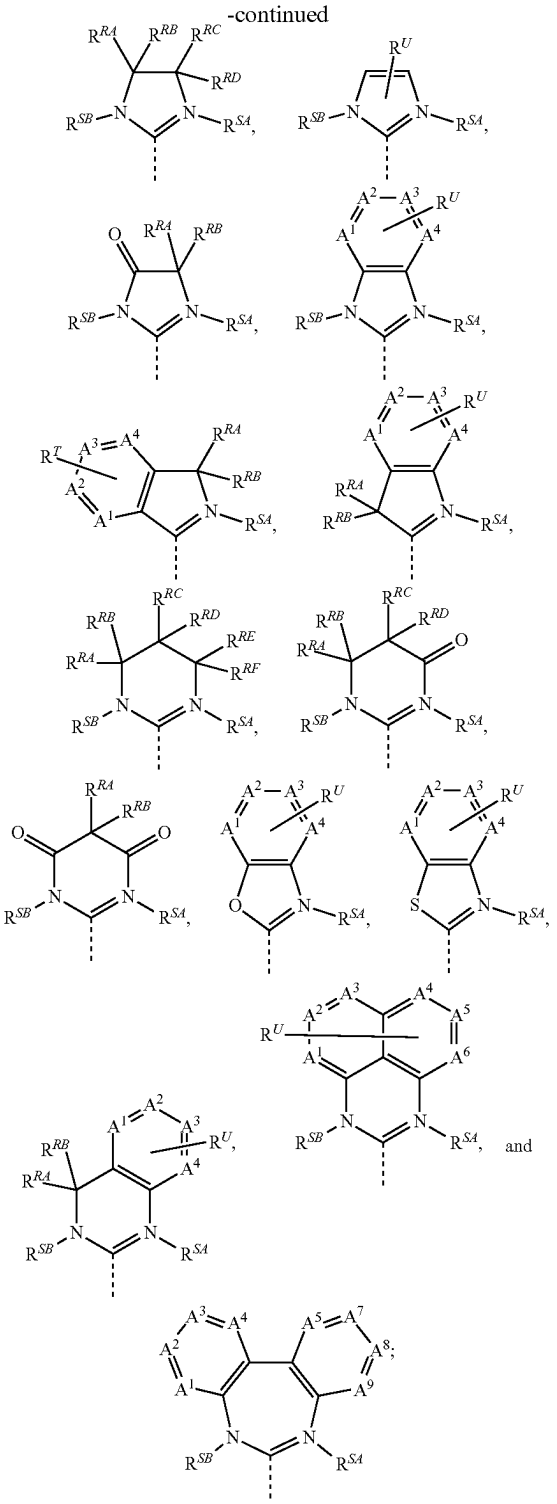
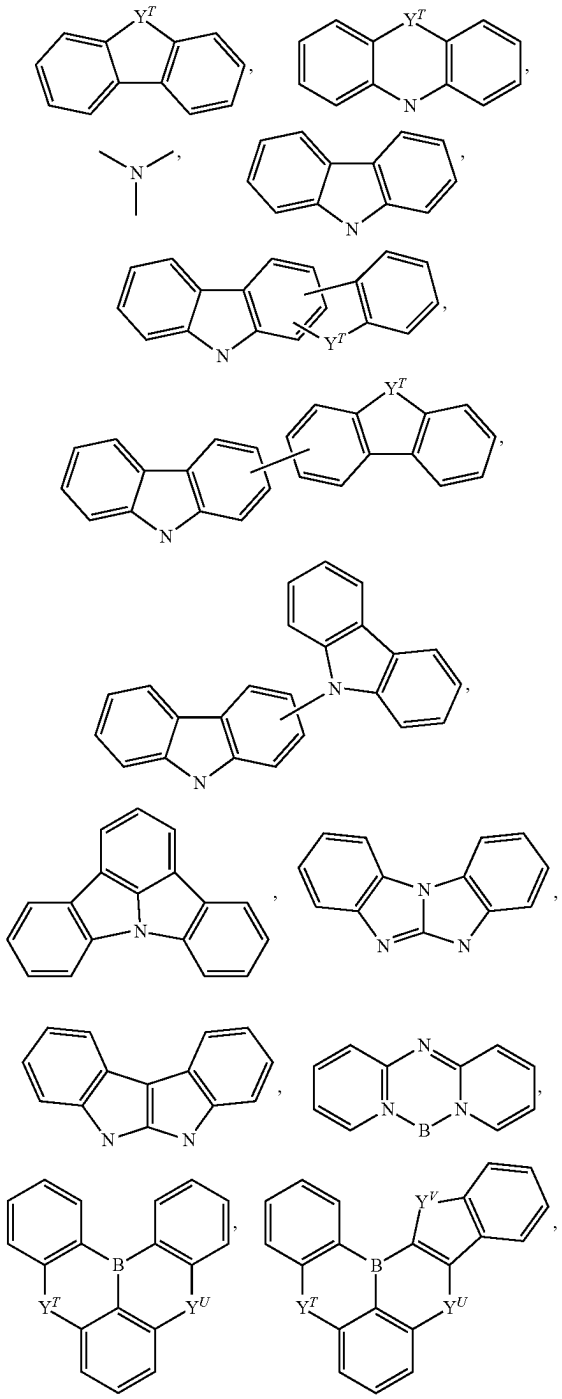


[0385] wherein A^1-A^9 are each independently selected from C or N;

[0386] each R^P, R^Q, and R^U independently represents mono-, np to the maximum substitutions, or no substitutions;

[0387] wherein each R^P, R^P, R^U, R^{SA}, R^{SB}, R^{RA}, R^{RB}, R^{RC}, R^{RD}, R^{RE}, and R^{RF} is independently a hydrogen or a substituent selected from the group consisting of the General Substituents as defined herein; any two substituents can be joined or fused to form a ring.

[0388] In some embodiments of the OLED, the delayed fluorescence material comprises at least one of the donor moieties selected from the group consisting of:



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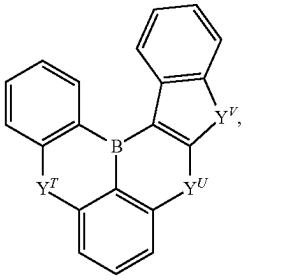

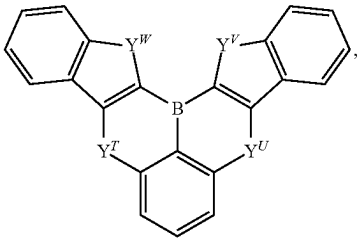

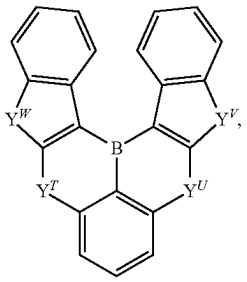

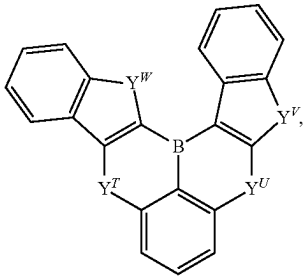

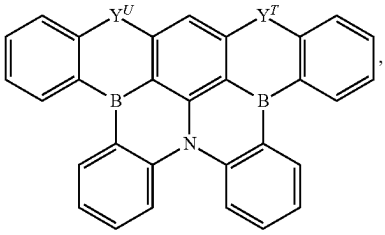

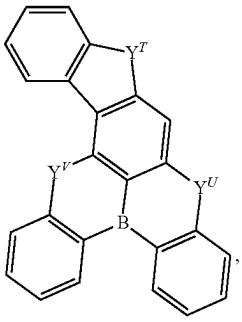

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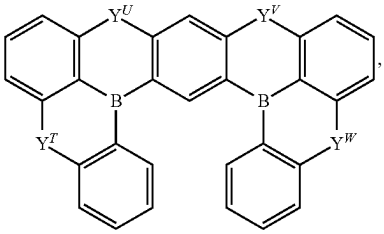

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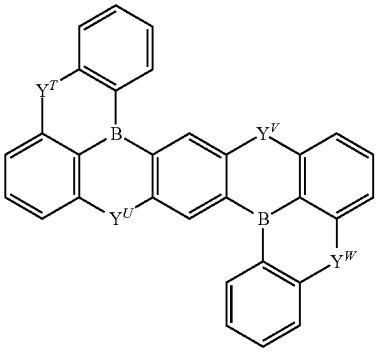
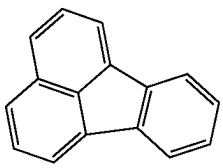


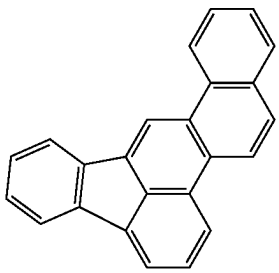
wherein Y^T, Y^U, Y^V, and Y^W are each independently selected from the group consisting of B, C, Si, Ge, N, P, O, S, Se, C═O, S═O, and SO_2.

[0389] In some of the above embodiments, any carbon ring atoms up to maximum of a total number of three, together with their substituents, in each phenyl ring of any of above structures can be replaced with N.

[0390] In some embodiments, the delayed fluorescence material comprises at least one of the acceptor moieties selected from the group consisting of nitrile, isonitrile, borane, fluoride, pyridine, pyrimidine, pyrazine, triazine, aza-carbazole, aza-dibenzothiophene, aza-dibenzofuran, aza-dibenzoselenophene, aza-triphenylene, imidazole, pyrazole, oxazole, thiazole, isoxazole, isothiazole, triazole, thiadiazole, and oxadiazole. In some embodiments, the acceptor moieties and the donor moieties as described herein can be connected directly, through a conjugated linker, or a non-conjugated linker, such as a sp^3 carbon or silicon atom.

[0391] In some embodiments, the fluorescent material comprises at least one of the chemical moieties selected from the group consisting of:





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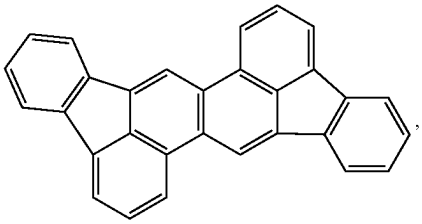

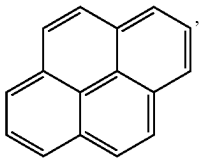

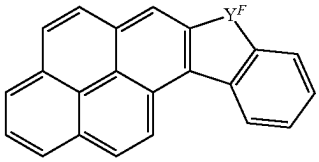

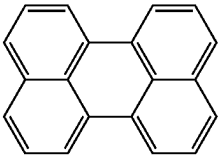

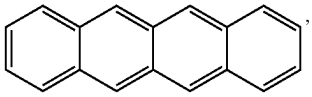

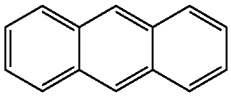

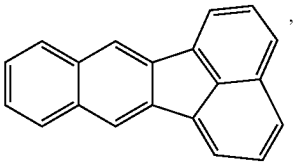

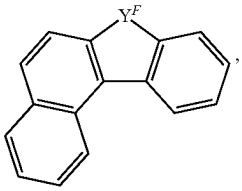

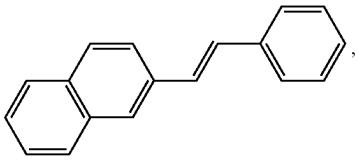

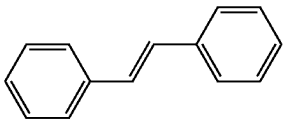

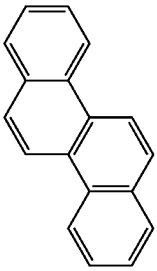

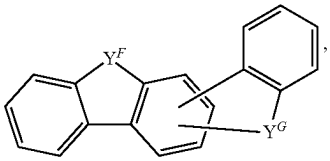

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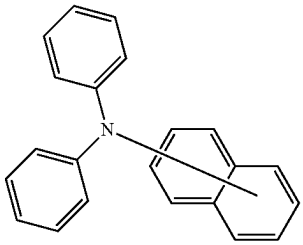

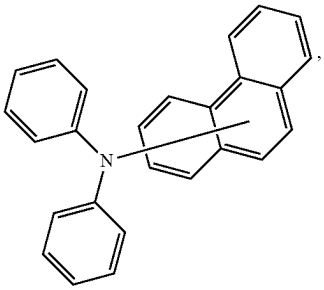

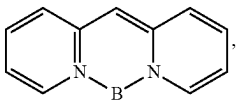

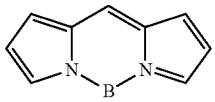

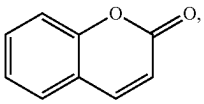

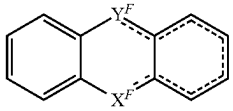

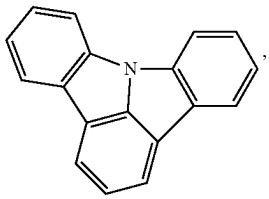

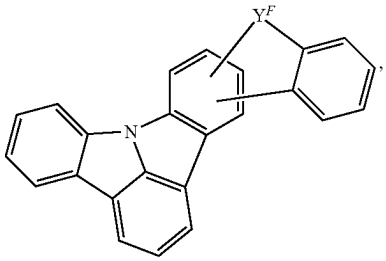

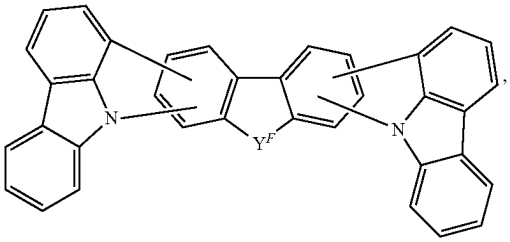

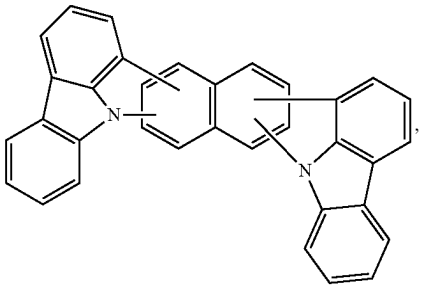

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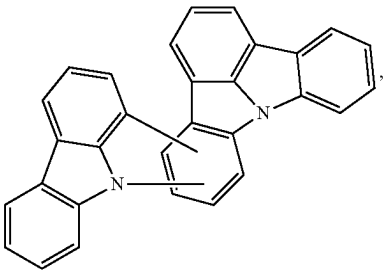

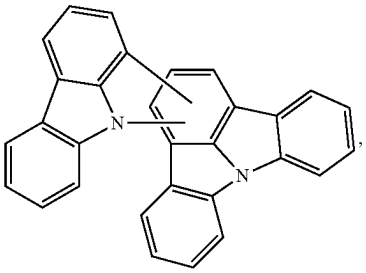

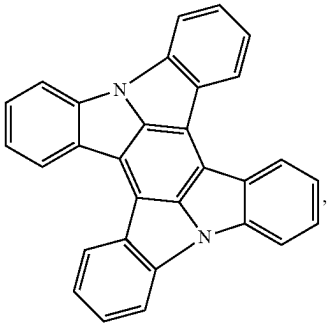

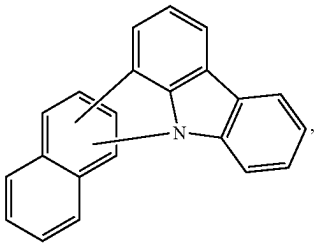

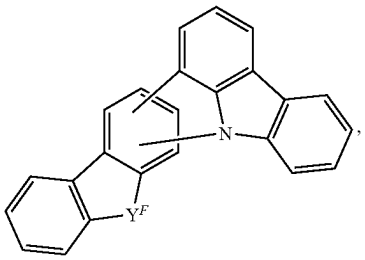

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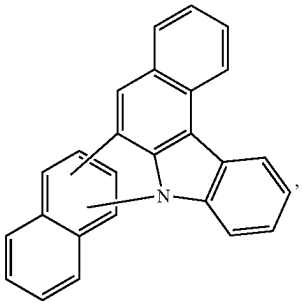

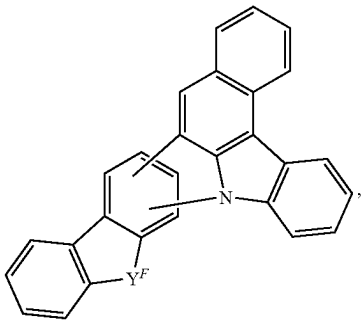

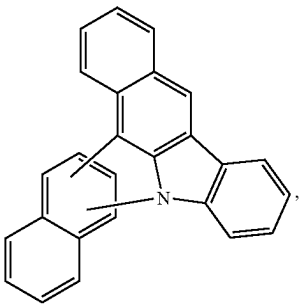

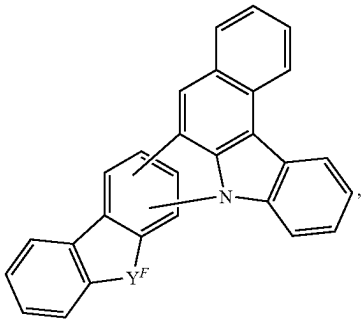

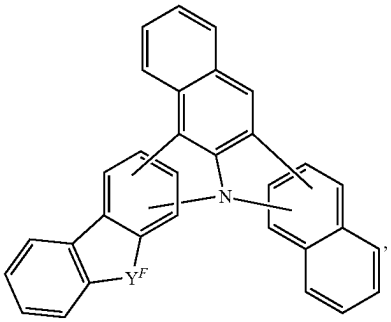

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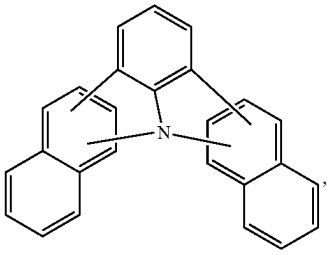

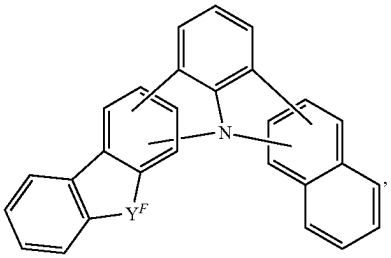

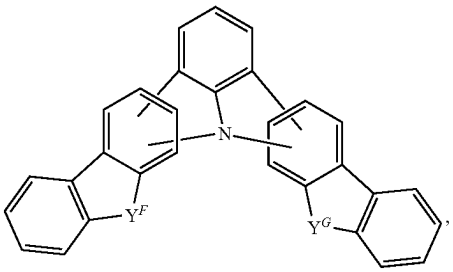

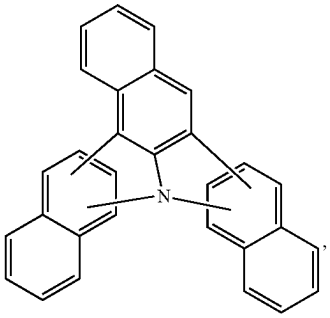

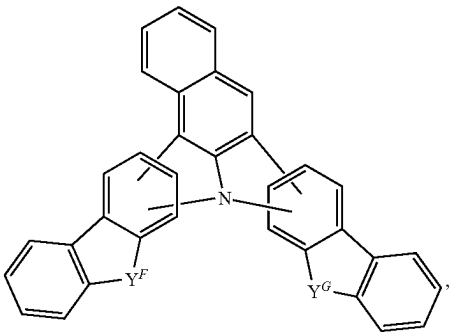

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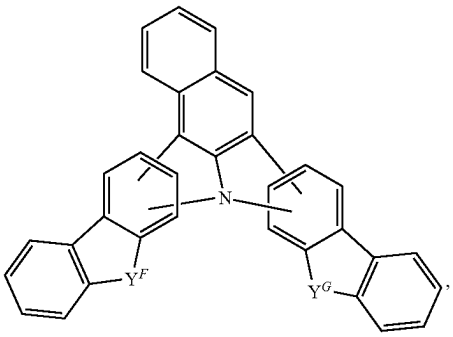

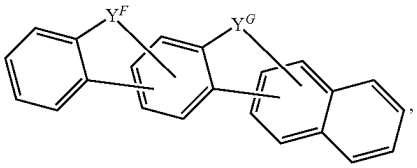

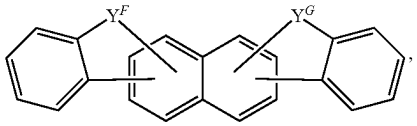

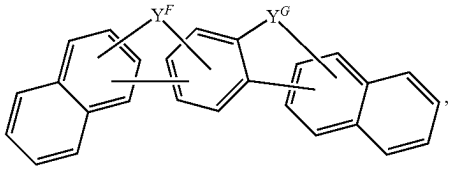

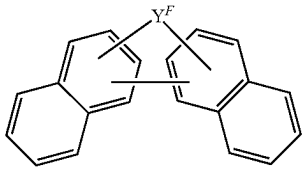

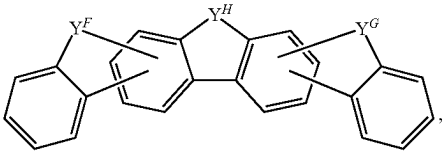

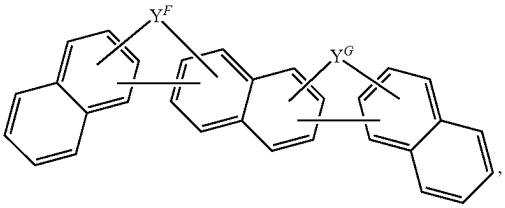

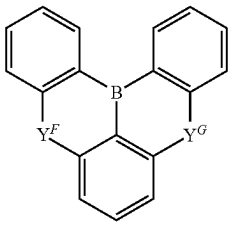

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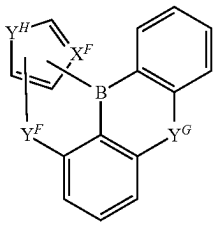

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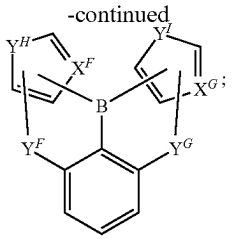


[0392] wherein Y^F, Y^G, Y^H and Y^I are each independently selected from the group consisting of B, C, Si, Ge, N, P, O, S, Se, C═O, S═O, and SO_2;

[0393] wherein X^F and X^G are each independently selected from the group consisting of C and N.

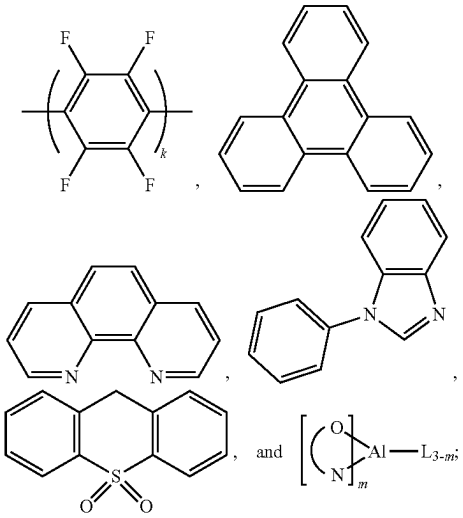
[0394] In some of the above embodiments, any carbon ring atoms up to maximum of a total number of three, together with their substituents, in each phenyl ring of any of above structures can be replaced with N.

f) HBL:

[0395] A hole blocking layer (HBL) may be used to reduce the number of holes and/or excitons that leave the emissive layer. The presence of such a blocking layer in a device may result in substantially higher efficiencies and/or longer lifetime as compared to a similar device lacking a blocking layer. Also, a blocking layer may be used to confine emission to a desired region of an OLED. In some embodiments, the HBL material has a lower HOMO (further away from the vacuum level) and/or higher triplet energy than one or more of the emitters closest to the HBL interface.

[0396] In some embodiments, a compound used in the HBL contains the same molecule or the same functional groups used as host described above.

[0397] In some embodiments, a compound used in the HBL comprises at least one of the following moieties selected from the group consisting of:



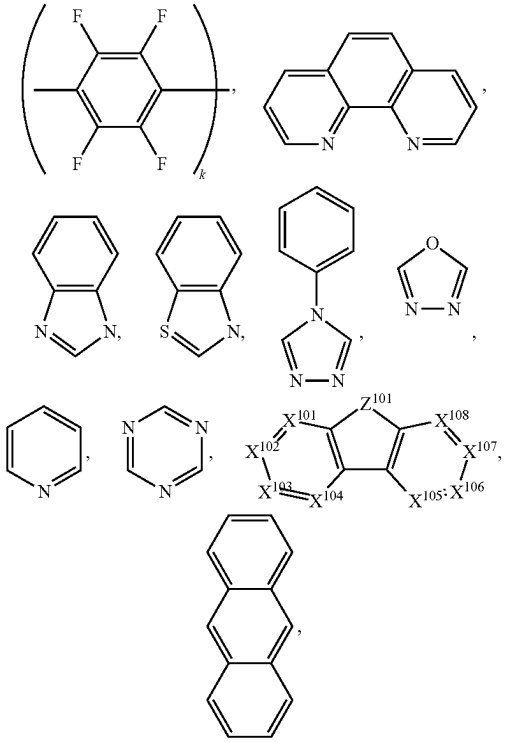
wherein

[0398] k is an integer from 1 to 20; L^{101} is another ligand, k' is an integer from 1 to 3.

g) ETL:

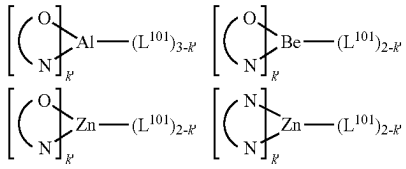
[0399] Electron transport layer (ETL) may include a material capable of transporting electrons. Electron transport layer may be intrinsic (undoped), or doped. Doping may be used to enhance conductivity. Examples of the ETL material are not particularly limited, and any metal complexes or organic compounds may be used as long as they are typically used to transport electrons.

[0400] In some embodiments, compound used in ETL comprises at least one of the following moieties in the molecule:



and fullerenes; wherein k is an integer from 1 to 20, X^{101} to X^{108} is selected from C or N; Z^{101} is selected from the group consisting of C, N, O, and S.

[0401] In some embodiments, the metal complexes used in ETL contains, but not limit to the following general formula:



[0402] wherein (O—N) or (N—N) is a bidentate ligand, having metal coordinated to atoms O, N or N, N; L^{101} is another ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached to the metal.

[0403] In some embodiments, the ETL material is selected from the group consisting of anthracene-benzoimidazole

compounds, aza triphenylene derivatives, anthracene-benzothiazole compounds, metal 8-hydroxyquinolates, metal hydroxybenoquinolates, bathocuprine compounds, 5-member ring electron deficient heterocycles (e.g., triazole, oxadiazole, imidazole, benzoimidazole), silole compounds, arylborane compounds, fluorinated aromatic compounds, fullerene (e.g., C60), triazine complexes, and Zn(N^N) complexes.

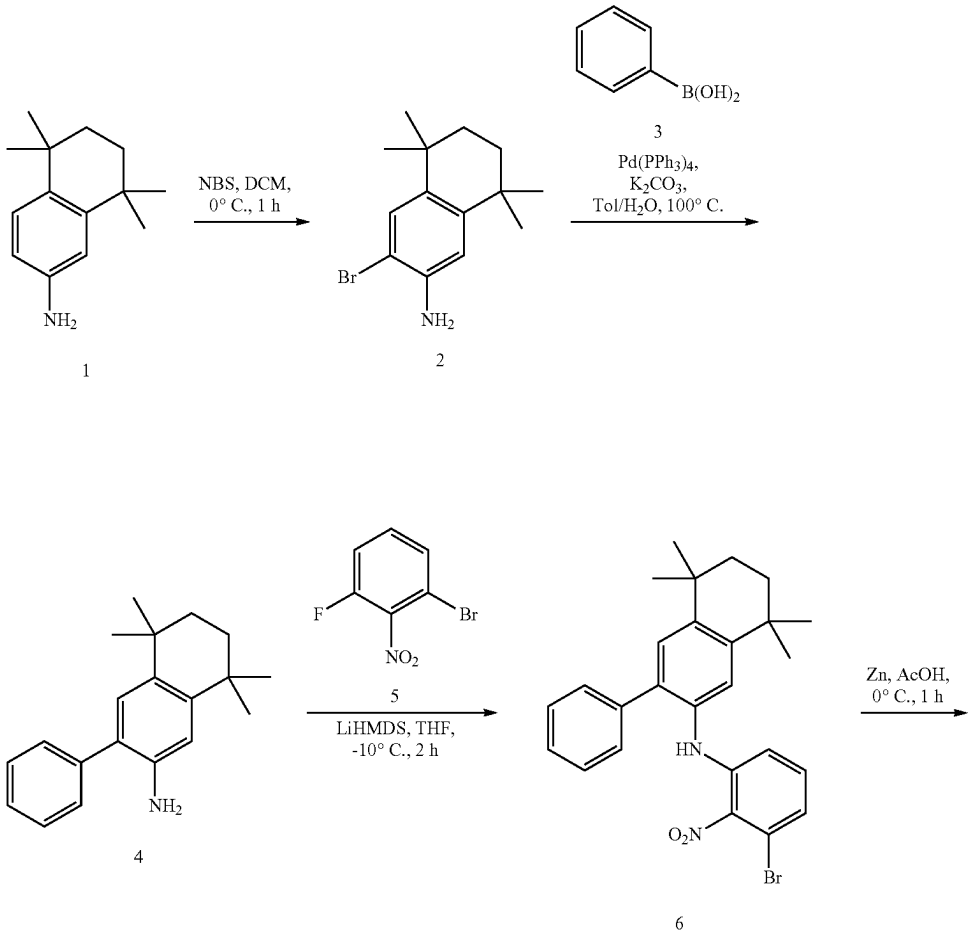
h) Charge Generation Layer (CGL)

[0404] In tandem or stacked OLEDs, the CGL plays an essential role in the performance, which is composed of an n-doped layer and a p-doped layer for injection of electrons and holes, respectively. Electrons and holes are supplied from the CGL and electrodes. The consumed electrons and holes in the CGL are refilled by the electrons and holes injected from the cathode and anode, respectively; then, the bipolar currents reach a steady state gradually. Typical CGL materials include n and p conductivity dopants used in the transport layers.

[0405] In any compounds disclosed herein, the hydrogen atoms can be partially or fully deuterated. The minimum amount of hydrogen of the compound being deuterated is selected from the group consisting of 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, and 100%. As used herein, percent deuteration has its ordinary meaning and includes the percent of all possible hydrogen and deuterium atoms that are replaced by deuterium atoms. In some embodiments, the deuterium atoms are attached to an aromatic ring. In some embodiments, the deuterium atoms are attached to a saturated carbon atom, such as an alkyl or cycloalkyl carbon atom. In some other embodiments, the deuterium atoms are attached to a heteroatom, such as Si, or Ge atom.

[0406] 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.

E. Experimental Data



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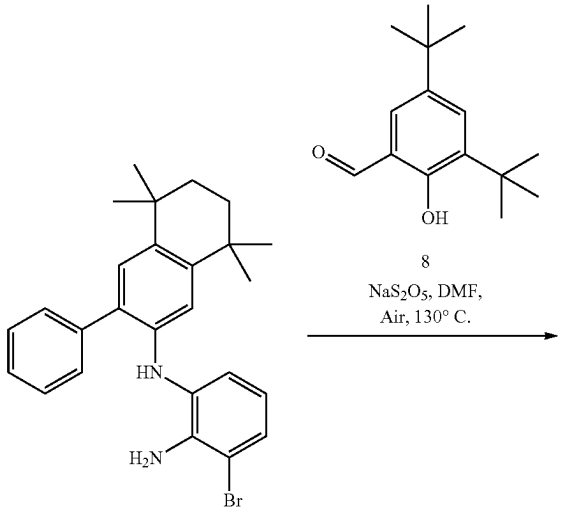
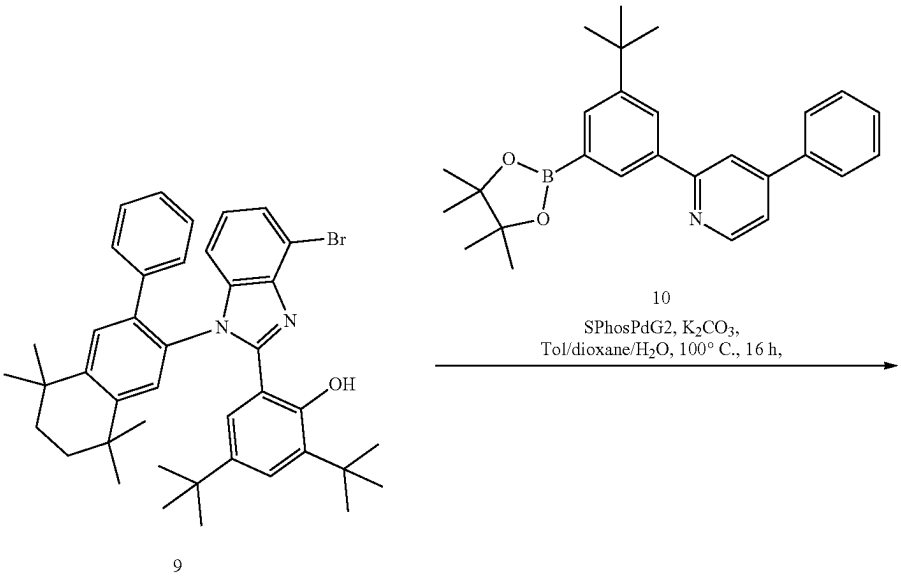
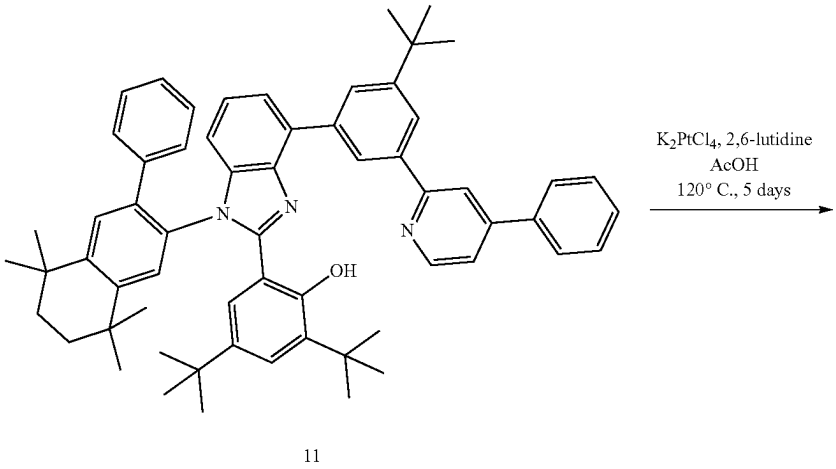

O
OH
8
NaS_2O_5, DMF,
Air, 130° C.
HN
H_2N
Br
7


O
B
O
N
10
SPhosPdG2, K_2CO_3,
Tol/dioxane/H_2O, 100° C., 16 h,
Br
N
N
OH
9


K_2PtCl_4, 2,6-lutidine
AcOH
120° C., 5 days
N
N
N
OH
11

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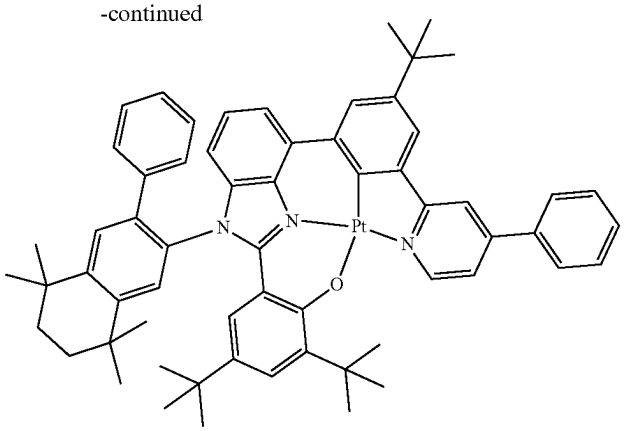
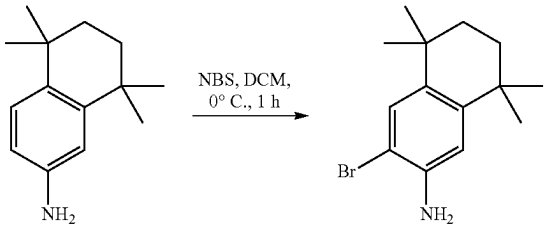


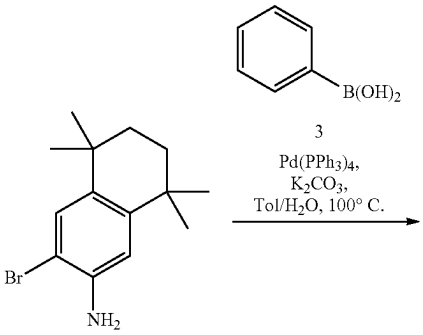
Synthesis of 3-bromo-5,5,8,8-tetramethyl-5,6,7,8-tetrahydronaphthalen-2-amine



1 2

[0407] 5,5,8,8-tetramethyl-5,6,7,8-tetrahydronaphthalen-2-amine (8.8 g, 43.28 mmol, 1.0 eq) and dichloromethane were added to a 100 mL two-neck round bottom flask. The mixture was cooled in an ice bath and N-bromosuccinimide (7.32 g, 41.12 mmol, 0.95 eq) was added. The reaction mixture was then allowed to stir for 1 hour. The reaction mixture was concentrated in vacuo to give compound 2 noted above.

Synthesis of 5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-amine



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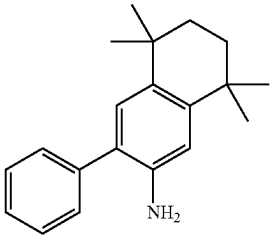
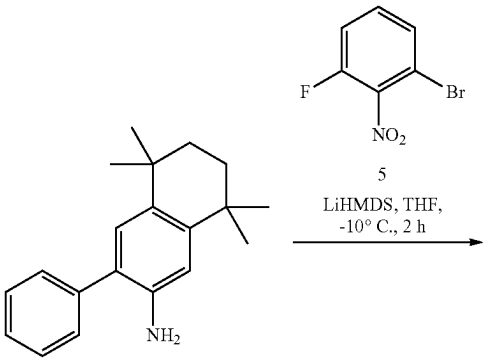


4

[0408] Phenylboronic acid (5.38 g, 44.15 mmol, 1.40 eq), toluene, and water were added to a round bottom flask containing crude 3-bromo-5,5,8,8-tetramethyl-5,6,7,8-tetrahydronaphthalen-2-amine (8.90 g, 31.54 mmol, 1.0 eq). Tetrakis(triphenylphosphine)palladium (1.82 g, 1.58 mmol, 0.05 eq) and potassium carbonate (8.72 g, 63.07 mmol, 2.0 eq) were added, and the reaction mixture was heated at 100° C. and stirred overnight. The reaction mixture was concentrated, dichloromethane (70 mL) was added, and the organic layer was washed with water. The organic layer was dried over $MgSO_4$, filtered, and concentrated in vacuo to give crude residue, which was purified by column chromatography to give a light brown solid (5.87 g, 49%).

Synthesis of N-(3-bromo-2-nitrophenyl)-5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-amine



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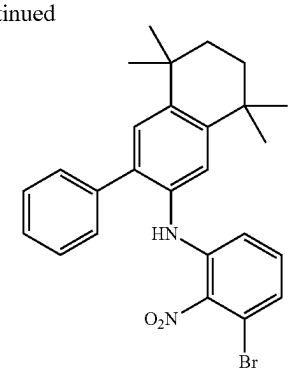

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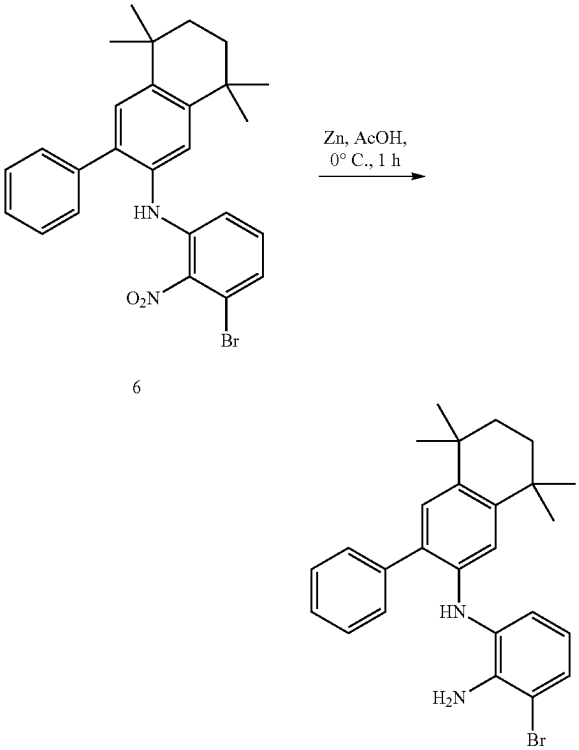
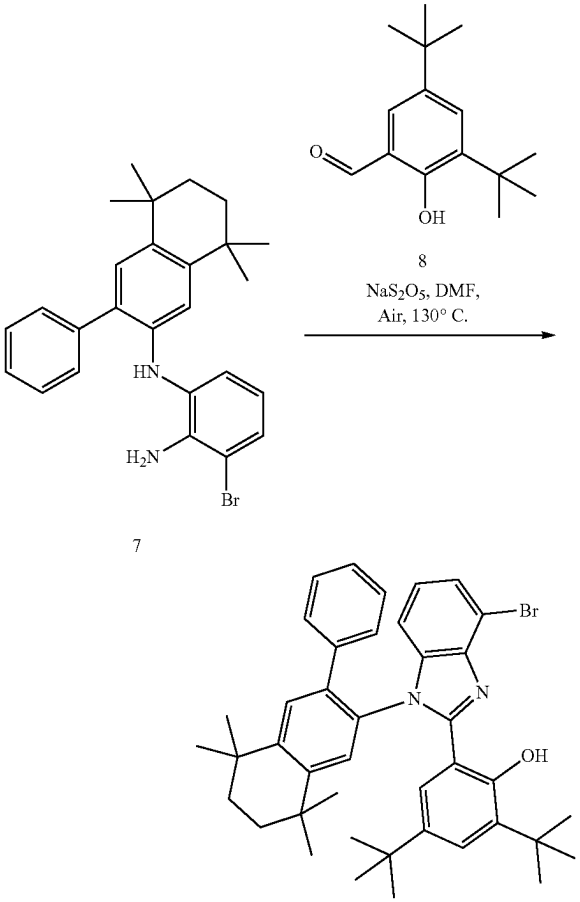
[0409] 5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-amine (1.27 g, 4.40 mmol, 1.0 eq), 1-fluoro-3-bromo-2-nitrobenzene (1.16 g, 5.28 mmol, 1.2 eq) and anhydrous THF were added to a 500 mL round-bottom flask. The mixture was cooled to −20° C. and **1**M LiHMDS in THF (6.8 ml, 6.8 mmol) was added. The reaction was then quenched. Dichloromethane was added to the reaction, the layers were separated, the organic phase was dried over $MgSO_4$, filtered, and concentrated in vacuo to give the crude product (2.4 g).

Synthesis of 3-bromo-N1-(5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-yl)benzene-1,2-diamine



[0410] Crude N-(3-bromo-2-nitrophenyl)-5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-amine (9.2 g) and acetic acid and methanol were added to a three-necked 250 ml round bottom flask. The reaction mixture was then cooled to 10° C. in an ice bath and zinc powder (5.02 g, 76.76 mmol, 4.0 eq) was added. The reaction mixture was stirred for 45 minutes. Ethyl acetate was added and then filtered through a pad of Celite (diatomaceous earth). The filtrate was concentrated in vacuo and the organic layer was washed with saturated sodium bicarbonate solution. The organic layer was dried with $MgSO_4$, filtered, and concentrated in vacuo to give a red solid (15.5 g crude).

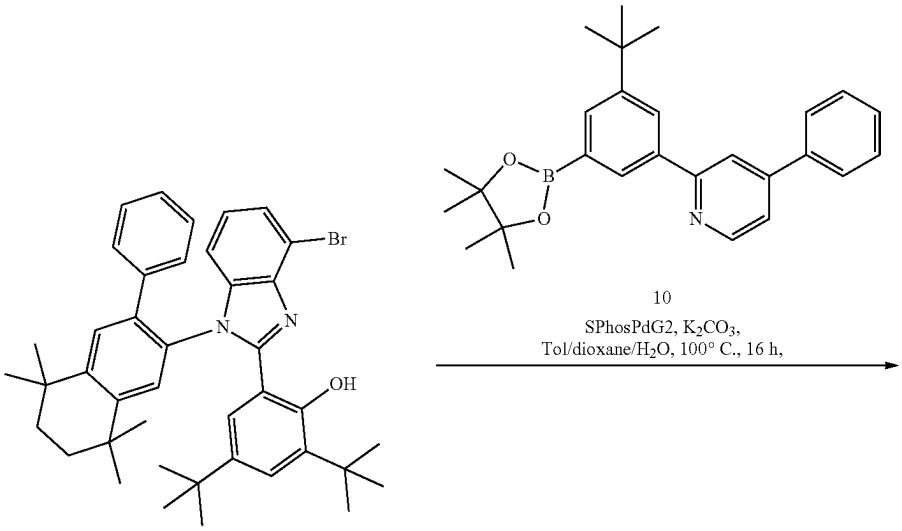
Synthesis of 2-(4-bromo-1-(5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-yl)-1H-benzo[d]imidazol-2-yl)-4,6-di-tert-butylphenol



[0411] N-(3-bromo-2-nitrophenyl)-5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-amine (40 w/w % 15.50 g, 13.79 mmol, 1 eq) and 3,5-di-tert-butyl-2-hydroxybenzaldehyde (4.526 g, 19.31 mmol, 1.4 eq) were charged to a 500 mL round bottom flask and then dissolved in dimethylformamide. Sodium metabisulfite (5.245 g, 27.59 mmol, 2 eq) was charged and the reaction mixture was heated to 130° C. overnight. The reaction mixture was cooled to room

temperature, deionized water (100 mL) was added, and the precipitate was collected by filtration as an off-white solid (6.85 g, 74%).

Synthesis of 2,4-di-tert-butyl-6-(4-(3-(tert-butyl)-5-(4-phenylpyridin-2-yl)phenyl)-1-(5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-yl)-1H-benzo[d]imidazol-2-yl)phenol



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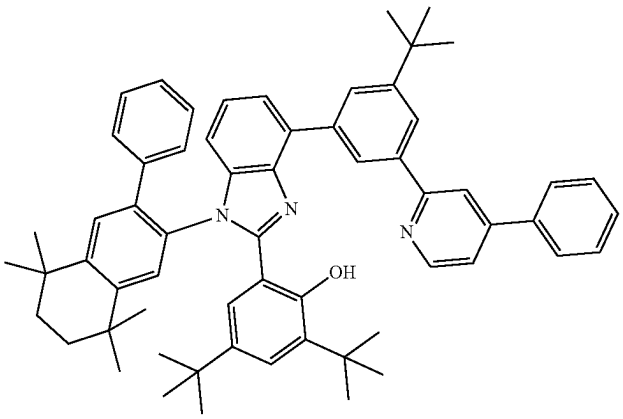

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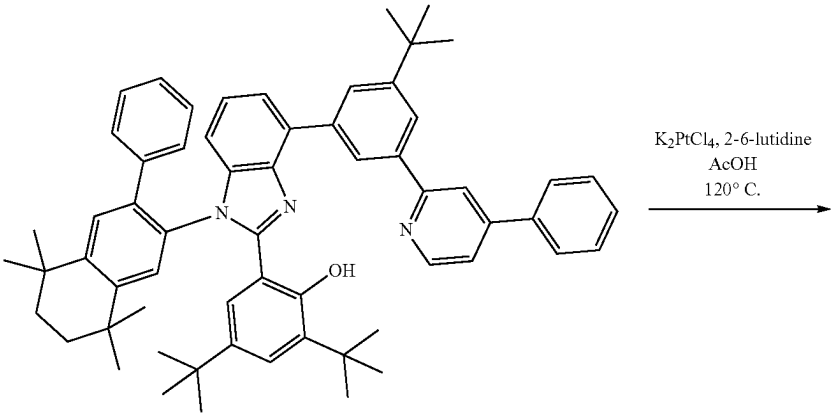
[0412] 2-(4-bromo-1-(5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-yl)-1H-benzo[d]imidazol-2-yl)-4,6-di-tert-butylphenol (3.0 g, 1 Eq, 4.520 mmol), 2-(3-(tert-butyl)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl) phenyl)-4-phenylpyridine (2.242 g, 1.2 Eq, 5.424 mmol), toluene, and water were added to a 250 mL round bottom flask. SPhosPdG2 (162.9 mg, 0.05 Eq, 226.0 μmol) and potassium carbonate (1.249 g, 2 Eq, 9.040 mmol) were added and the reaction mixture was heated at 100° C. overnight. The reaction mixture was allowed to cool to room temperature and the toluene was removed in vacuo. EtOAc and water were added, and the phases were separated. The EtOAc later was concentrated in vacuo giving crude product, which was purified by column chromatography to give an off-white solid (1.78 g, 55%).

Synthesis of 2,4-di-tert-butyl-6-(4-(3-(tert-butyl)-5-(4-phenylpyridin-2-yl)phenyl)-1-(5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-yl)-1H-benzo[d]imidazol-2-yl)phenol platinum complex



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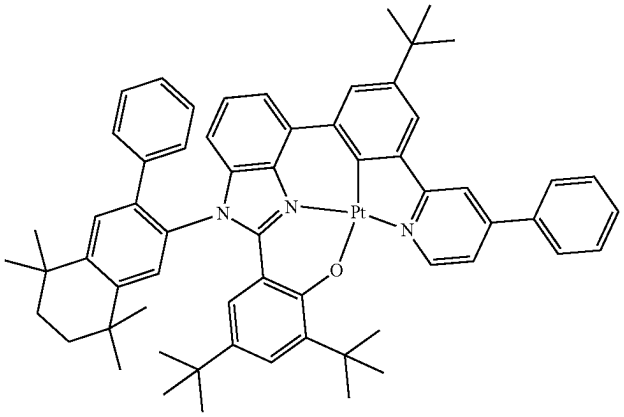


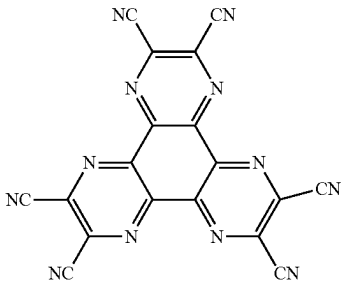
Emitter 1

[0413] Potassium tetrachloroplatinate(II) (575 mg, 1.1 Eq, 1.387 mmol), 2,4-di-tert-butyl-6-(4-(3-(tert-butyl)-5-(4-phenylpyridin-2-yl)phenyl)-1-(5,5,8,8-tetramethyl-3-phenyl-5,6,7,8-tetrahydronaphthalen-2-yl)-1H-benzo[d]imidazol-2-yl)phenol (1.1 g, 1 Eq, 1.261 mmol), 2,6-dimethylpyridine (405.2 mg, 0.45 mL, 3 Eq, 3.782 mmol) and acetic acid were added to a 50 mL Schlenk tube. The Schlenk tube was placed in a preheated oil bath at 120° C. and stirred overnight. The reaction mixture was allowed to cool to room temperature and water was added. The yellow precipitate was filtered and purified by column chromatography to give Pt[LA'27-(L1)(T15)(R7)(R7)(R1)][Ly23-(R1)(R7)(R5)(R1)] as a yellow solid (2.11 g, 86%).

[0414] OLED devices were fabricated using Emitter 1 or Comparison 1 as a green emitter. The device performance data results are shown in Table 1, where the EQE and voltage are taken at 10 mA/cm^2 and the lifetime (LT_{95}) is the time to reduction of brightness to 95% of the initial luminance at a constant current density of 80 mA/cm^2.

[0415] The compounds used are:

Compound 1



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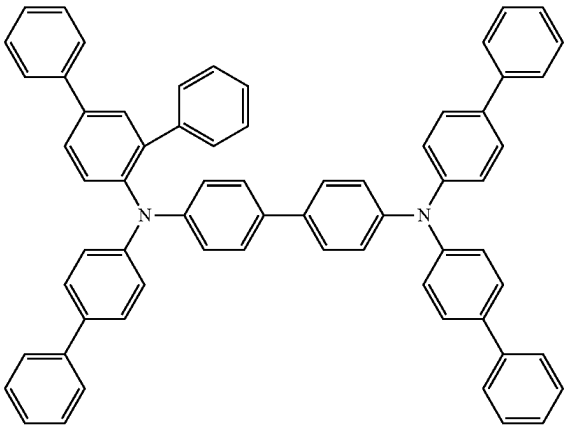
Compound 2



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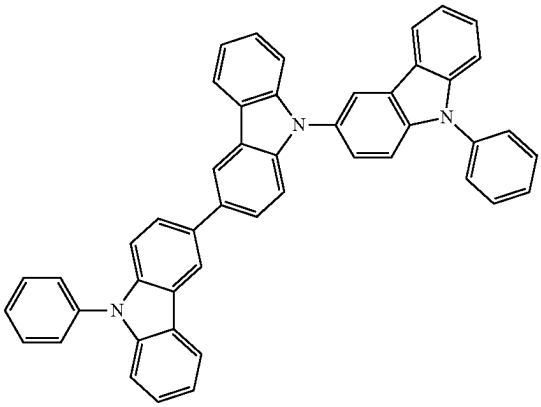
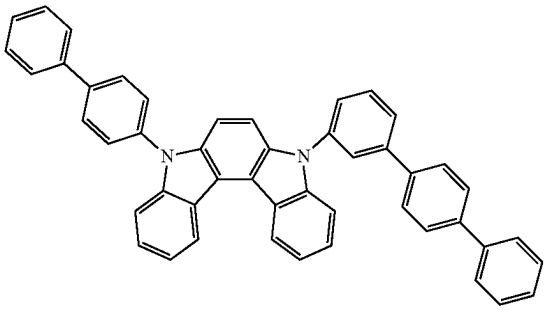


Compound 4



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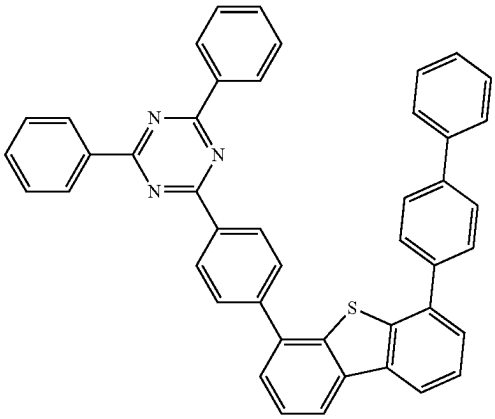
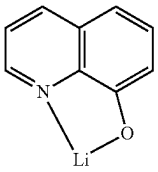
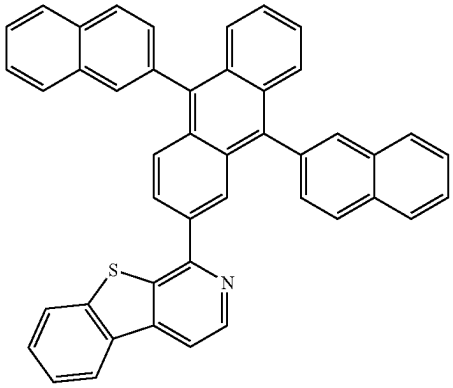
Compound 5



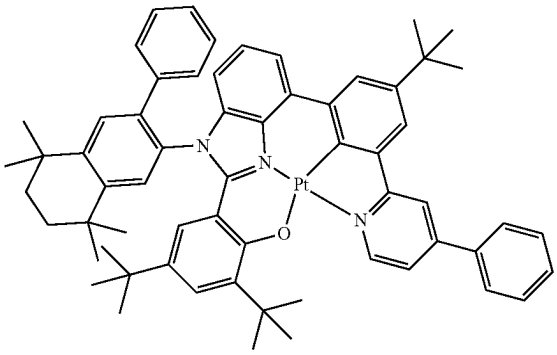
Compound 6



Compound 7



Emitter 1



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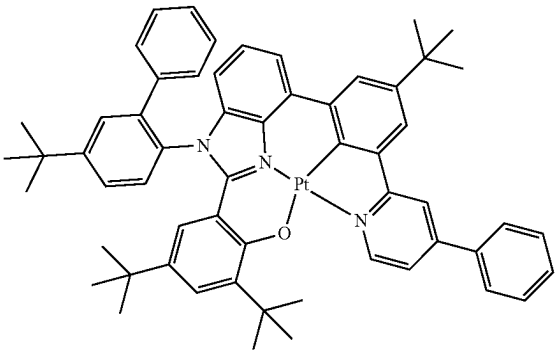
Comparison 1



[0416] OLEDs were grown on a glass substrate pre-coated with an indium-tin-oxide (ITO) layer having a sheet resistance of 15-S2/sq. Prior to any organic layer deposition or coating, the substrate was degreased with solvents and then treated with an oxygen plasma for 1.5 minutes with 50 W at 100 mTorr and with UV ozone for 5 minutes. The devices were fabricated in high vacuum (<10-Torr) by thermal evaporation. The anode electrode was 750 Å of indium tin oxide (ITO). All devices were 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 with a moisture getter incorporated inside the package. Doping percentages are in volume percent.

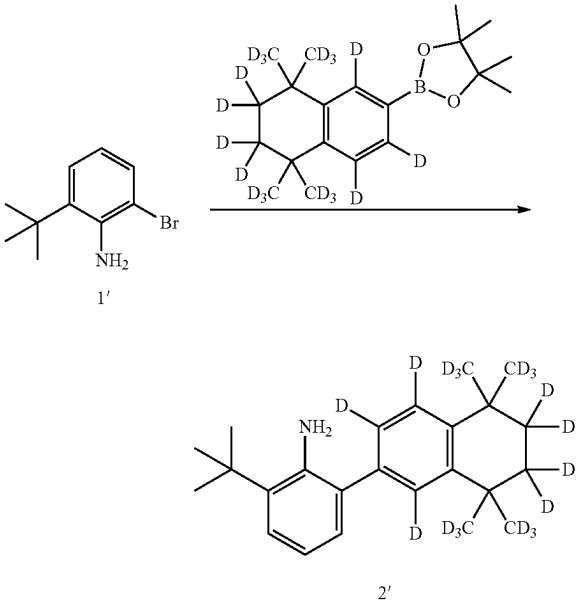
[0417] The devices shown in Table 1 had organic layers consisting of, sequentially, from the ITO surface, 100 Å of Compound 1 (HIL), 400 Å of Compound 2 (HTL), 50 Å of Compound 3 (EBL), 400 Å of Compound 4 doped with 20% of Compound 5, and 5% of Emitter (EML), 50 of Compound 5 (BL), 300 Å of Compound 6 doped with 35% of Compound 7 (ETL), 10 Å of Compound 6 (EIL) followed by 1,000 Å of Al (Cathode). The device performance results for Example 1 device with Emitter 1 as the emitter (Example 1) and Comparison 1 device with Comparison 1 compound as the emitter are shown in Table 1. The EQE and LT_{95} for the device Example 1 are reported relative to the values for Comparison 1.

TABLE 1

Device Data

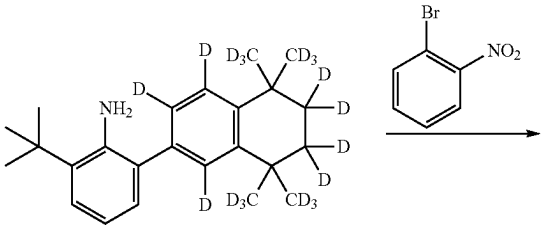
		at 10 mA/cm^2			at 80 mA/cm^2
Device	Emitter	λmax (nm)	CIE	EQE	LT_{95}
Example 1	Emitter 1	526	(0.325, 0.635)	1.04	1.00
Comparison 1	Comparison 1	526	(0.325, 0.635)	1.00	1.00

[0418] The above data shows that Example 1 device, which includes the inventive compound Emitter 1, exhibited an increased EQE compared to the Comparison 1 device using a related analog, Comparison 1 compound as the emitter. The 4% higher EQE for Example 1 is beyond any value that could be attributed to experimental error and the observed improvement is significant. Based on the fact that the devices have same device structure with the only difference being the strapped alkyl on the emitter, the significant performance improvement observed in the above data is unexpected. Without being bound by any theory, this improvement may be attributed to increased steric bulk which is believed to be beneficial.



Synthesis of 2-(tert-butyl)-6-(5,5,8,8-tetrakis (methyl-d3)-5,6,7,8-tetrahydronaphthalen-2-yl-1,3,4, 6,6,7,7-d7)aniline(2')

[0419] 2-bromo-6-(tert-butyl)aniline 1' (35.0 g, 153 mmol, 1 equiv), 4,4,5,5-tetramethyl-2-(5,5,8,8-tetrakis(methyl-d3)-5,6,7,8-tetrahydronaphthalen-2-yl-1,3,4,6,6,7,7-d7)-1,3,2-dioxaborolane (56.6 g, 169 mmol, 1.1 equiv), sodium carbonate (48.8 g, 460 mmol, 3 equiv) were added to dioxane (350 mL) and water (140 mL) and sparged with nitrogen for 15 minutes. Sphos-pd-G2 (11.1 g, 15.3 mmol, 0.1 equiv) was added and the mixture was stirred at 85° C. for 16 hours. The mixture was cooled to room temperature and passed through a plug of Celite (diatomaceous earth) and silica. Ethyl acetate and water were added, and the layers were separated. The organic layer was concentrated, and the crude product was purified by column chromatography (2% ethyl acetate in heptane) to give compound 2' (31 g, 54% yield) as an off white solid.



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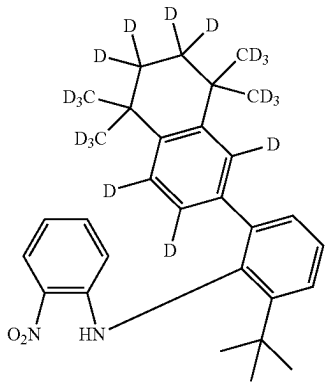
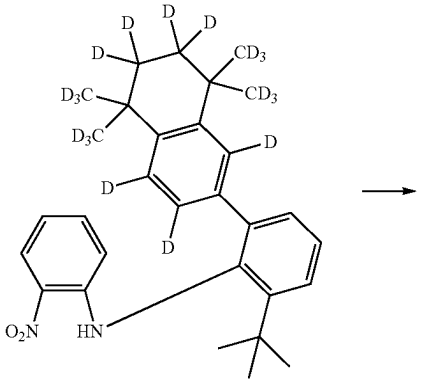


3'

Synthesis of 2-(tert-butyl)-N-(2-nitrophenyl)-6-(5,5,8,8-tetrakis(methyl-d3)-5,6,7,8-tetrahydronaphthalen-2-yl-1,3,4,6,6,7,7-d7)aniline (3')

[0420] Toluene (450 mL) was charged to the mixture of compound 2' (30.0 g, 84.6 mmol, 1.0 equiv), 1-bromo-2-nitrobenzene (20.5 g, 102 mmol, 1.2 equiv), sodium-tert-butoxide (16.3 g, 169 mmol, 3 equiv). The slurry was then sparged with nitrogen for 15 minutes and then added tri-tert-butylphosphonium tetrafluoroborate (4.90 g, 16.9 mmol, 0.2 equiv) and palladium acetate (3.80 g, 16.9 mmol, 0.2 equiv). The reaction mixture was then refluxed for 12 hours. The reaction was cooled to room temperature and quenched with water (200 mL). The mixture was passed through a plug of Celite and silica gel and the crude was rinsed with ethyl acetate. The layers separated and the organic layer was concentrated. The crude solid was treated with methanol (400 mL) and water (400 mL) at 40° C. and cooled to room temperature to get the precipitate. The precipitate was filtered and dried in vacuum oven at 60° C. for 12 hours to give compound 3' (34 g, 82% yield) as a yellow solid.



3'

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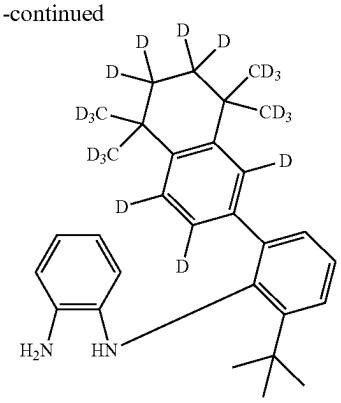
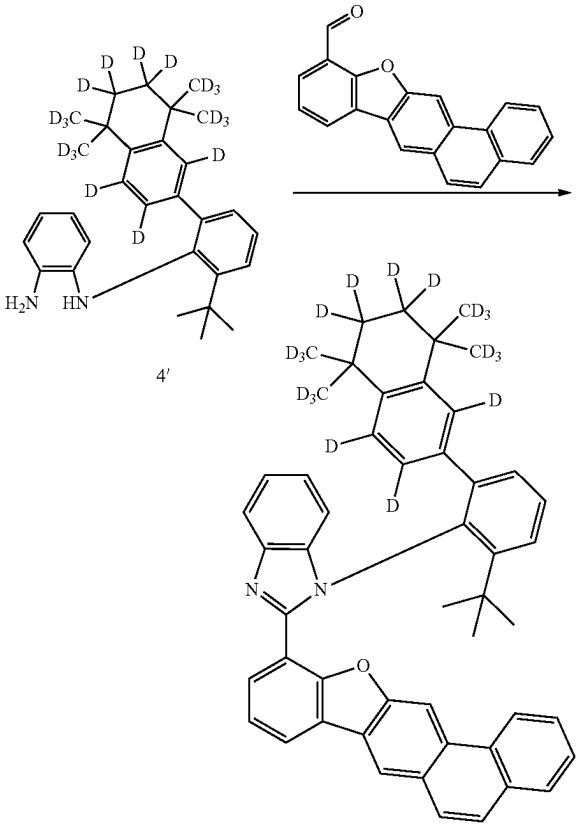


4'

Synthesis of N1-(2-(tert-butyl)-6-(5,5,8,8-tetrakis(methyl-d3)-5,6,7,8-tetrahydronaphthalen-2-yl-1,3,4,6,6,7,7-d7)phenyl)benzene-1,2-diamine (4')

[0421] A solution of 2-(tert-butyl)-N-(2-nitrophenyl)-6-(5,5,8,8-tetrakis(methyl-d3)-5,6,7,8-tetrahydronaphthalen-2-yl-1,3,4,6,6,7,7-d7)aniline 3' (3.00 g, 6.31 mmol) in ethanol (45 mL) was added ammonium chloride (1.01 g, 689 μL, 18.9 mmol), water (15 mL), and iron (Celite plug, and the filtrate was concentrated under vacuum. The crude was purified by column chromatography (10% ethyl acetate in heptane) to give compound 4' (2.6 g, 93% yield).



4'

5'

Synthesis of 1-(2-(tert-butyl)-6-(5,5,8,8-tetrakis (methyl-d3)-5,6,7,8-tetrahydronaphthalen-2-yl-1,3,4, 6,6,7,7-d7)phenyl)-2-(phenanthro[3,2-b]benzofuran-11-yl)-1H-benzo[d]imidazole (5')

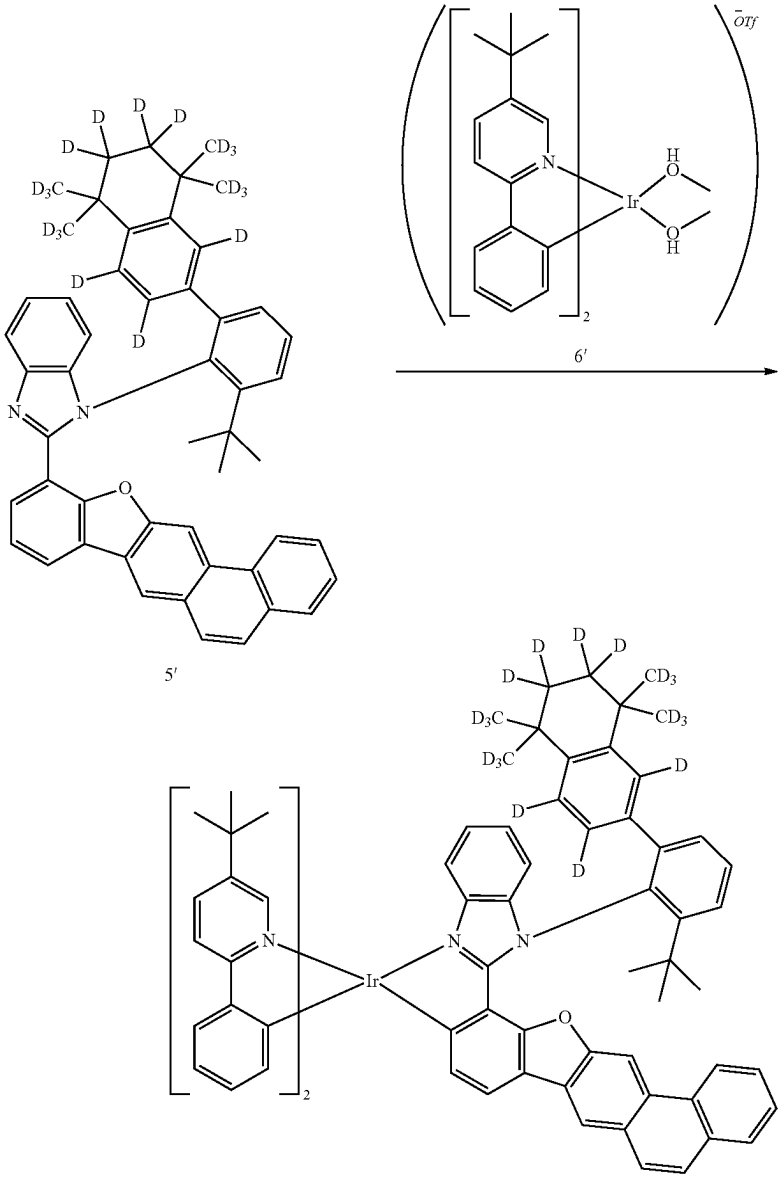
[0422] A solution of phenanthro[3,2-b]benzofuran-11-carbaldehyde (1.40 g, 4.72 mmol), 4' (2.32 g, 5.197 mmol) in DMF (60 mL) was added Sodium bisulfite (1.23 g, 11.8 mmol). The mixture was heated in an oil bath set at 130° C. for 3 days. The reaction was extracted with ethyl acetate, and the organic layer was washed with brine, dried with sodium sulfate, filtered and concentrated under vacuum. The crude was purified by column chromatography (5% ethyl acetate/ 35% heptane in DCM) to give compound 5' (1.2 g, 35% yield)

Synthesis of the Inventive Example

[0423] To a solution of 5' (1.00 g, 1.39 mmol) and 6' (1.54 g, 1.87 mmol) in 2-ethoxyethanol (25 mL) was added 2,6-dimethylpyridine (742 mg, 806 μL, 6.93 mmol). The reaction was stirred at 120° C. for 18 hours, cooled to room temperature and concentrated under reduced pressure. The crude material was purified on silica gel chromatography, eluting with 65% toluene in heptanes, to give the Inventive example (0.45 g, 24% yield) as a yellow solid.

Device Example

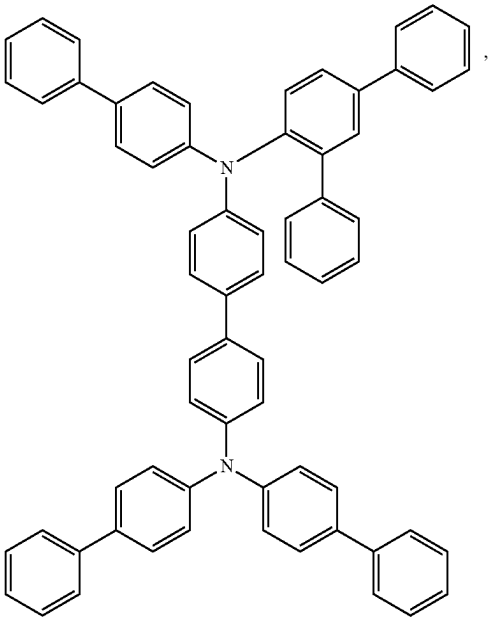
[0424] All example devices were fabricated by high vacuum (<10-?Torr) thermal evaporation. The anode elec-



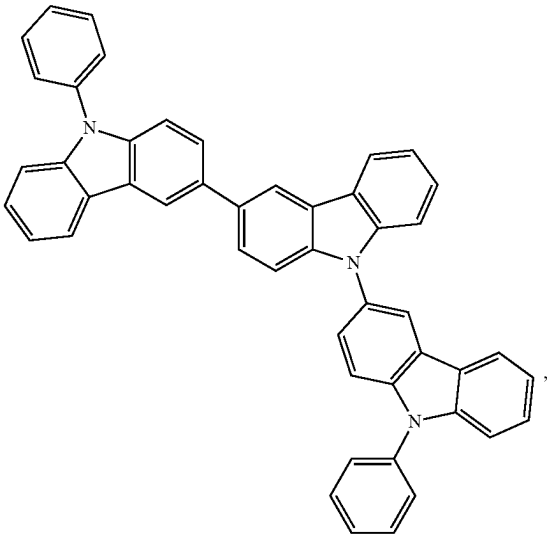
Inventive example

trode was 800 Å of indium tin oxide (ITO). The cathode consisted of 10 Å of Liq (8-hydroxyquinoline lithium) followed by 1,000 Å of A1. All devices were 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 with a moisture getter 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 HTM as a hole transporting layer (HTL); emissive layer (EML) with thickness 400 Å; 50 Å of EBM as an electron blocking layer (EBL); Emissive layer containing H-host (H1): E-host (H2) in 7:3 ratio and 5 weight % of green emitter; 50 Å of H2 as a hole blocking layer (HBL); 350 Å of Liq (8-hydroxyquinoline lithium) doped with 35% of ETM as the ETL. The device structure is shown in Table 2. The chemical structures of the device materials are shown below.

HTM



EBM



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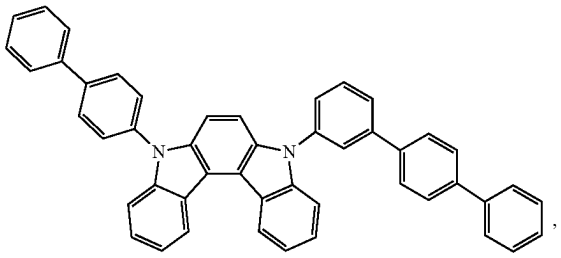
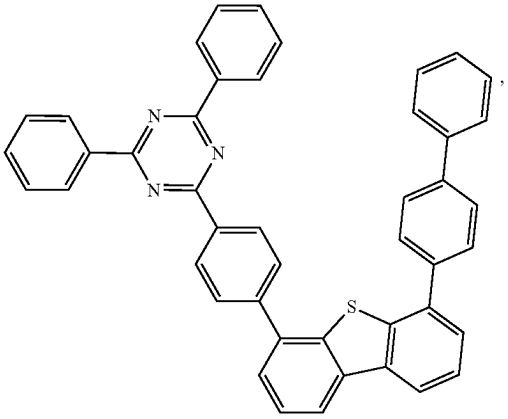
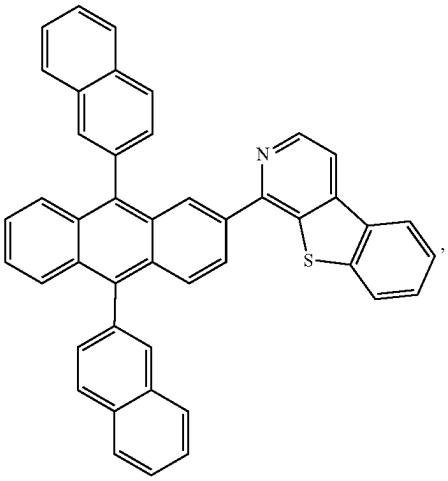
H1



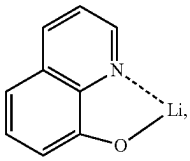
H2



ETM



Liq



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Comparative example

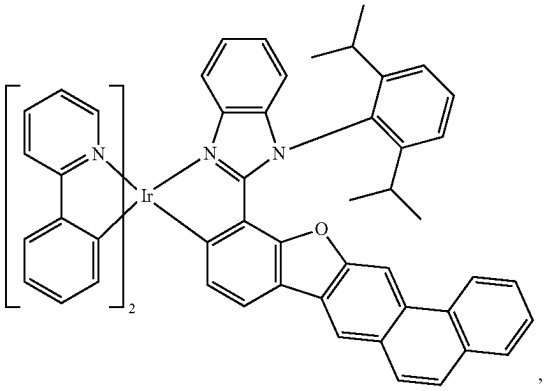


TABLE 2

Device layer materials and thicknesses

Layer	Material	Thickness [Å]
Anode	ITO	800
HIL	LG-101	100
HTL	HTM	400
EBL	EBM	50
EML	H1:H2:Emitter 5%	400
HBL	H2	50
ETL	Liq:ETM 35%	350
EIL	Liq	10
Cathode	Al	1,000

[0425] Upon fabrication, the device was tested to measure EL and JVL. For this purpose, the samples were energized by the 2 channel Keysight B2902A SMU at a current density of 10 mA/cm^2 and measured by the Photo Research PR735 Spectroradiometer. Radiance (W/str/cm^2) from 380 nm to 1080 nm, and total integrated photon count were collected. The devices were then placed under a large area silicon photodiode for the JVL sweep. The integrated photon count of the device at 10 mA/cm^2 is used to convert the photodiode current to photon count. The voltage is swept from 0 to a voltage equating to 200 mA/cm^2. The EQE of the device is calculated using the total integrated photon count. All results are summarized in Table 3. LE and EQE of inventive example (Device 1) are reported as relative numbers normalized to the results of the comparative example (Device 2).

TABLE 3

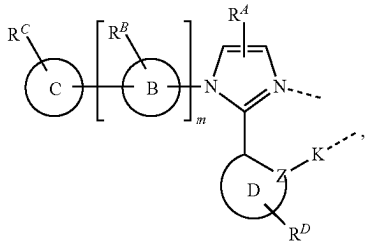
device results

		1931 CIE					
				λ max	FWHM	At 10 mA/cm^2*	
Device	Emitter	x	y	[nm]	[nm]	LE	EQE
Device 1	Inventive Example	0.346	0.631	529	24	1.05	1.04
Device 2	Comparative Example	0.353	0.624	528	53	1.00	1.00

[0426] Table 3 provides a summary of performance of electroluminescence device of the materials. The inventive device (Device 1) shows narrower lineshape with FWHM of 24 nm. In general, the FWHM for a phosphorescent emitter complex is broad, normally above 50 nm as shown in the comparative example here. It has been a long-sought goal to achieve the narrow FWHM. The narrower FWHM, the better color purity for the display application. As background information, the ideal line shape is a single wavelength (single line). As can be seen here, the current inventive compounds can cut down the FWHM number to half from the comparative one. Moreover, the inventive example shows higher LE and EQE compared to the comparative example 2. The improvement of these values is above the value that could be attributed to experimental error and the observed improvement is significant. The performance improvement observed in the above data was unexpected. All results show the significance of the inventive compounds for applications in organic light emitting diodes.

What is claimed is:

1. A compound having a first ligand L_A comprising a structure of Formula I:



wherein:

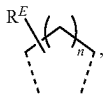
each of moiety B, moiety C, and moiety D is independently a monocyclic ring or a polycyclic fused ring system, wherein the monocyclic ring or each ring of the polycyclic fused ring system is independently a 5-membered to 10-membered carbocyclic or heterocyclic ring;

m is 0, 1, 2, or 3;

Z is C or N;

K is selected from the group consisting of a direct bond, O, S, N(R^{α}), P(R^{α}), B(R^{α}), C(R^{α})(R), and Si(R^{α})(R^{β});

at least one of a moiety B or moiety C has a structure of Formula II



fused thereto;

where n is 1, 2, or 3;

the dashed lines in Formula II indicate a direct bond to two adjacent carbon atoms;

each of R^A, R^B, R^C, R^D, and R^E independently represents mono to the maximum allowable substitutions, or no substitutions;

each R^α, R^β, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, selenyl, and combinations thereof;

L_A is coordinated to a metal M by the dashed lines in Formula I;

metal M has an atomic mass of at least 40 and may be coordinated to other ligands;

L_A can join with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and

any two substituents can be joined or fused to form a ring.

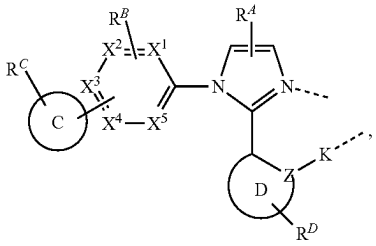
2. The compound of claim **1**, wherein each R^α, R^β, R^A, R^B, R^C, R^D, and R^E is independently hydrogen or a substituent selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, heteroalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, aryl, heteroaryl, nitrile, isonitrile, sulfanyl, and combinations thereof.

3. The compound of claim **1**, wherein each of moiety B and moiety C is independently selected from the group consisting of benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, triazole, naphthalene, quinoline, isoquinoline, quinazoline, benzofuran, aza-benzofuran, benzoxazole, aza-benzoxazole, benzothiophene, aza-benzothiophene, benzothiazole, aza-benzothiazole, benzoselenophene, aza-benzoselenophene, indene, aza-indene, indole, aza-indole, benzimidazole, aza-benzimidazole, carbazole, aza-carbazole, dibenzofuran, aza-dibenzofuran, dibenzothiophene, aza-dibenzothiophene, quinoxaline, phthalazine, phenanthrene, aza-phenanathrene, anthracene, aza-anthracene, phenanthridine, fluorene, and aza-fluorene; and/or wherein moiety D is selected from the group consisting of benzene, pyridine, pyrimidine, pyridazine, pyrazine, triazine, imidazole, imidazole derived carbene, pyrazole, pyrrole, oxazole, furan, thiophene, thiazole, triazole, naphthalene, quinoline, isoquinoline, quinazoline, benzofuran, aza-benzofuran, phenanthro[3,2-b]benzofuran, benzoxazole, aza-benzoxazole, benzothiophene, aza-benzothiophene, benzothiazole, aza-benzothiazole, benzoselenophene, aza-benzoselenophene, indene, aza-indene, indole, aza-indole, benzimidazole, benzimidazole derived carbene, aza-benzimidazole, aza-benzimidazole derived carbene, benzobenzimidazole, aza-benzobenzimidazole, carbazole, aza-carbazole, dibenzofuran, aza-dibenzofuran, dibenzothiophene, aza-dibenzothiophene, quinoxaline, phthalazine, phenanthrene, aza-phenanathrene, anthracene, aza-anthracene, phenanthridine, fluorene, and aza-fluorene.

4. The compound of claim **1**, wherein at least one R^A comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof; and/or wherein at least one R^B comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof; and/or wherein at least one R^C comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof; and/or wherein at least one R^D comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof; and/or wherein at least one R^E comprises a substituent selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

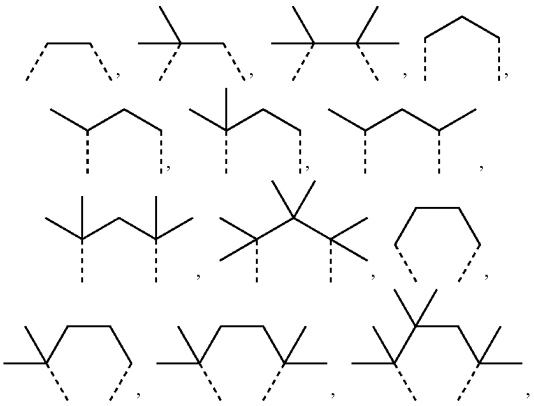
5. The compound of claim **1**, wherein two R^A are joined or fused to form a ring A1; and/or wherein two R^E bonded to adjacent carbons are joined or fused to form a ring; and/or wherein moiety B has a structure of Formula II fused thereto; and/or wherein moiety C has a structure of Formula II fused thereto.

6. The compound of claim **1**, wherein the first ligand comprises a structure of Formula IA,



wherein each of X^1 to X^5 is independently C or N.

7. The compound of claim **1**, wherein the Formula II is selected from the group consisting of:



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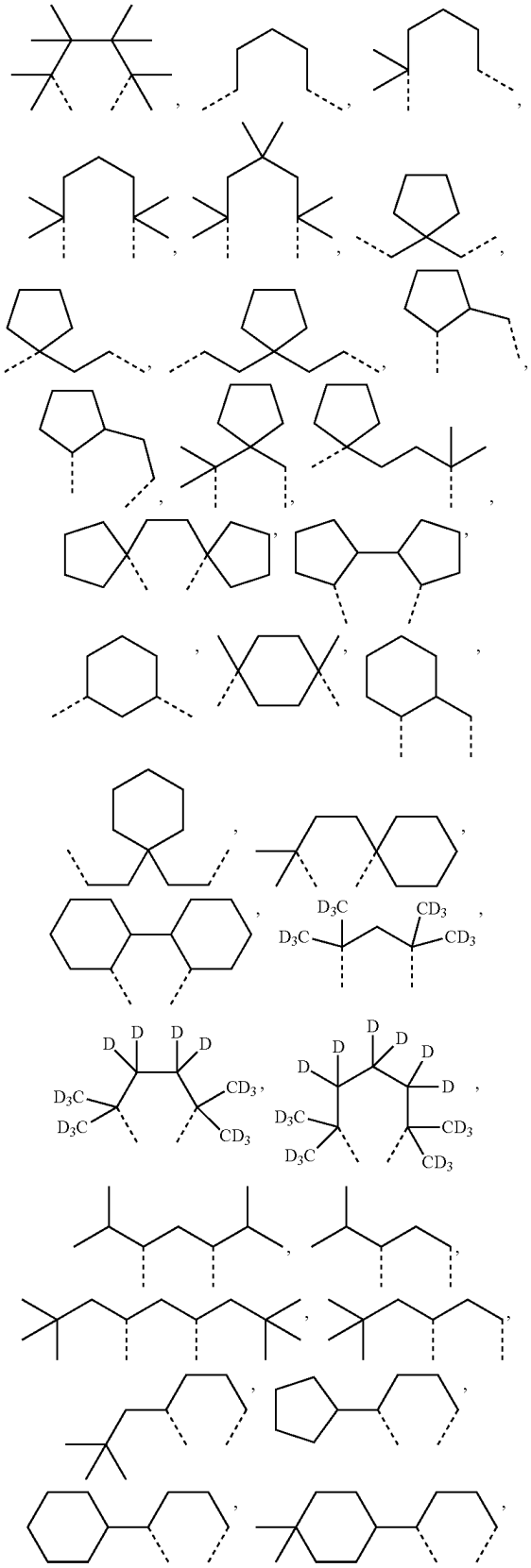

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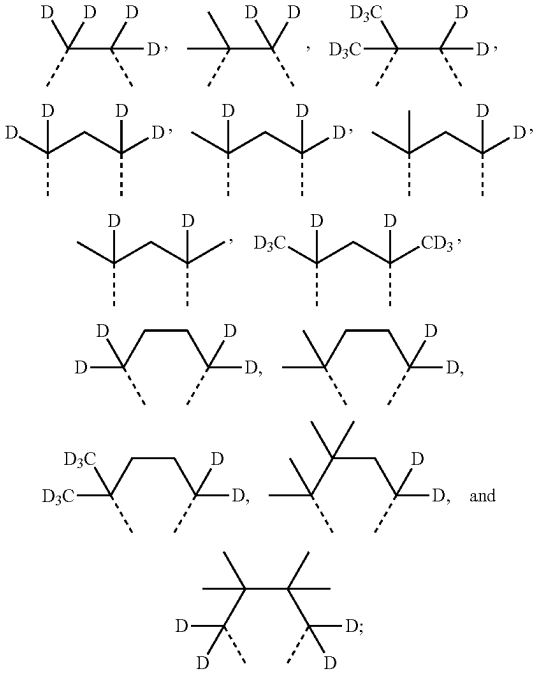
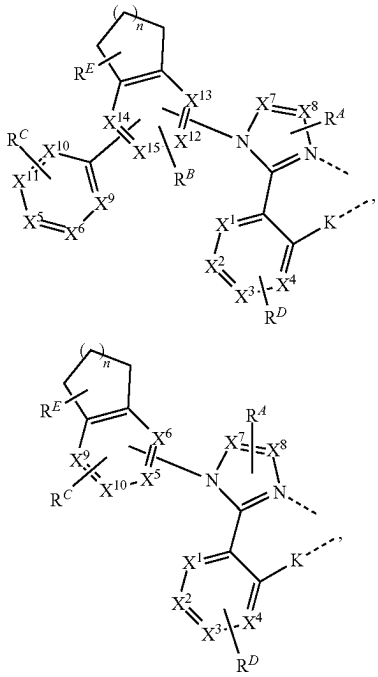


and/or wherein metal M is selected from the group consisting of Ir, Rh, Re, Ru, Os, Pt, Pd, Ag, Au, and Cu; and/or wherein K is a direct bond, O or S.

8. The compound of claim **1**, wherein the ligand L_A is selected from the group consisting of the structures of the following LIST 2:



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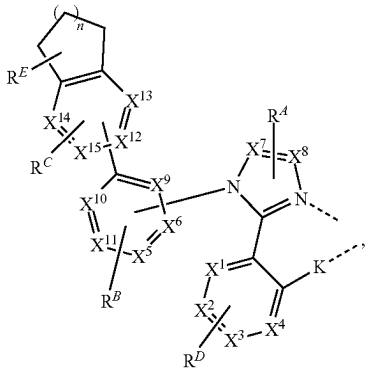

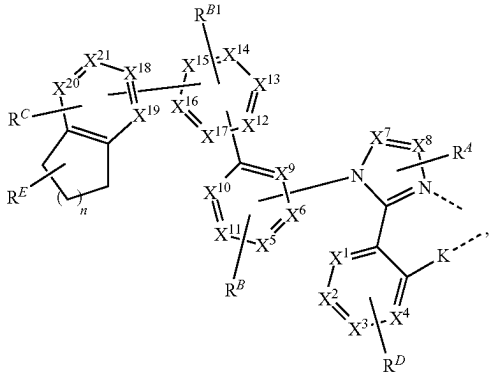

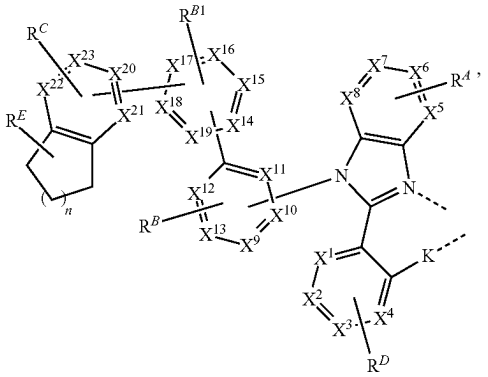

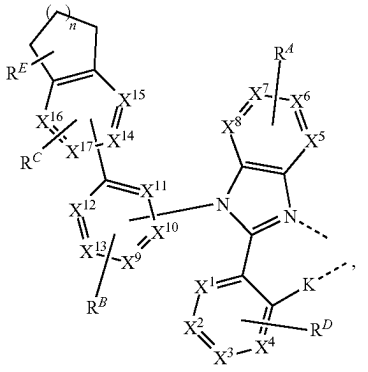

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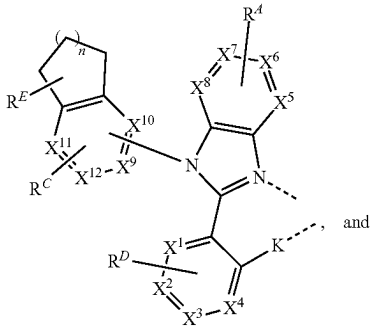
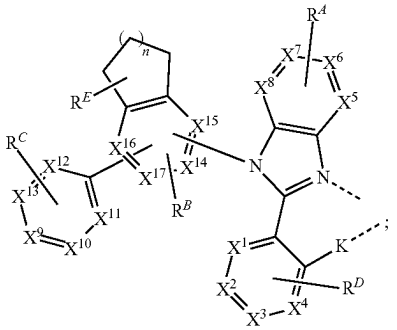


and



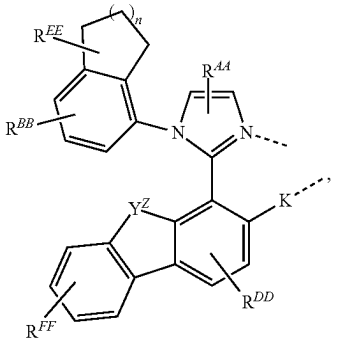
wherein

each of X^1 to X^{23} is independently C or N;

R^{B1} independently represents mono to the maximum allowable substitutions, or no substitutions;

each R^{B1} is independently hydrogen, or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, selenyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and any two substituents may be joined or fused to form a ring, or with other ligand to form a multidentate ligand; or

the ligand L_A selected from the group consisting of:



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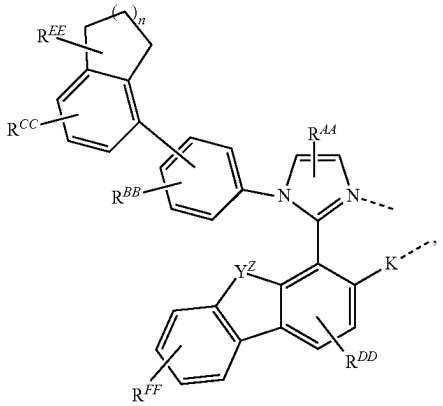

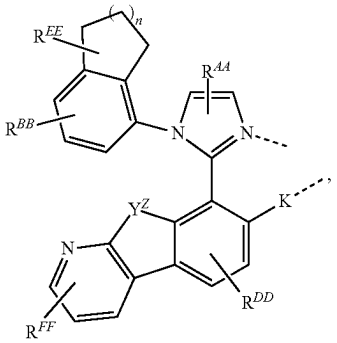

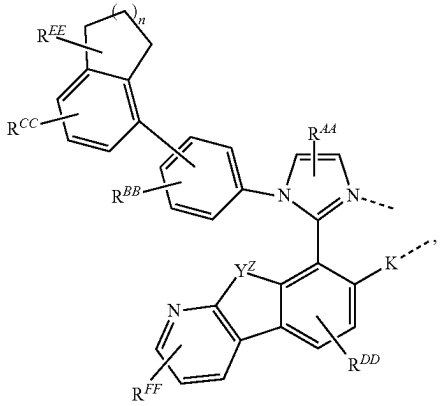

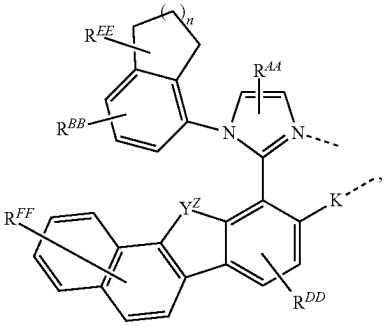

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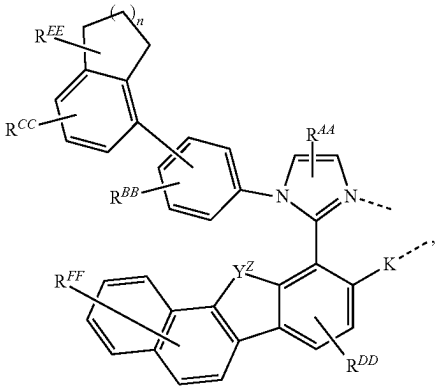

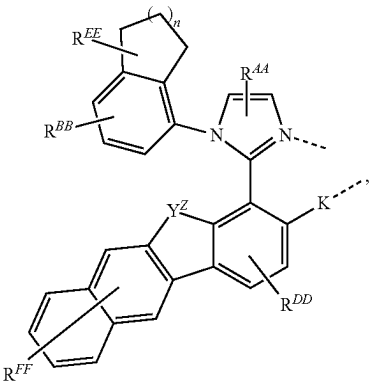

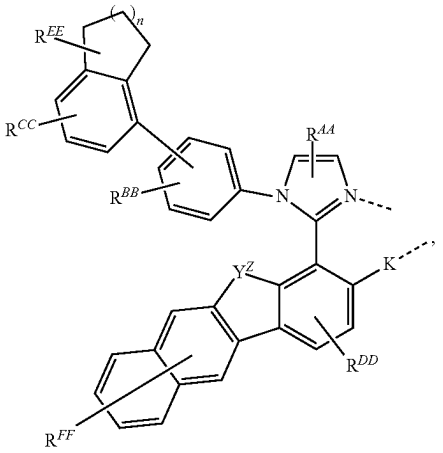

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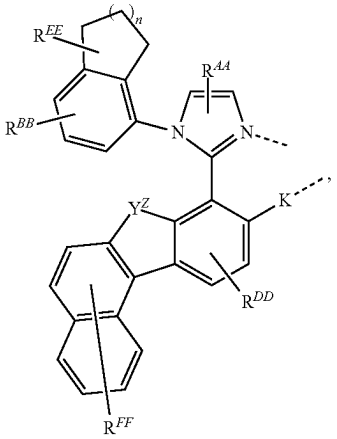

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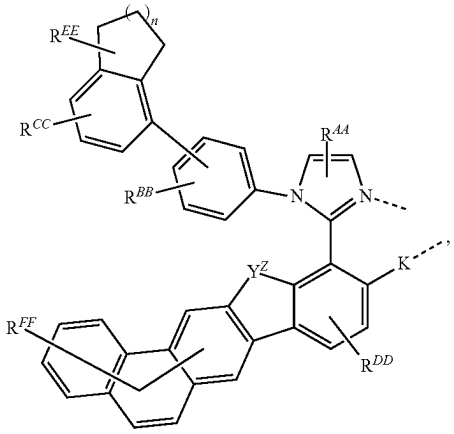

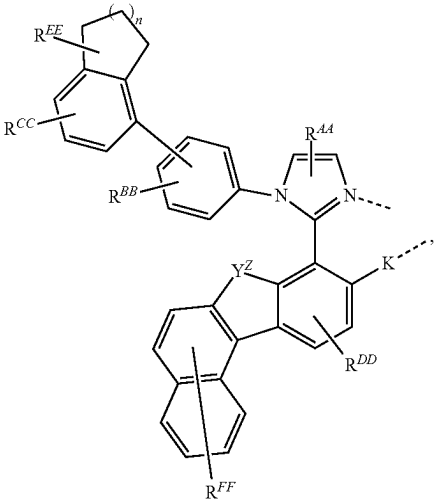

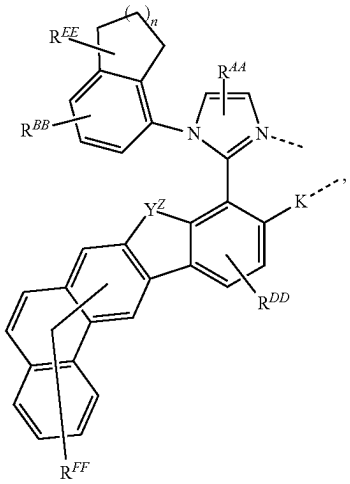

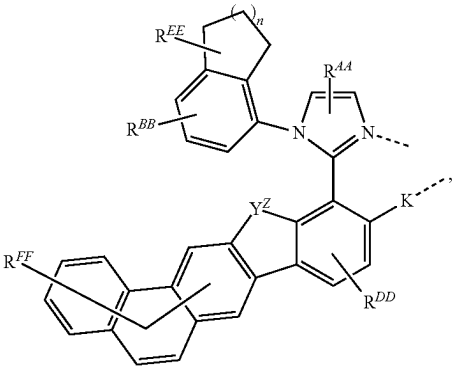

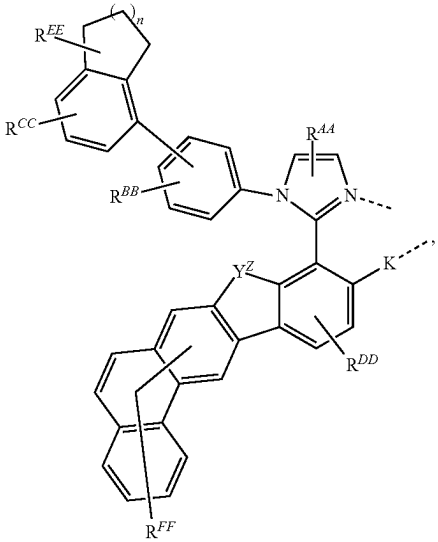

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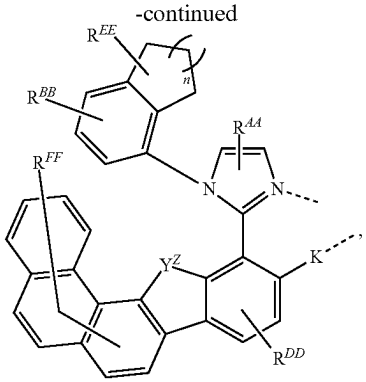

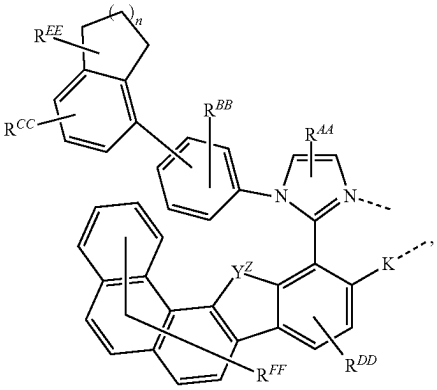

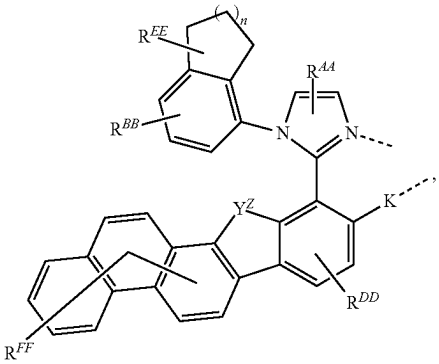

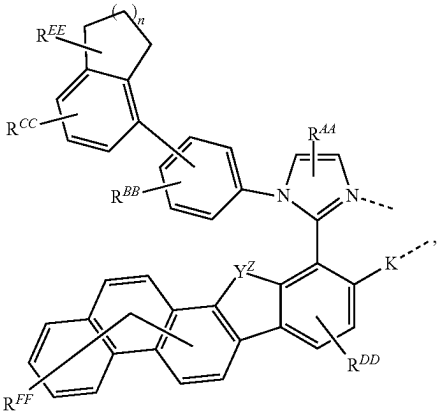

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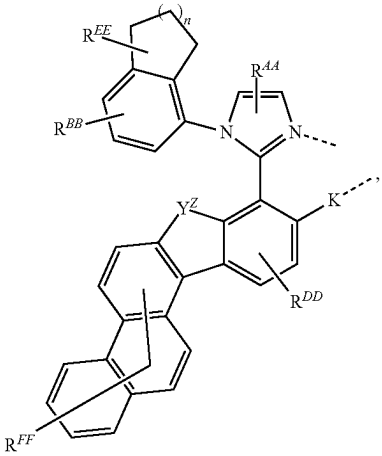

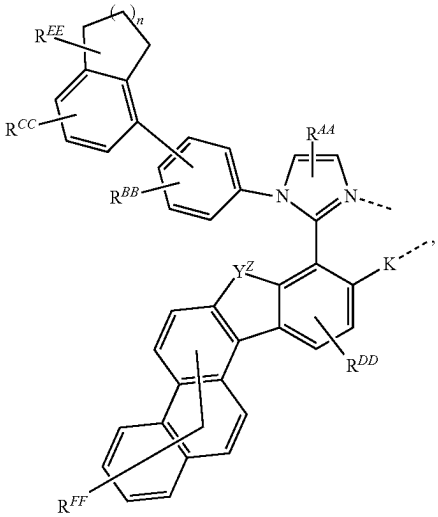

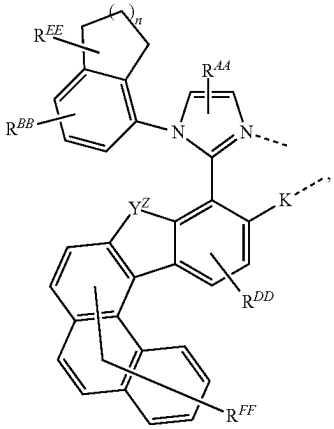

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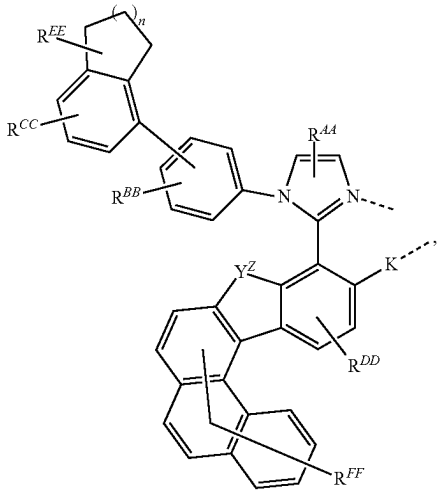

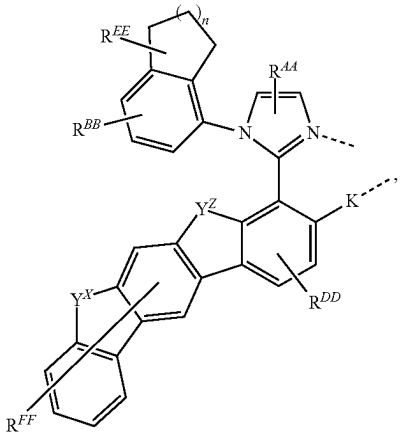

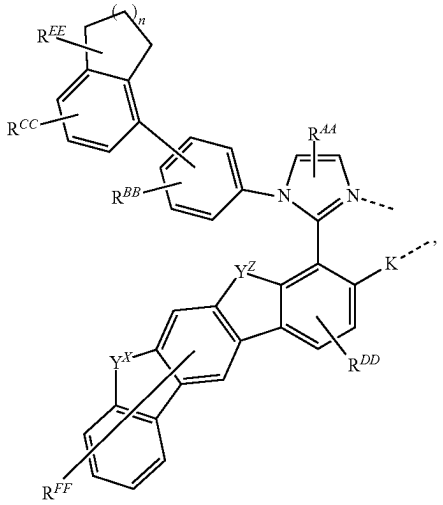

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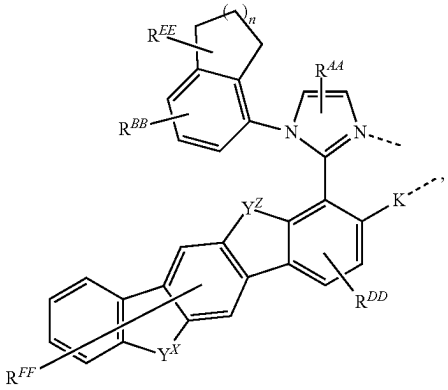

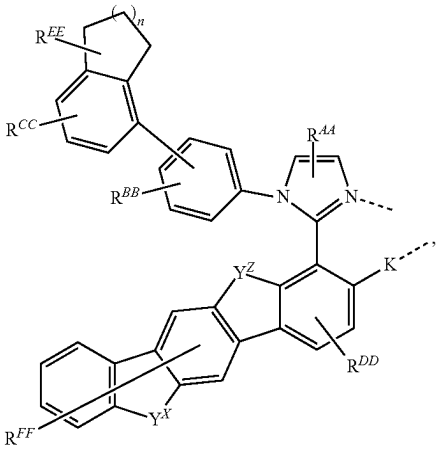

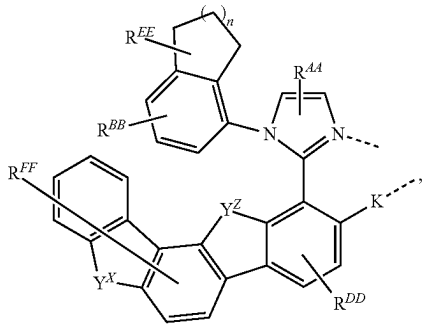

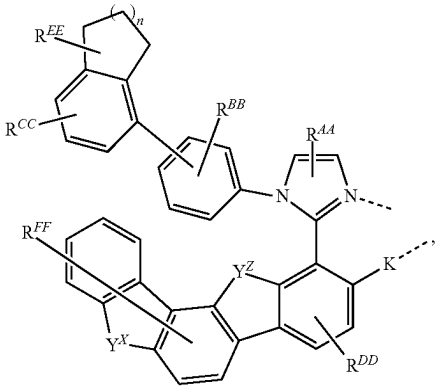

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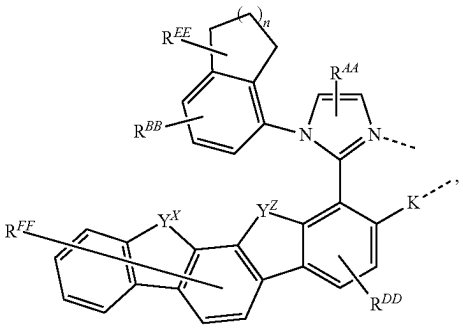

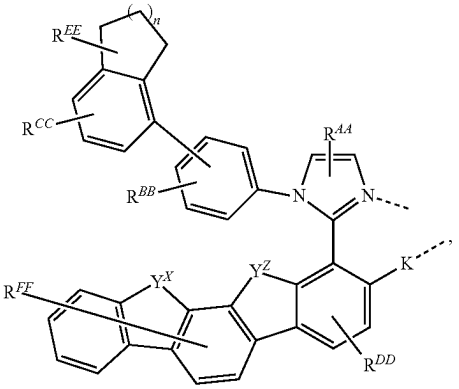

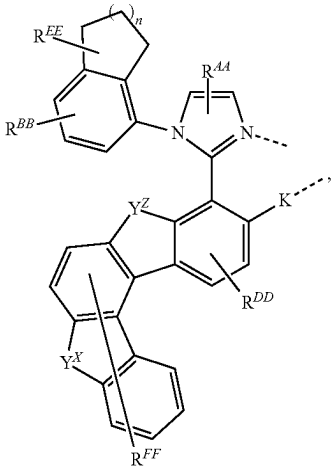

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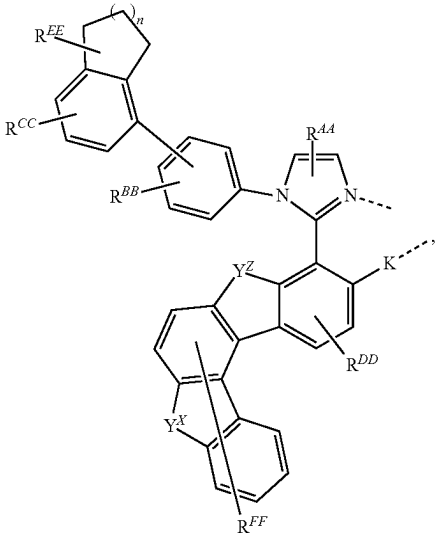

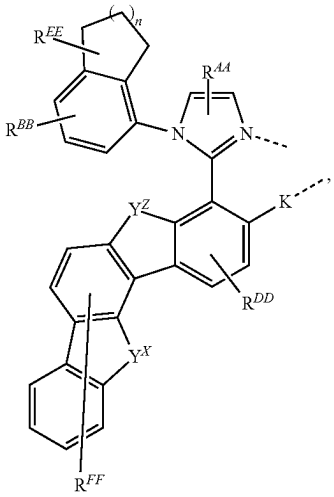

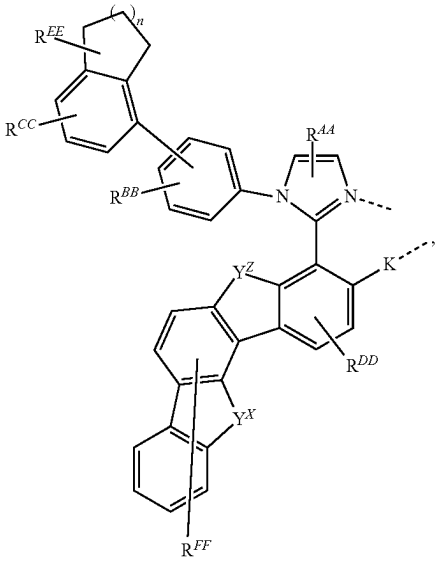

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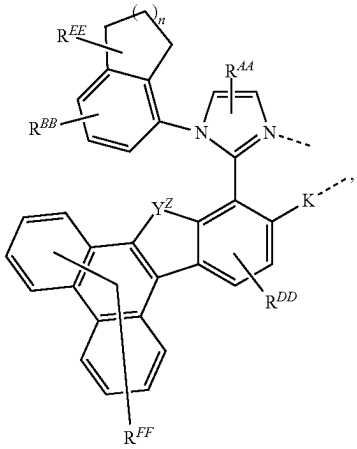

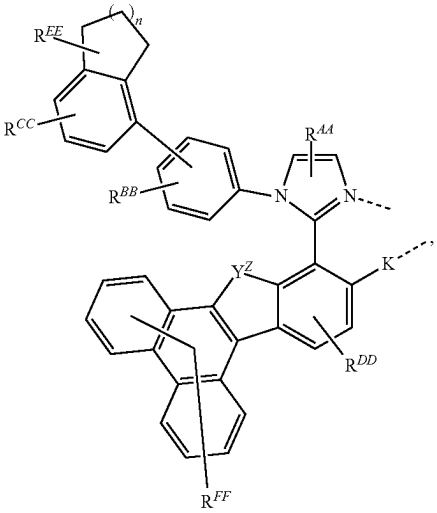

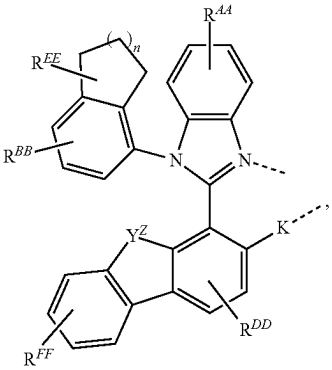

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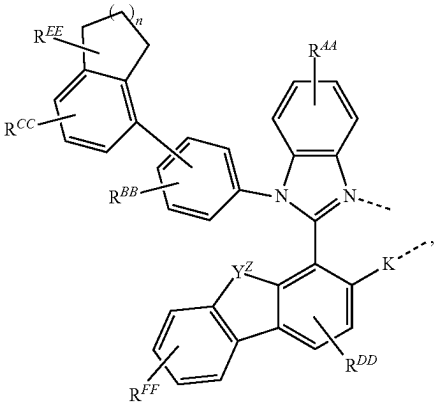

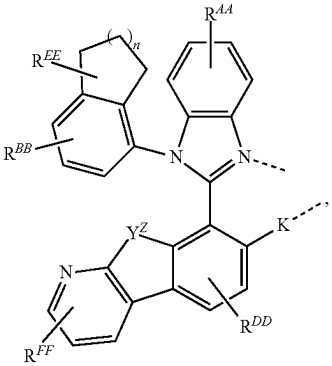

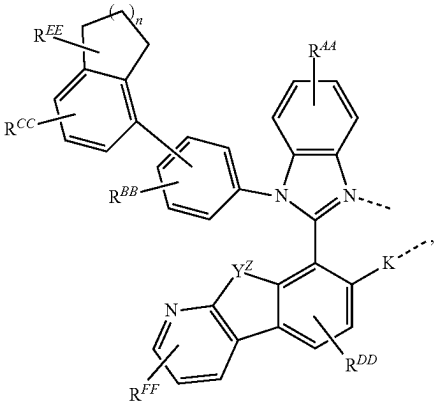

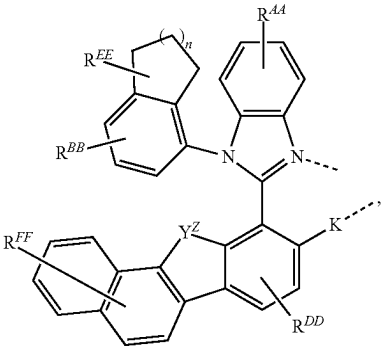

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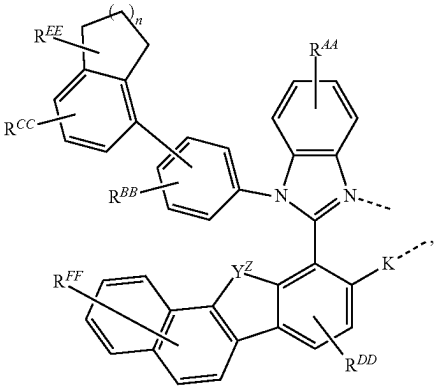

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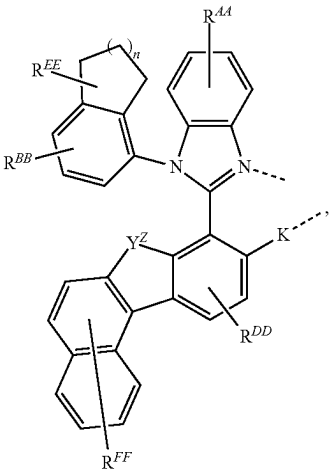

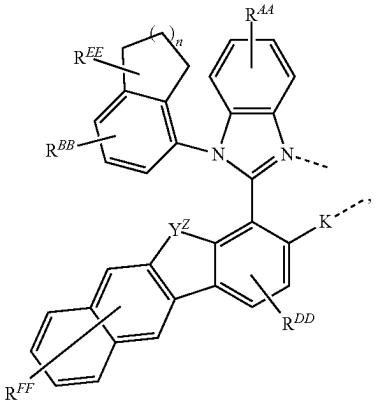

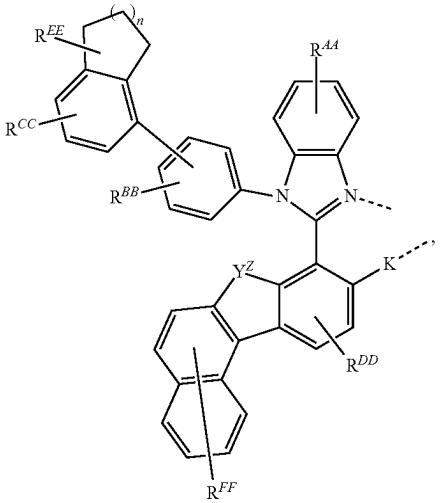

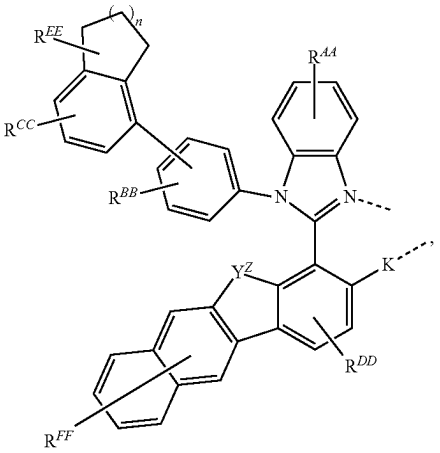

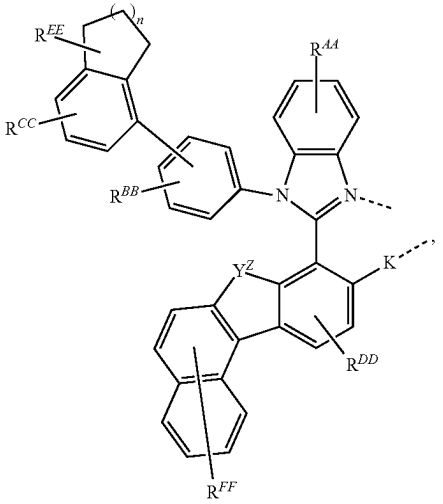

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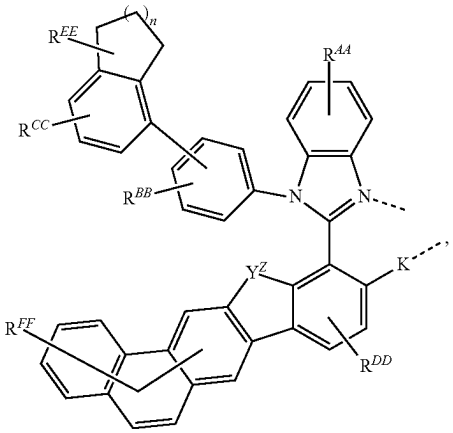

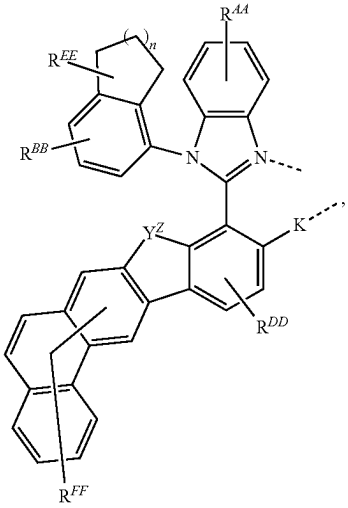

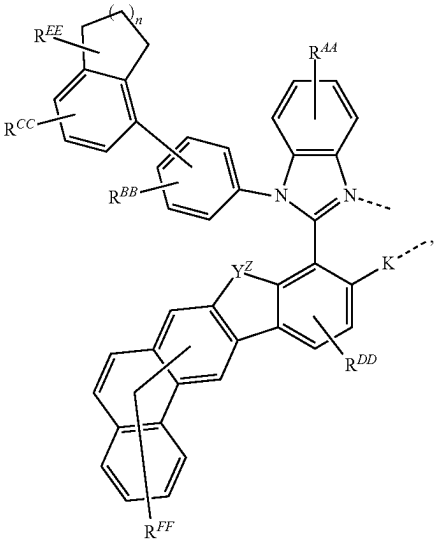

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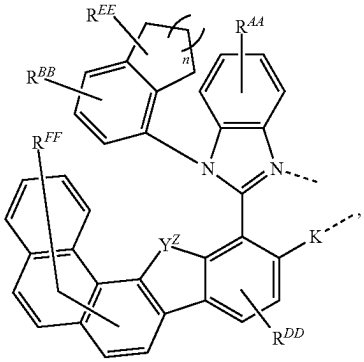

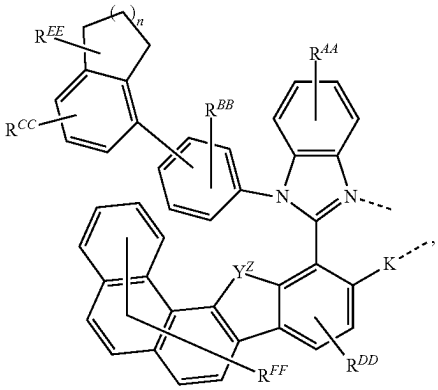

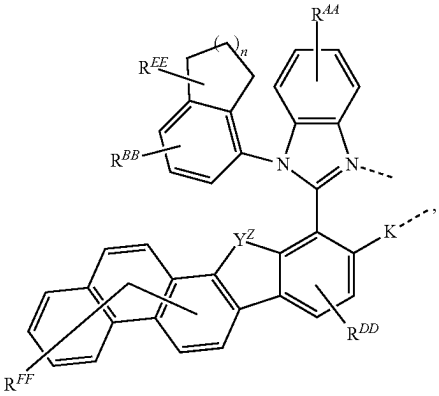

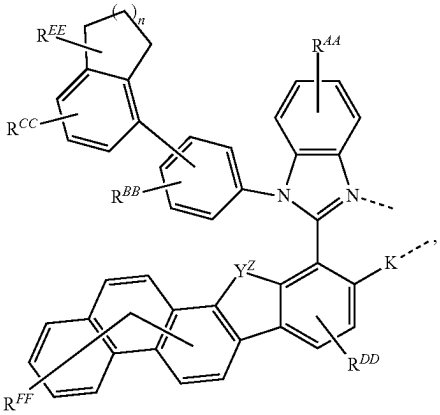

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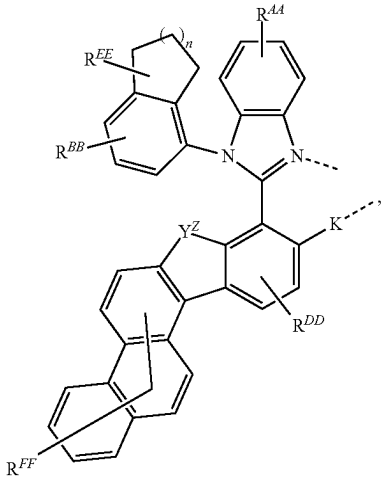

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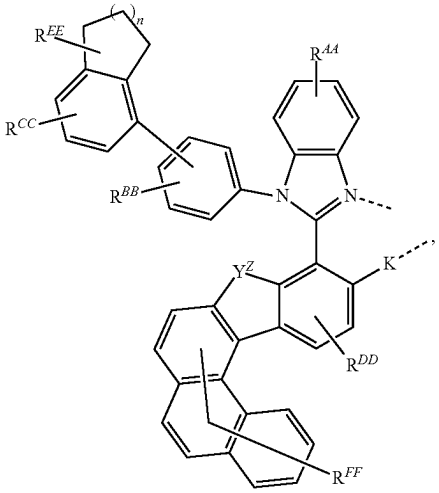

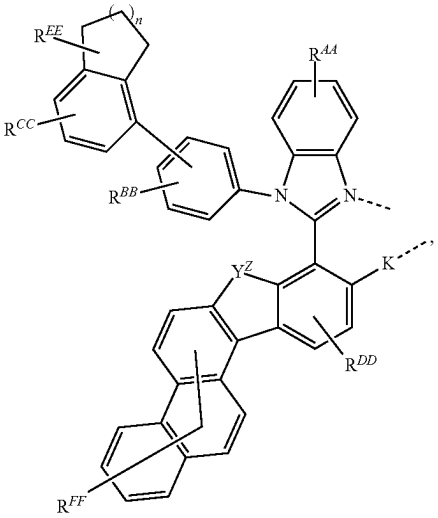

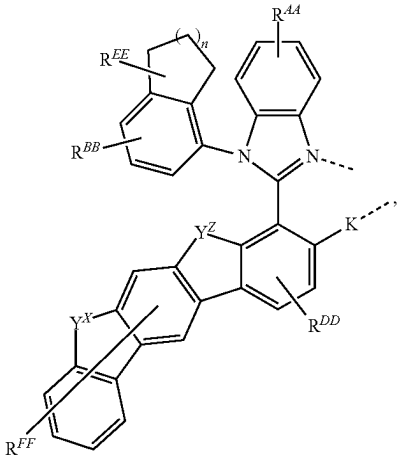

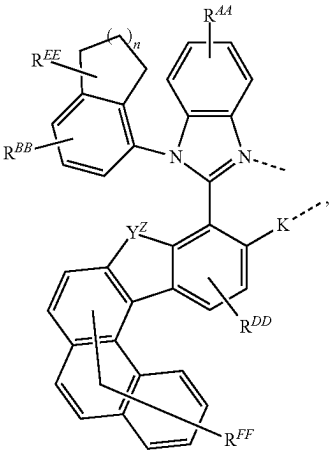

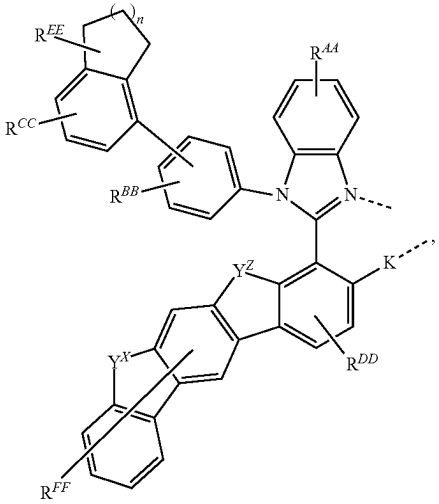

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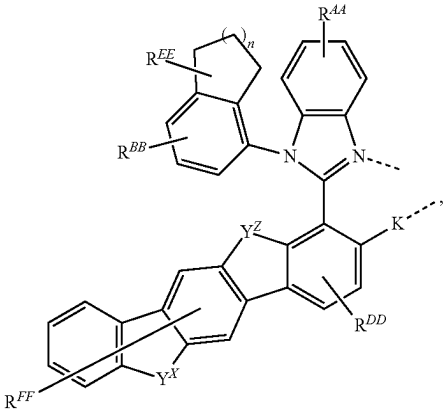

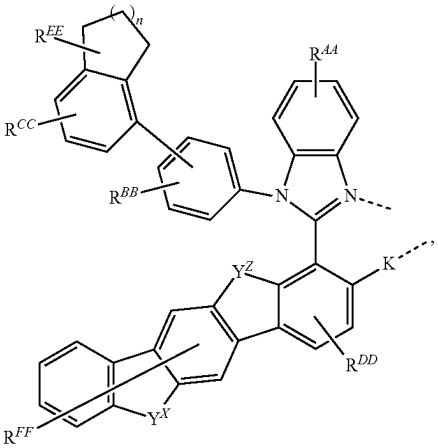

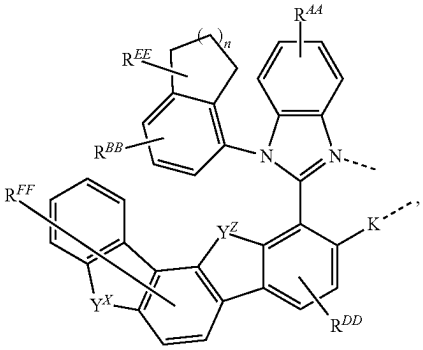

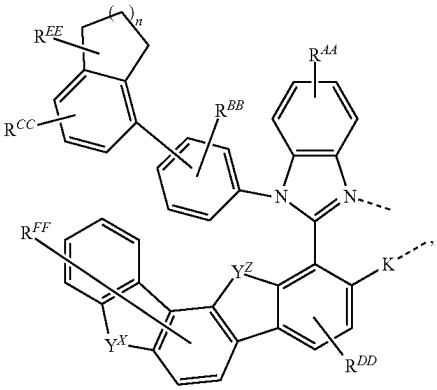

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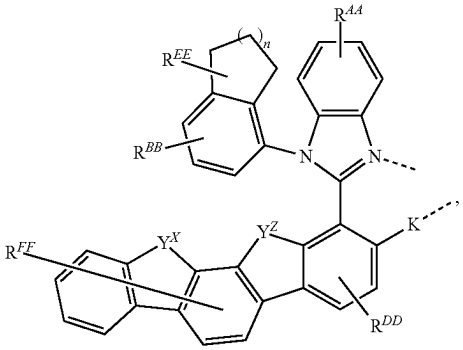

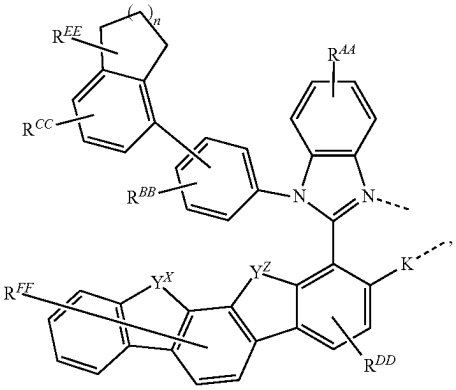

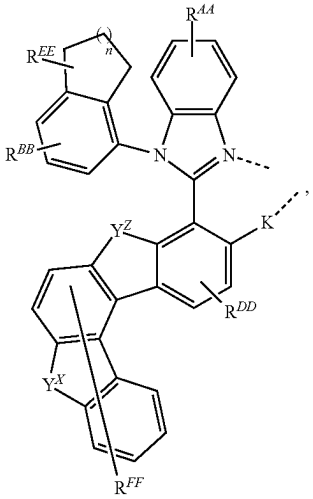

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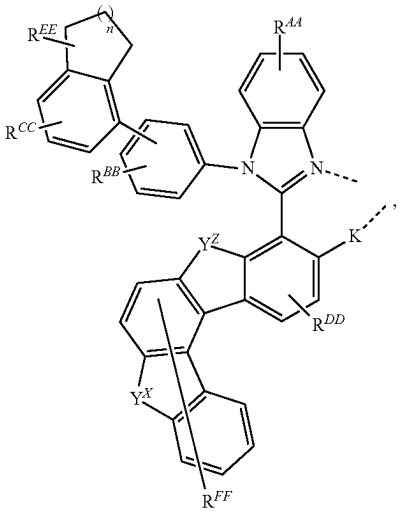

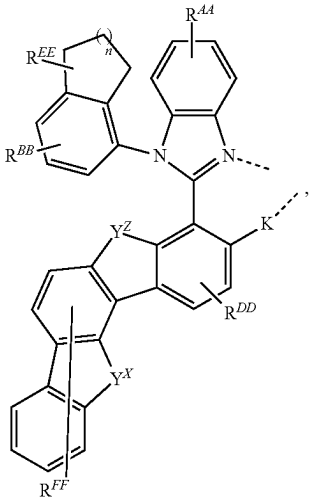

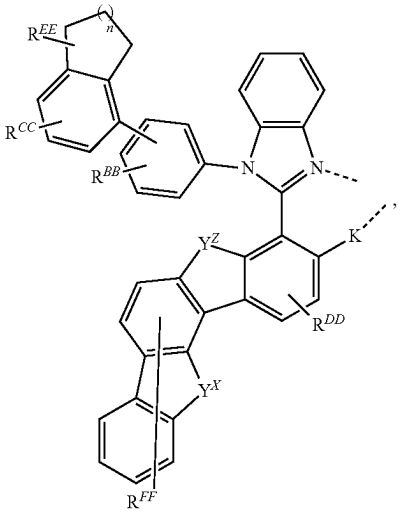

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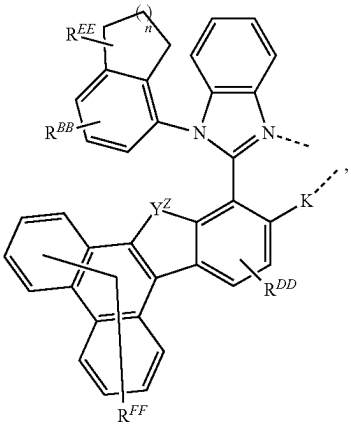

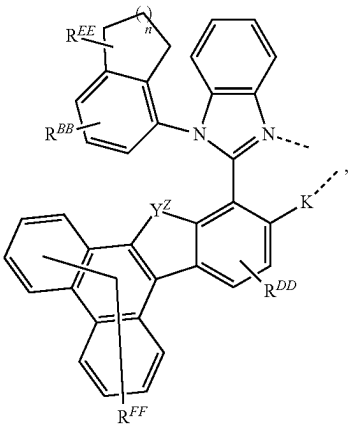

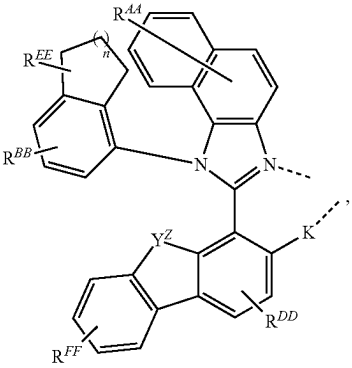

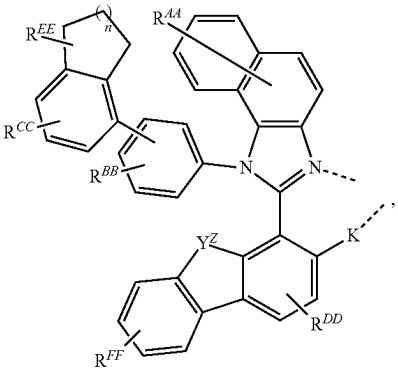

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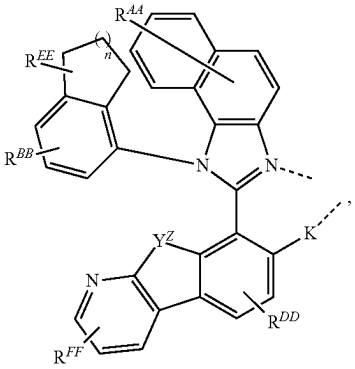

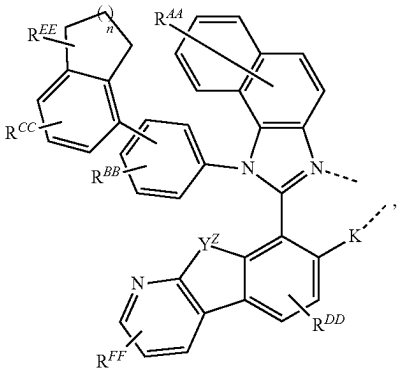

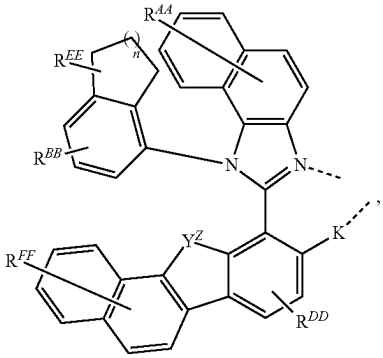

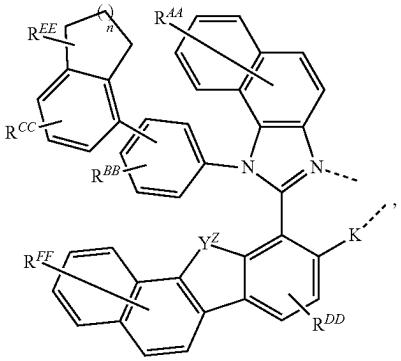

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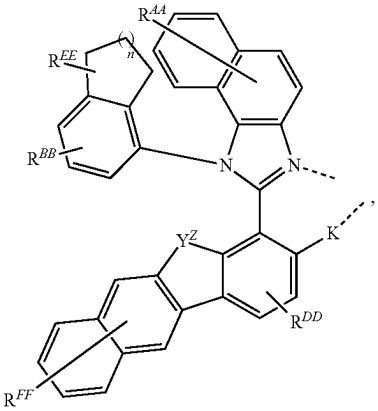

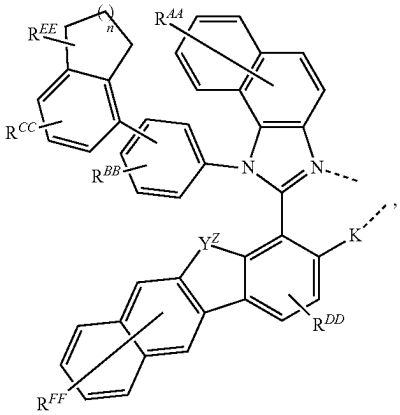

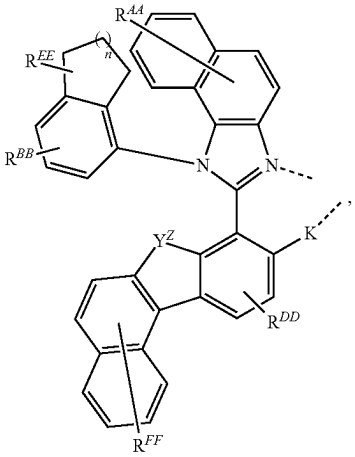

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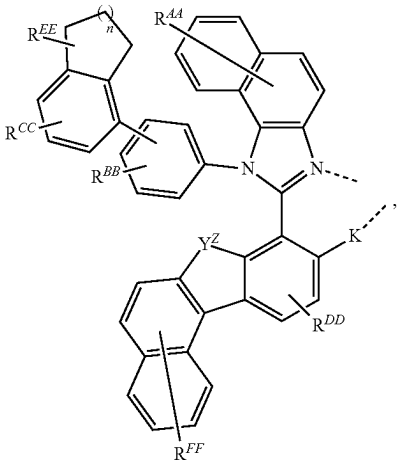

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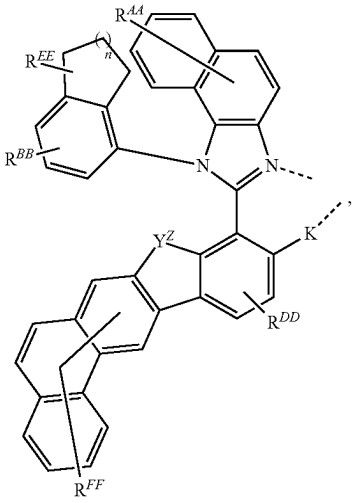

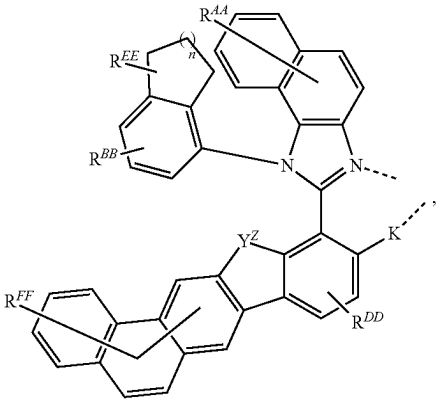

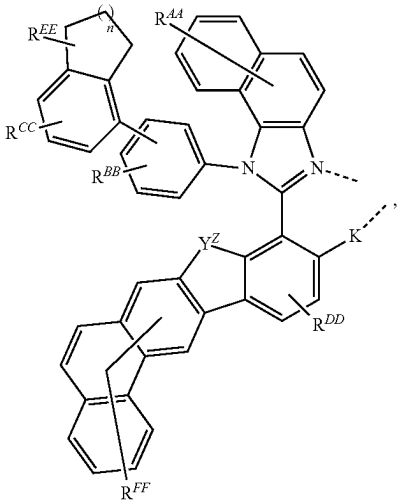

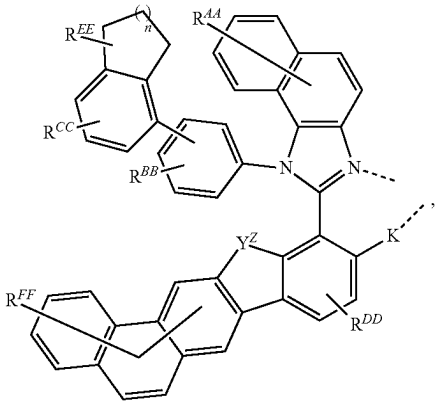

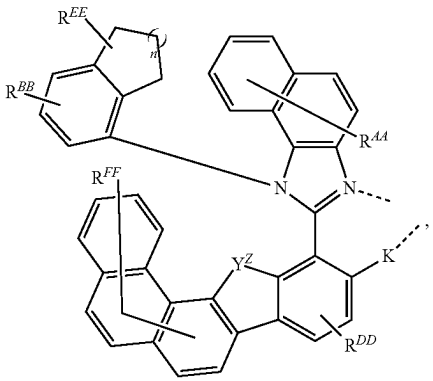

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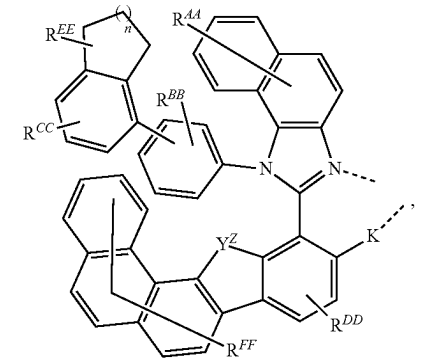

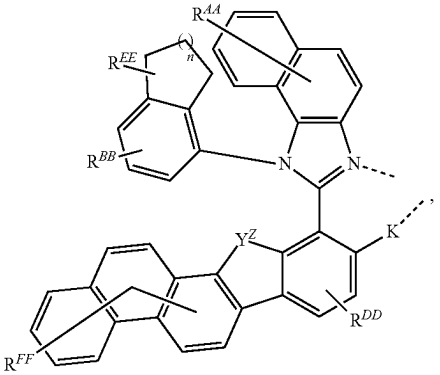

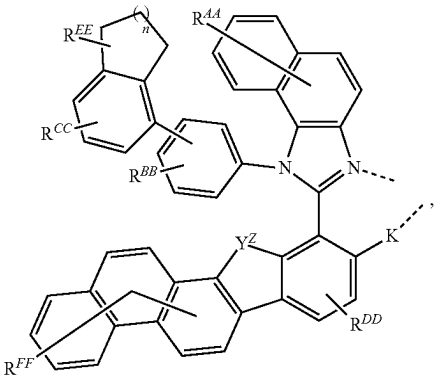

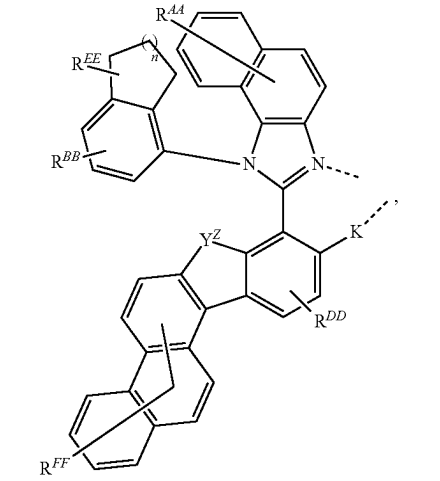

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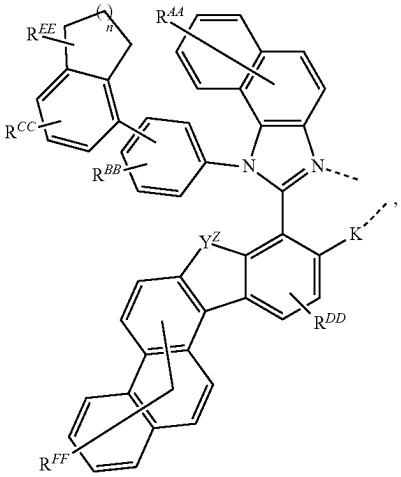

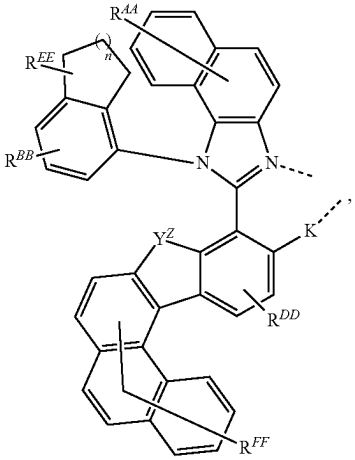

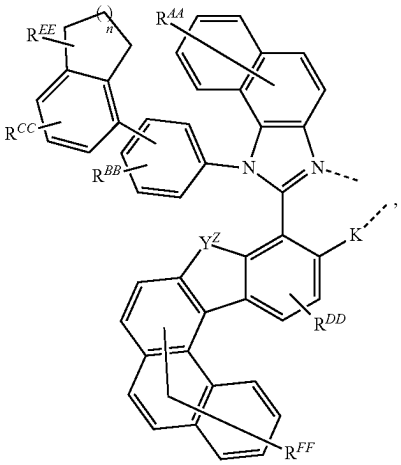

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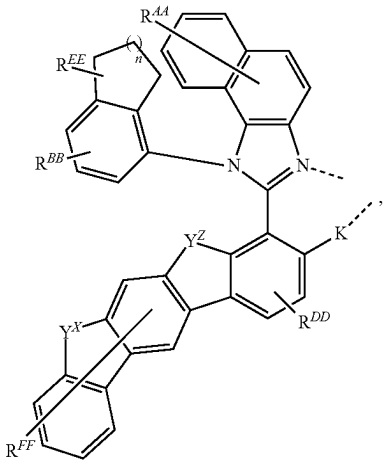

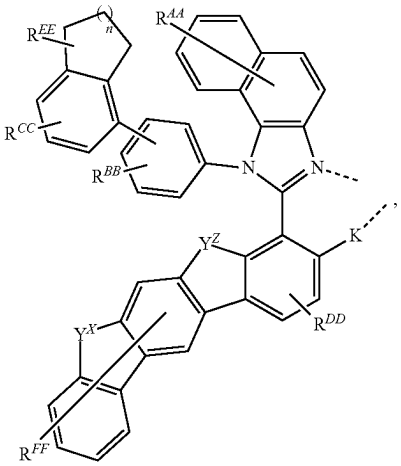

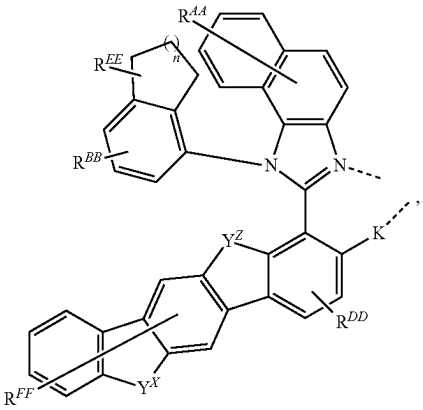

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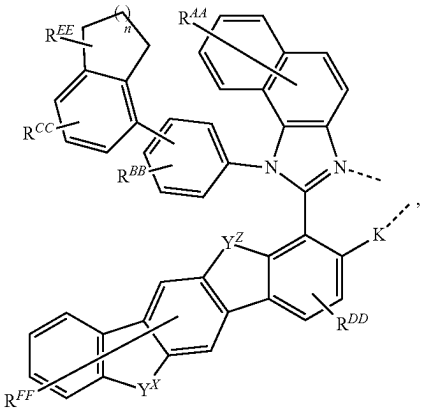

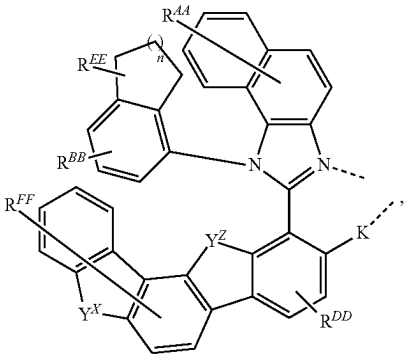

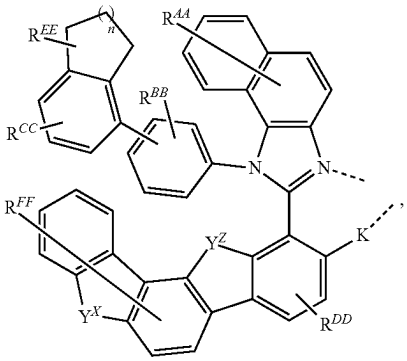

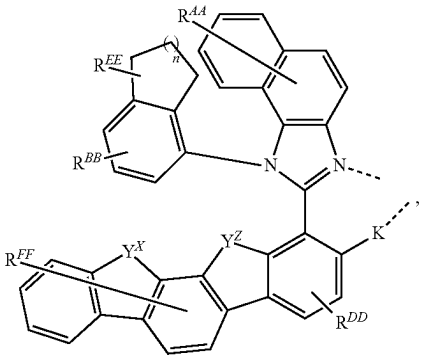

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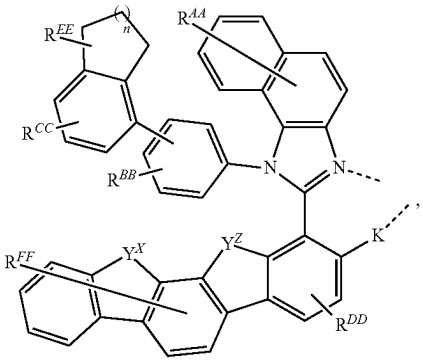

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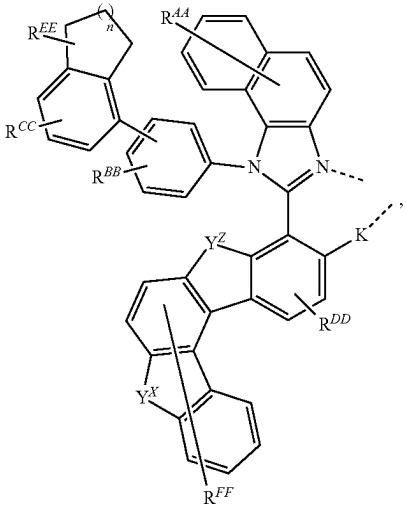

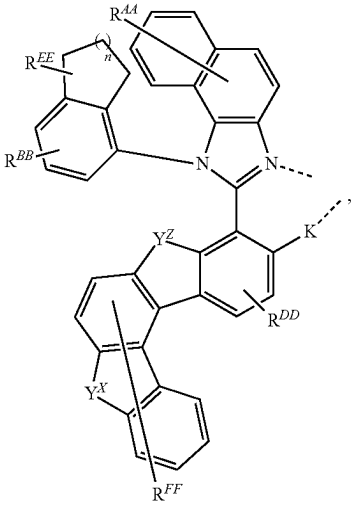

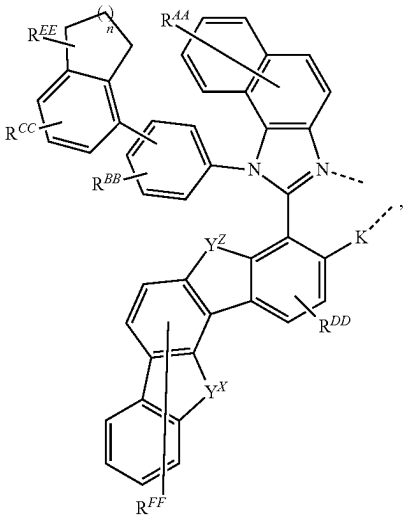

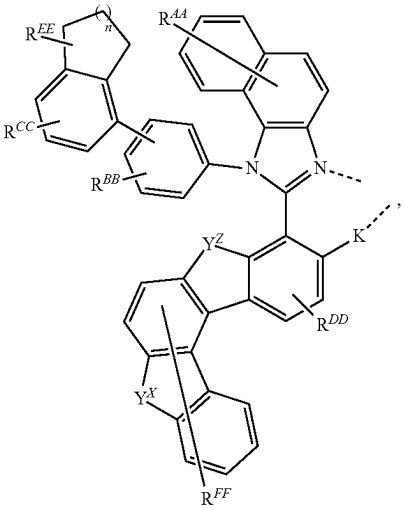

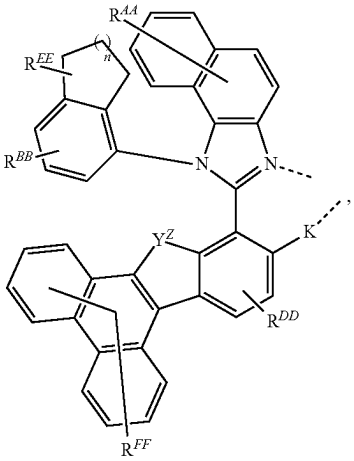

and

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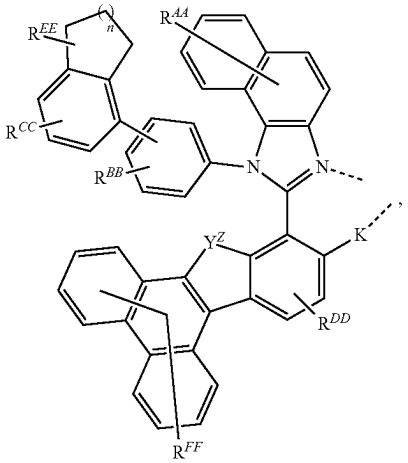


wherein:

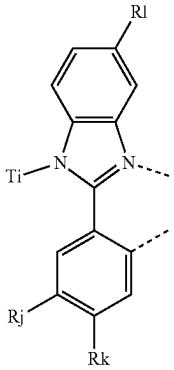
each of Y^Z and Y^X is independently selected from the group consisting of BR_e, NR_e, PR_e, O, S, Se, C═O, S═O, SO_2, CR_eR_f, SiR_eR_f, and GeR_eR_f;

each R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, and R^{FF} independently represent from mono to the maximum possible number of substitutions, or no substitution;

each R^{AA}, R^{BB}, R^{CC}, R^{DD}, R^{EE}, and R^{FF} is independently a hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, selenyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

any two substituents can be joined or fused to form a ring.

9. The compound of claim **1**, wherein the ligand L_A is selected from L_A i-(Ti)(Rj)(Rk)(Rl), wherein i is an integer from 1 to 24, Ti is selected from the group consisting of T1 to T76, and each Rj, Rk, and Rl is independently selected from the group consisting of R1 to R468; wherein each of L_A 1-(T1)(R1)(R1)(R1) to L_A 24-(T76)(R468)(R468)(R468) is defined as follows:

Compound	Structure of compound
L_A 1-(Ti)(Rj)(Rk)(Rl), wherein L_A 1-(T1)(R1)(R1)(R1) to L_A 1-(T76)(R468)(R468)(R468) have the structure	

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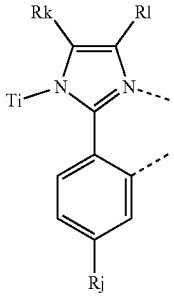
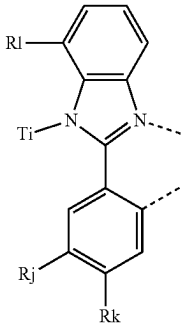
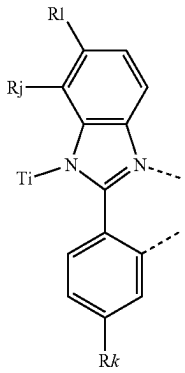
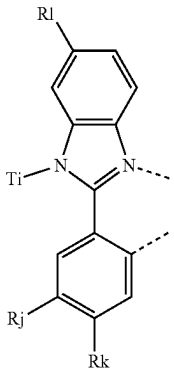
Compound	Structure of compound
L_A 2-(Ti)(Rj)(Rk)(Rl), wherein L_A 2-(T1)(R1)(R1)(R1) to L_A 2-(T76)(R468)(R468)(R468) have the structure	
L_A 3-(Ti)(Rj)(Rk)(Rl), wherein L_A 3-(T1)(R1)(R1)(R1) to L_A 3-(T76)(R468)(R468)(R468) have the structure	
L_A 4-(Ti)(Rj)(Rk)(Rl), wherein L_A 4-(T1)(R1)(R1)(R1) to L_A 4-(T76)(R468)(R468)(R468) have the structure	
L_A 5-(Ti)(Rj)(Rk)(Rl), wherein L_A 5-(T1)(R1)(R1)(R1) to L_A 5-(T76)(R468)(R468)(R468) have the structure	

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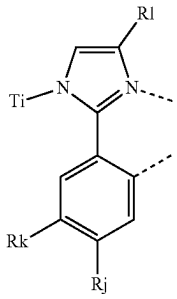
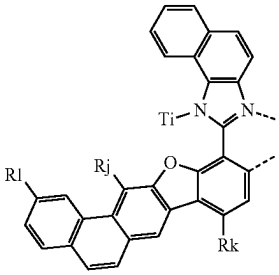
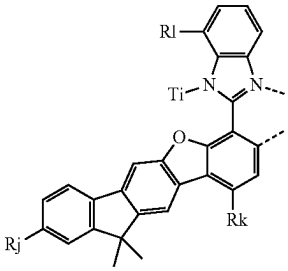
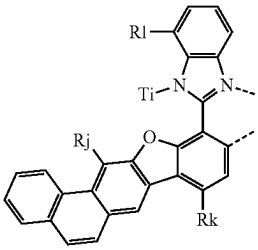
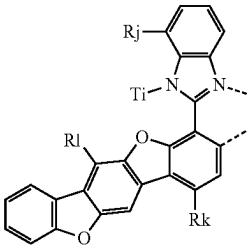
Compound	Structure of compound
L_A 6-(Ti)(Rj)(Rk)(Rl), wherein L_A 6-(T1)(R1)(R1)(R1) to L_A 6-(T76)(R468)(R468)(R468) have the structure	
L_A 7-(Ti)(Rj)(Rk)(Rl), wherein L_A 7-(T1)(R1)(R1)(R1) to L_A 7-(T76)(R468)(R468)(R468) have the structure	
L_A 8-(Ti)(Rj)(Rk)(Rl), wherein L_A 8-(T1)(R1)(R1)(R1) to L_A 8-(T76)(R468)(R468)(R468) have the structure	
L_A 9-(Ti)(Rj)(Rk)(Rl), wherein L_A 9-(T1)(R1)(R1)(R1) to L_A 9-(T76)(R468)(R468)(R468) have the structure	
L_A 10-(Ti)(Rj)(Rk)(Rl), wherein L_A 10-(T1)(R1)(R1)(R1) to L_A 10-(T76)(R468)(R468)(R468) have the structure	

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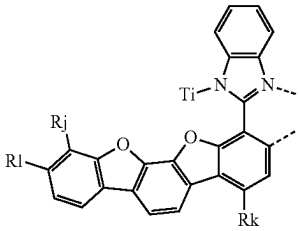
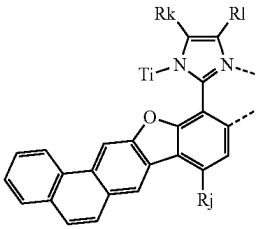
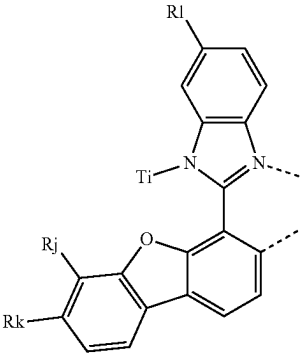
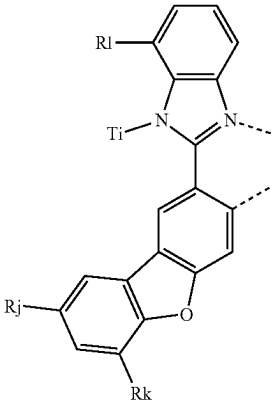
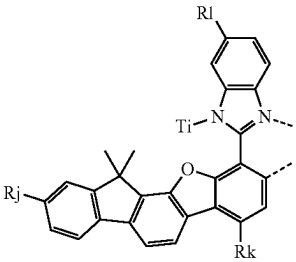
Compound	Structure of compound
L_A 11-(Ti)(Rj)(Rk)(Rl), wherein L_A 11-(T1)(R1)(R1)(R1) to L_A 11-(T76)(R468)(R468)(R468) have the structure	
L_A 12-(Ti)(Rj)(Rk)(Rl), wherein L_A 12-(T1)(R1)(R1)(R1) to L_A 12-(T76)(R468)(R468)(R468) have the structure	
L_A 13-(Ti)(Rj)(Rk)(Rl), wherein L_A 13-(T1)(R1)(R1)(R1) to L_A 13-(T76)(R468)(R468)(R468) have the structure	
L_A 14-(Ti)(Rj)(Rk)(Rl), wherein L_A 14-(T1)(R1)(R1)(R1) to L_A 14-(T76)(R468)(R468)(R468) have the structure	
L_A 15-(Ti)(Rj)(Rk)(Rl), wherein L_A 15-(T1)(R1)(R1)(R1) to L_A 15-(T76)(R468)(R468)(R468) have the structure	

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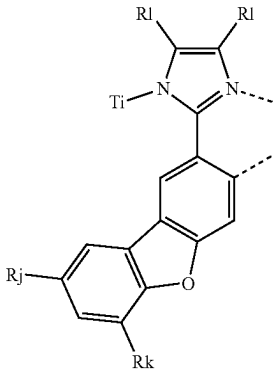
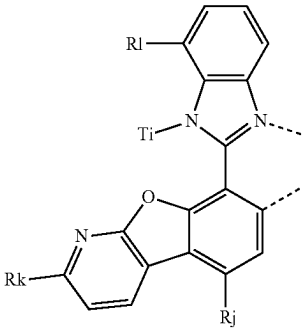
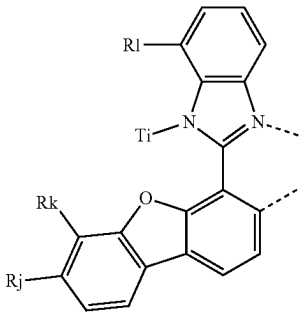
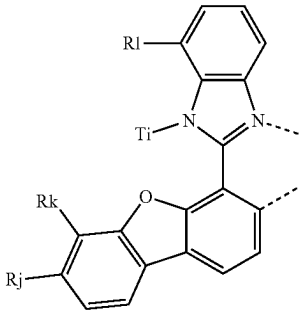
Compound	Structure of compound
L_A 16-(Ti)(Rj)(Rk)(Rl), wherein L_A 16-(T1)(R1)(R1)(R1) to L_A 16-(T76)(R468)(R468)(R468) have the structure	
L_A 17-(Ti)(Rj)(Rk)(Rl), wherein L_A 17-(T1)(R1)(R1)(R1) to L_A 17-(T76)(R468)(R468)(R468) have the structure	
L_A 18-(Ti)(Rj)(Rk)(Rl), wherein L_A 18-(T1)(R1)(R1)(R1) to L_A 18-(T76)(R468)(R468)(R468) have the structure	
L_A 19-(Ti)(Rj)(Rk)(Rl), wherein L_A 19-(T1)(R1)(R1)(R1) to L_A 19-(T76)(R468)(R468)(R468) have the structure	

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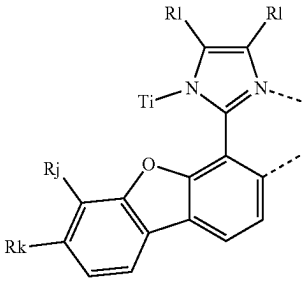
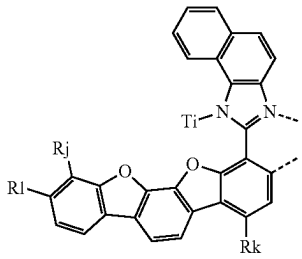
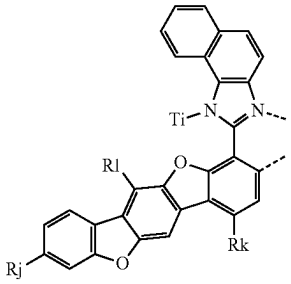
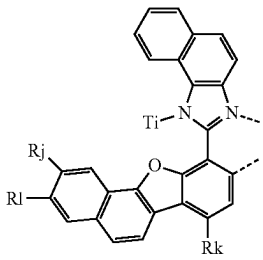
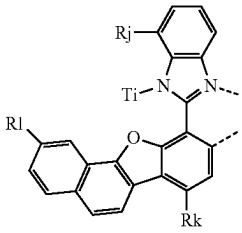
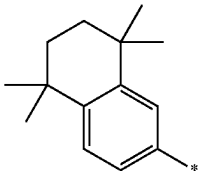
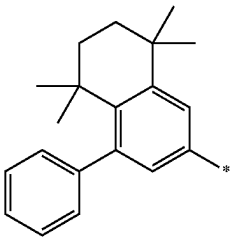
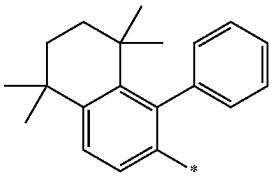
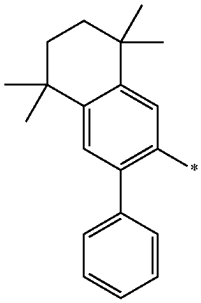
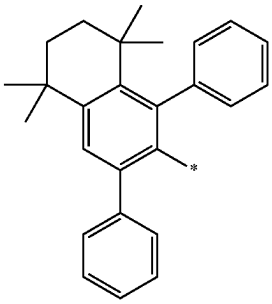
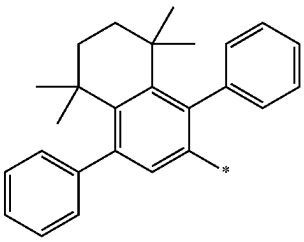
Compound	Structure of compound
L_A 20-(Ti)(Rj)(Rk)(Rl), wherein L_A 20-(T1)(R1)(R1)(R1) to L_A 20-(T76)(R468)(R468)(R468) have the structure	
L_A 21-(Ti)(Rj)(Rk)(Rl), wherein L_A 21-(T1)(R1)(R1)(R1) to L_A 21-(T76)(R468)(R468)(R468) have the structure	
L_A 22-(Ti)(Rj)(Rk)(Rl), wherein L_A 22-(T1)(R1)(R1)(R1) to L_A 22-(T76)(R468)(R468)(R468) have the structure	
L_A 23-(Ti)(Rj)(Rk)(Rl), wherein L_A 23-(T1)(R1)(R1)(R1) to L_A 23-(T76)(R468)(R468)(R468) have the structure	
L_A 24-(Ti)(Rj)(Rk)(Rl), wherein L_A 24-(T1)(R1)(R1)(R1) to L_A 24-(T76)(R468)(R468)(R468) have the structure	

wherein each of T1 to T76 is defined as follows:

	Structure
T1	
T2	
T3	
T4	
T5	
T6	

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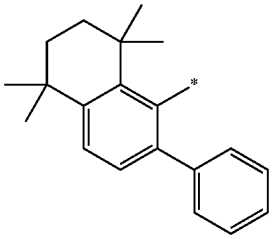
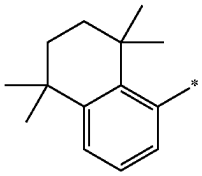
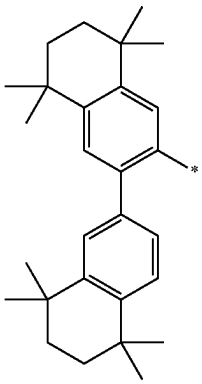
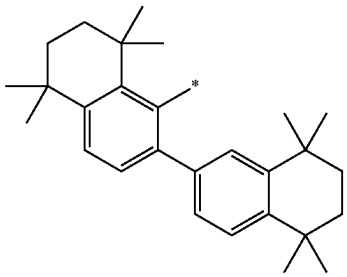
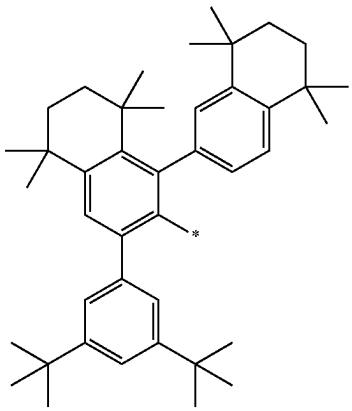
	Structure
T7	
T8	
T9	
T10	
T11	

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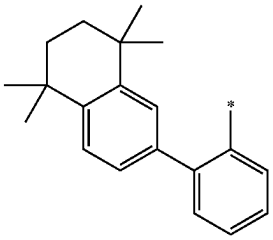
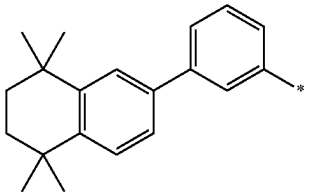
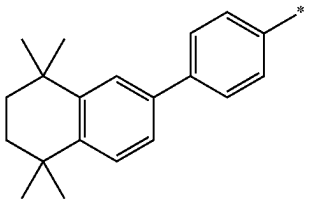
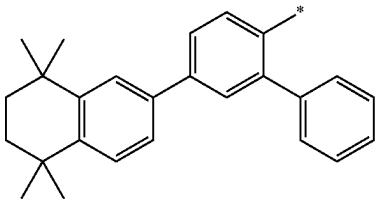
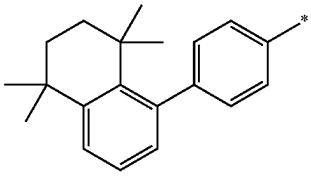
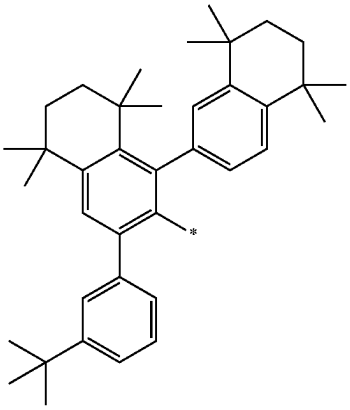
T12	
T13	
T14	
T15	
T16	
T17	

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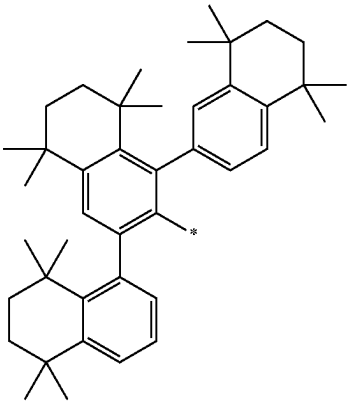
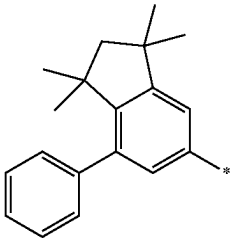
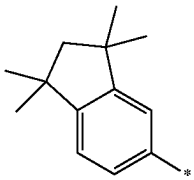
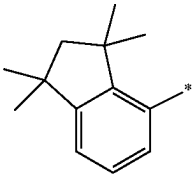
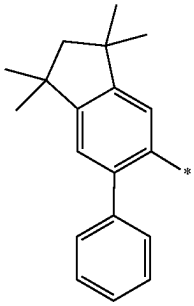
T18	
T19	
T20	
T21	
T22	

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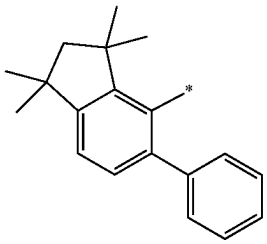
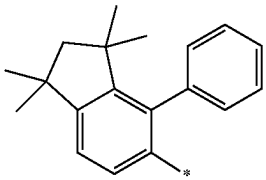
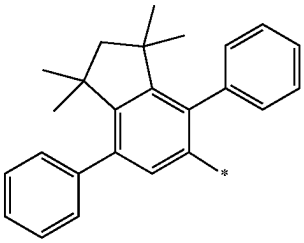
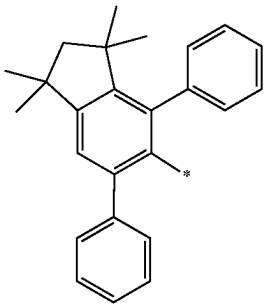
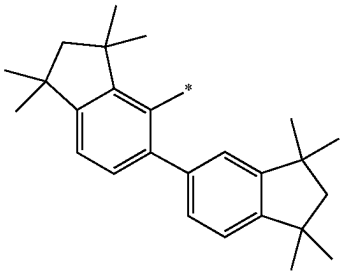
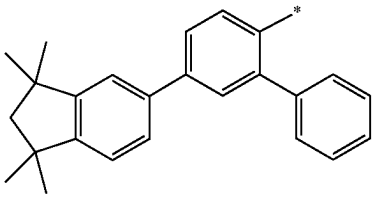
T23	
T24	
T25	
T26	
T27	
T28	

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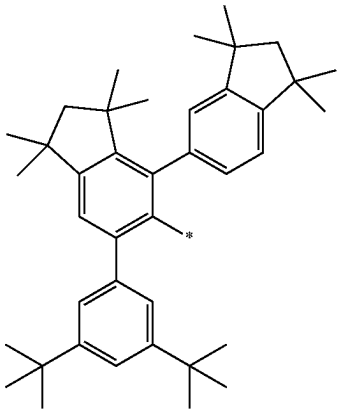
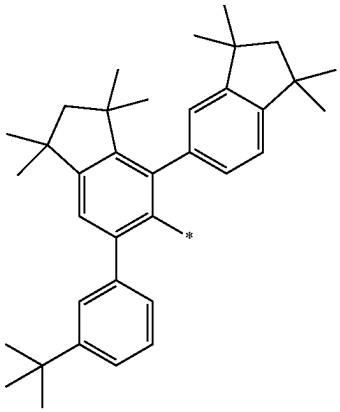
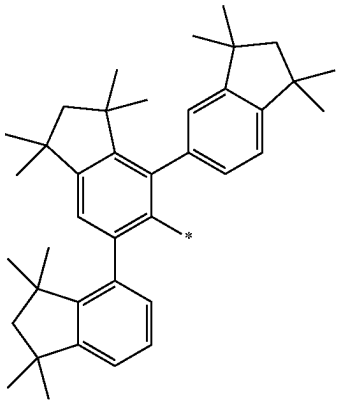
T29	
T30	
T31	

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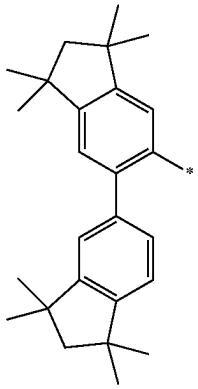
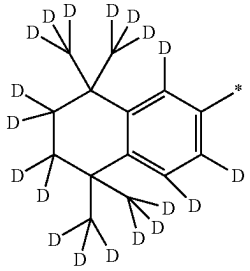
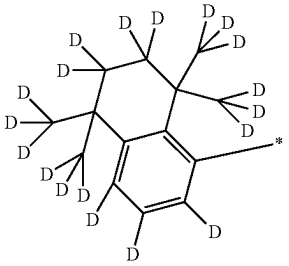
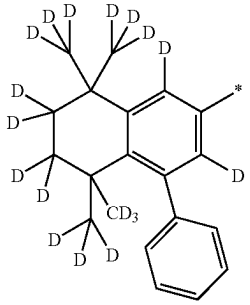
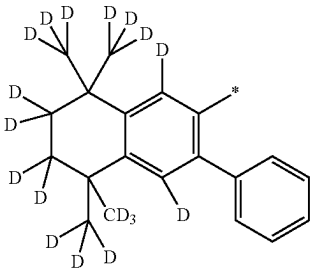
T32 
T33 
T34 
T35 
T36 

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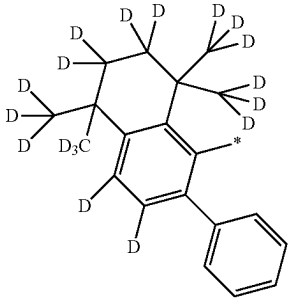
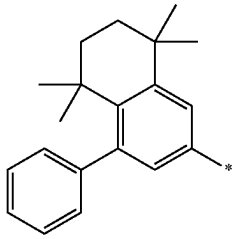
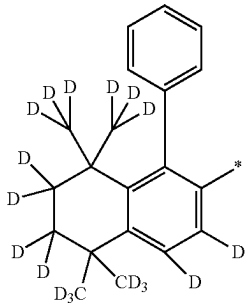
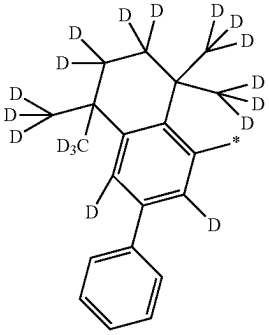
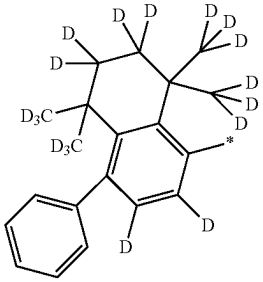
T37 
T38 
T39 
T40 
T41 

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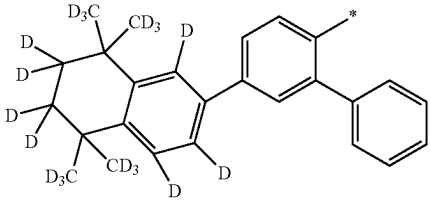
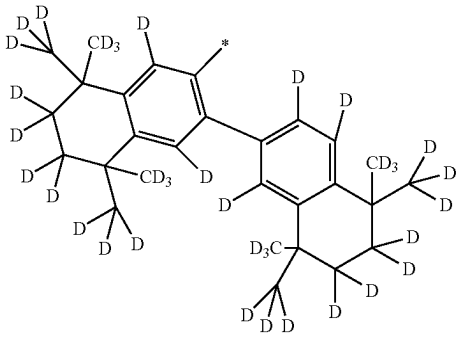
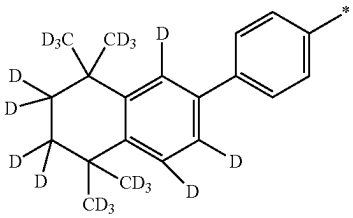
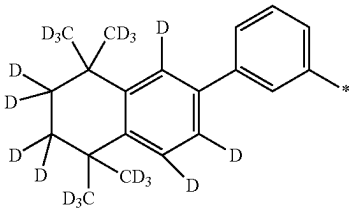
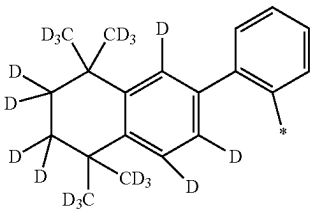
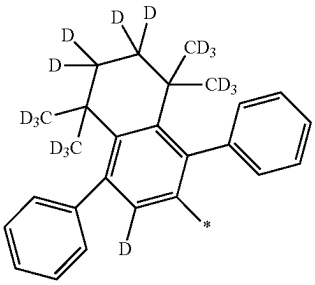
T42	
T43	
T44	
T45	
T46	
T47	

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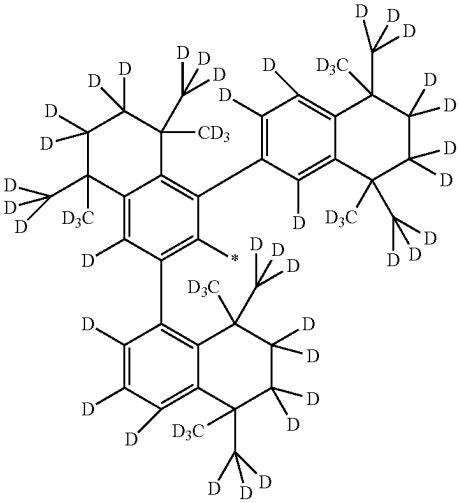
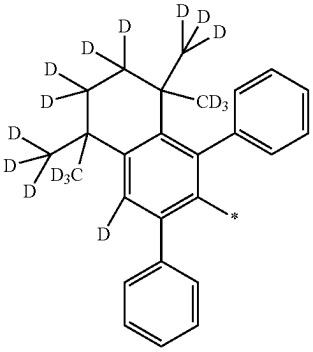
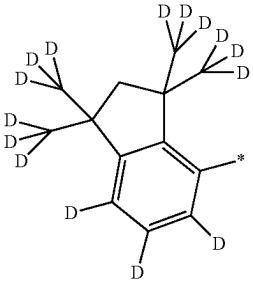
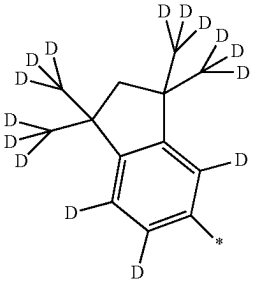
T48	
T49	
T50	
T51	

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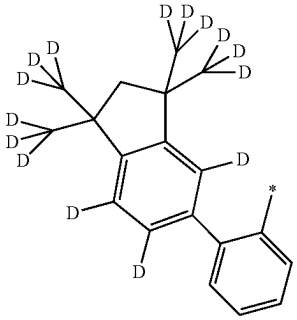
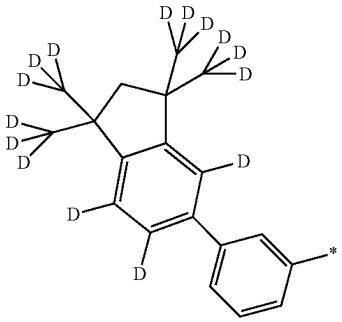
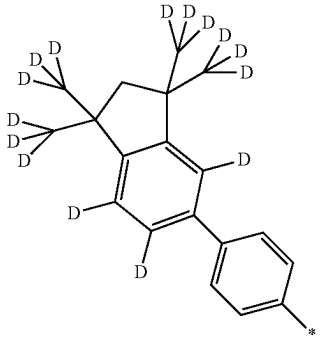
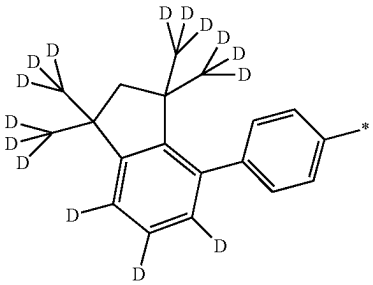
T52	
T53	
T54	
T55	

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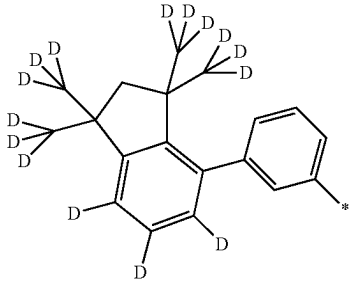
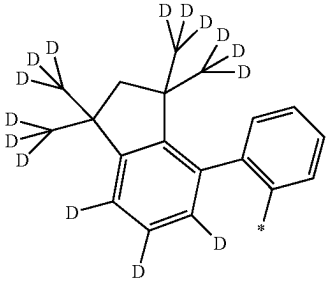
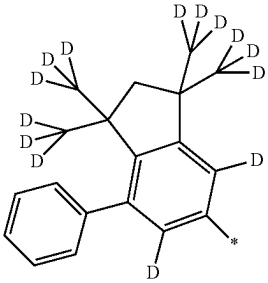
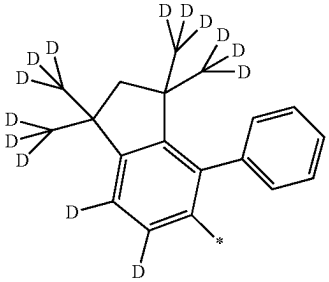
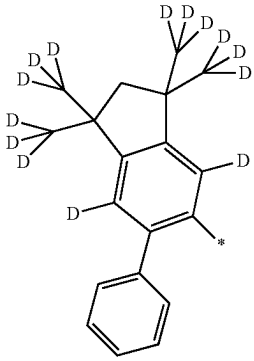
T56	
T57	
T58	
T59	
T60	

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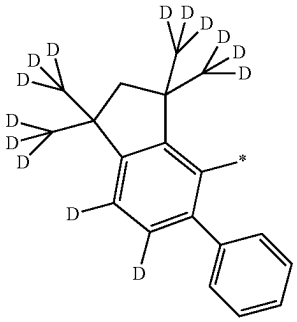
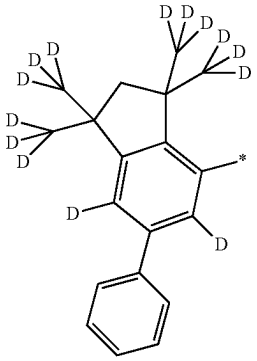
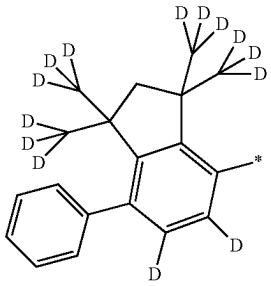
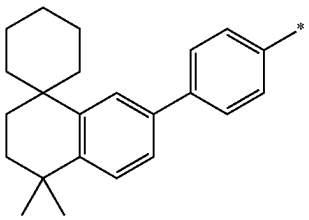
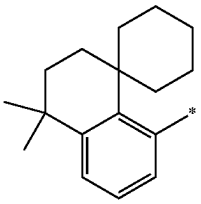
T61	
T62	
T63	
T64	
T65	

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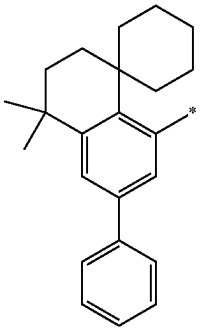
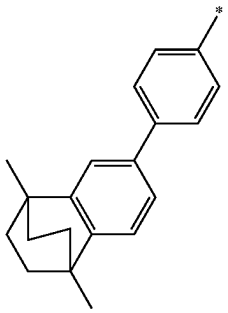
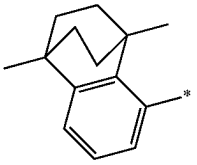
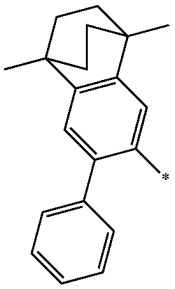
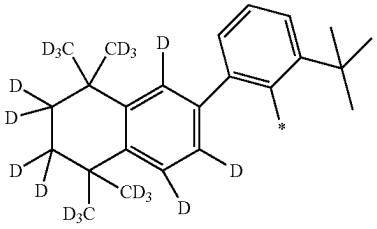
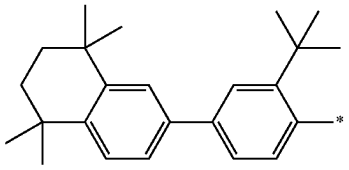
	Structure
T66	
T67	
T68	
T69	
T70	
T71	

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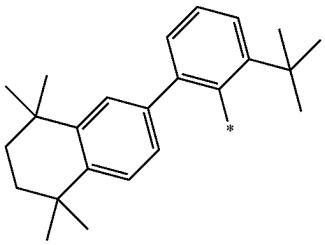
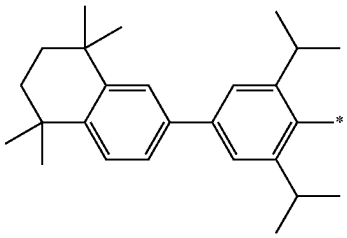
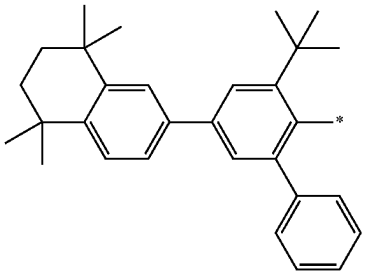
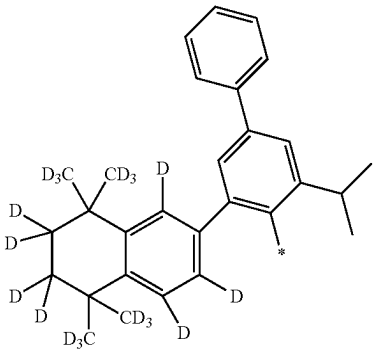
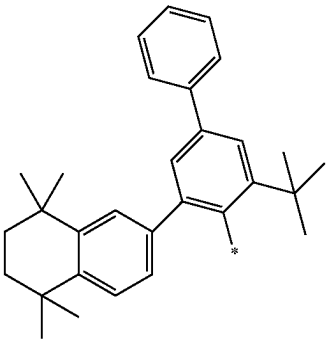
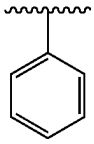
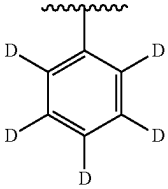
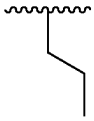
Structure	
T72	
T73	
T74	
T75	
T76	

wherein R1 to R468 are defined as follows:

Structure	
R1	
R2	
R3	
R4	
R5	
R6	
R7	
R8	
R9	
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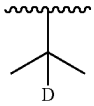
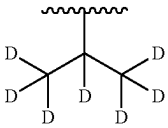
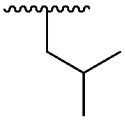
R11	
R12	
R13	

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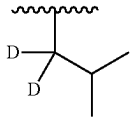
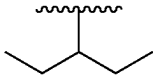
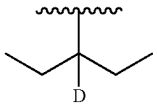
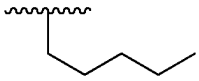
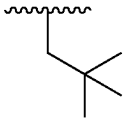
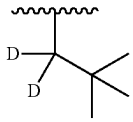
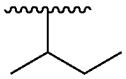
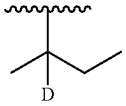
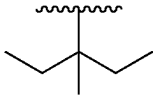
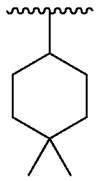
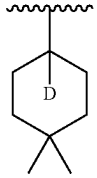
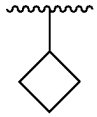
	Structure
R14	
R15	
R16	
R17	
R18	
R19	
R20	
R21	
R22	
R23	
R24	
R25	

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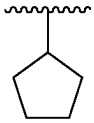
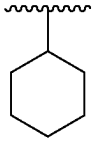
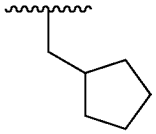
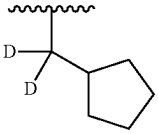
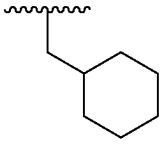
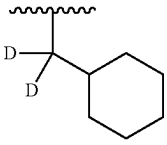
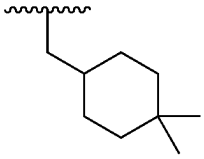
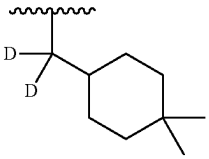
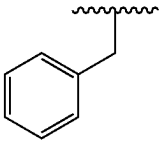
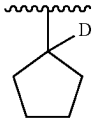
R26	
R27	
R28	
R29	
R30	
R31	
R32	
R33	
R34	
R35	

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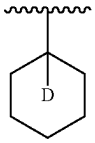
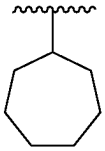
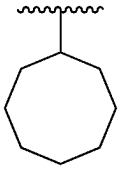
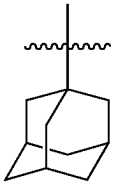
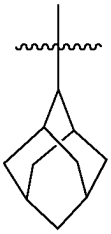
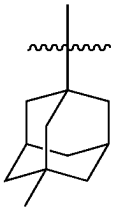
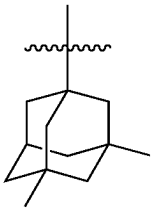
	Structure
R36	
R37	
R38	
R39	
R40	
R41	
R42	

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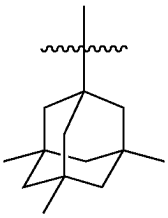
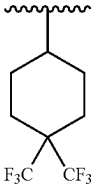
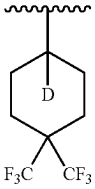
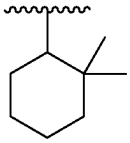
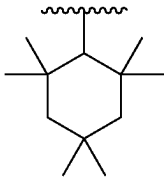
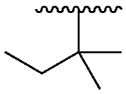
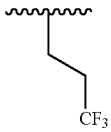
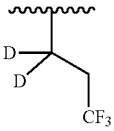
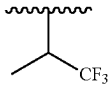
	Structure
R43	
R44	
R45	
R46	
R47	
R48	
R49	
R50	
R51	

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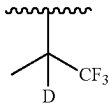
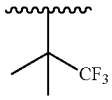
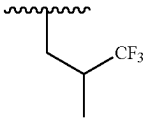
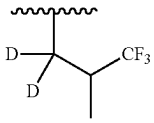
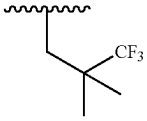
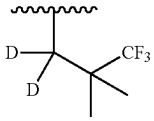
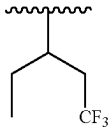
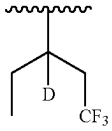
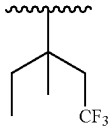
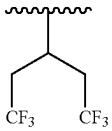
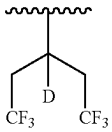
R52	
R53	
R54	
R55	
R56	
R57	
R58	
R59	
R60	
R61	
R62	

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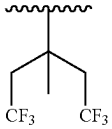
R63	
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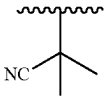
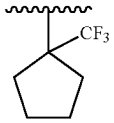
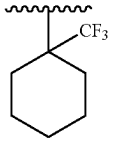
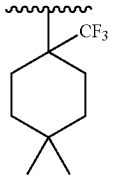
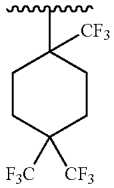
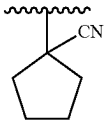
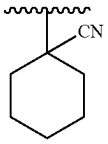
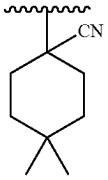
R65	
R66	
R67	
R68	
R69	
R70	
R71	
R72	

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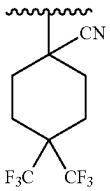
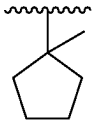
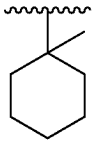
R73	
R74	
R75	
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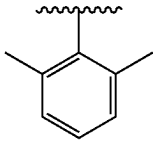
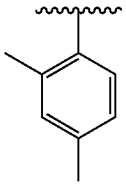
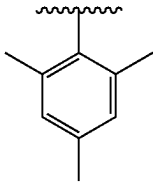
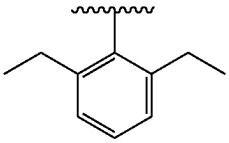
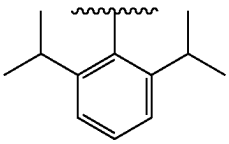
R77	
R78	
R79	
R80	
R81	

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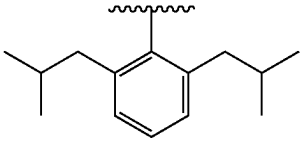
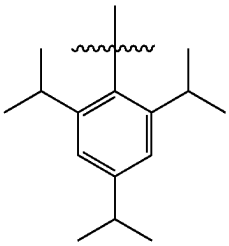
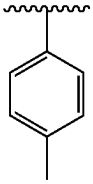
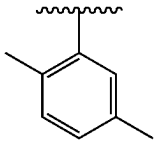
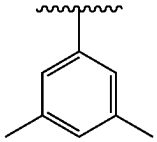
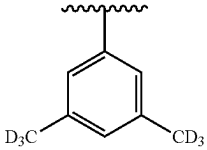
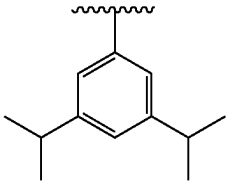
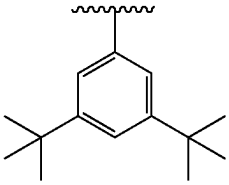
R82	
R83	
R84	
R85	
R86	
R87	
R88	
R89	

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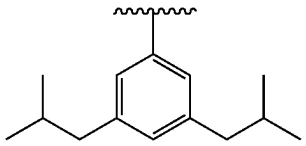
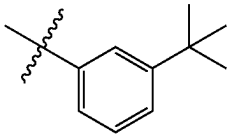
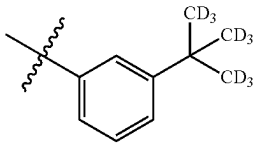
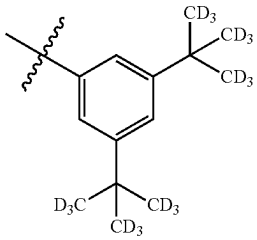
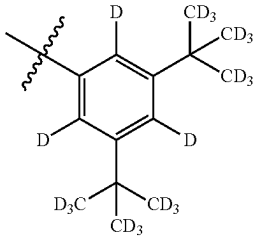
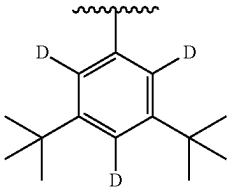
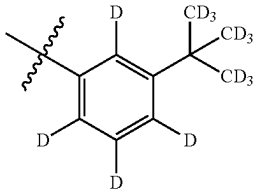
R90	
R91	
R92	
R93	
R94	
R95	
R96	

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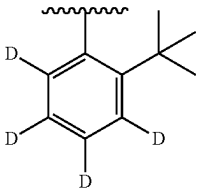
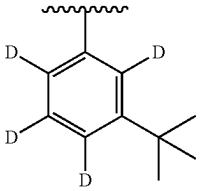
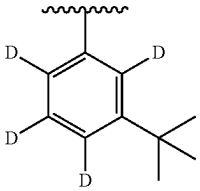
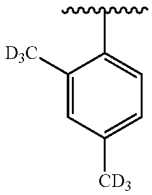
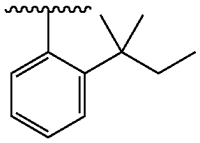
R97	
R98	
R99	
R100	
R101	
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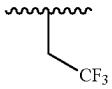
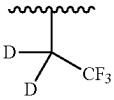
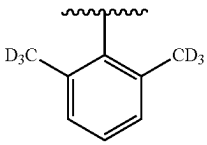
R104	
R105	
R106	

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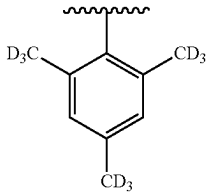
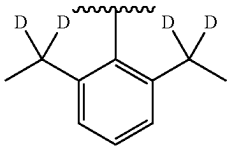
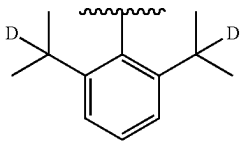
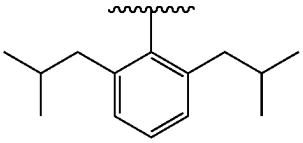
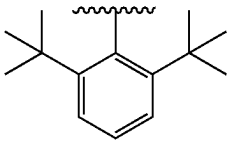
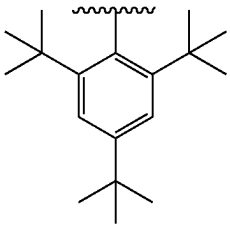
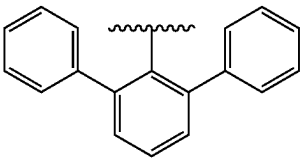
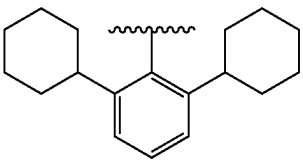
R107	
R108	
R109	
R110	
R111	
R112	
R113	
R114	

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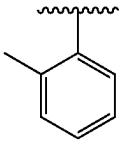
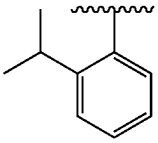
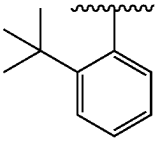
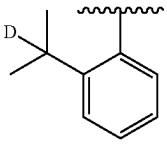
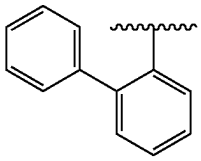
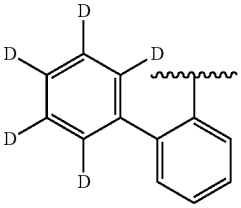
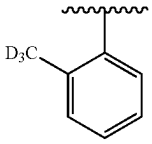
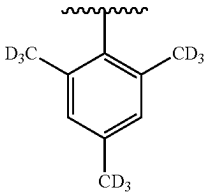
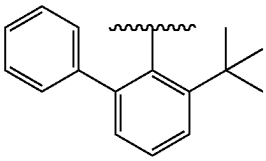
R115	
R116	
R117	
R118	
R119	
R120	
R121	
R122	
R123	

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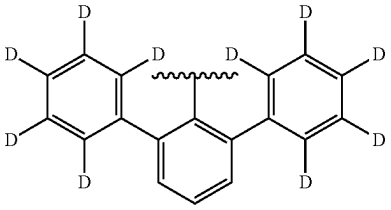
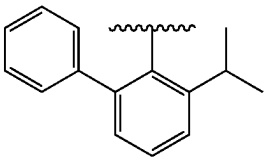
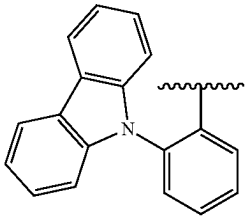
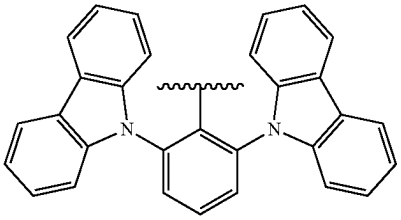
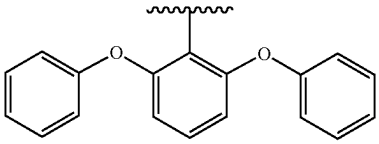
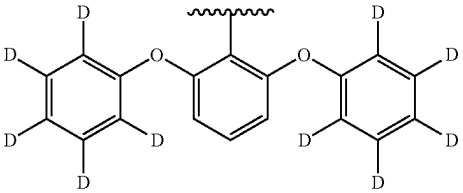
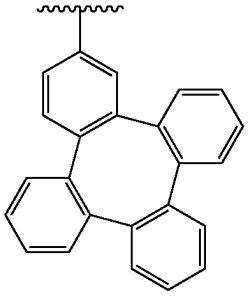
R124	
R125	
R126	
R127	
R128	
R129	
R130	

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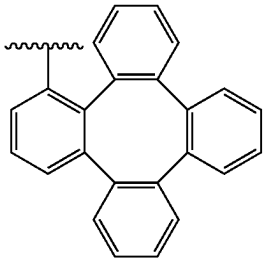
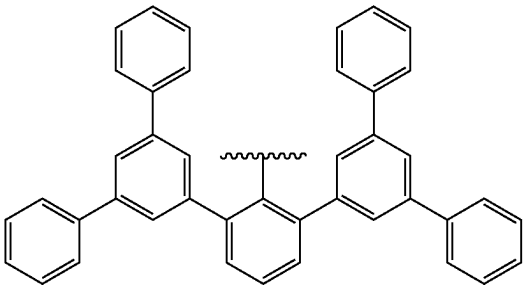
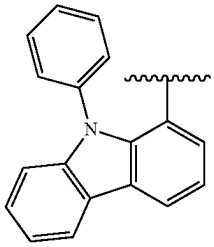
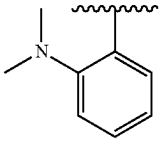
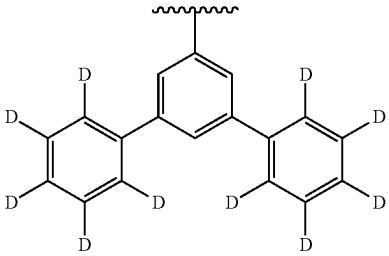
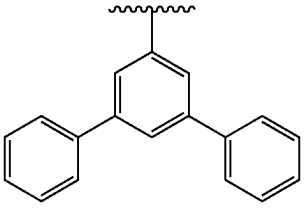
R131	
R132	
R133	
R134	
R135	
R136	

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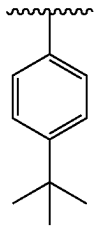
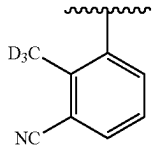
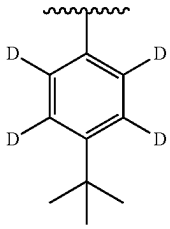
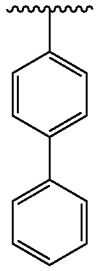
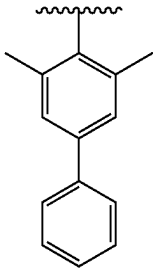
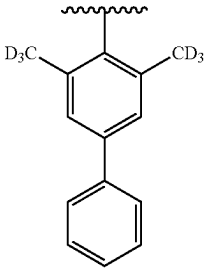
R137	
R138	
R139	
R140	
R141	
R142	

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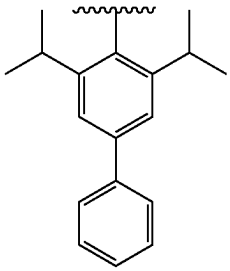
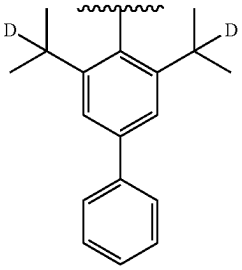
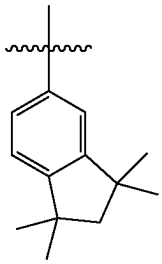
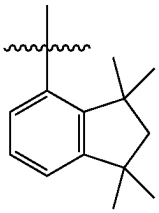
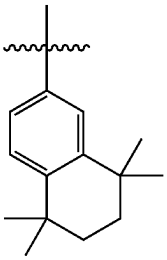
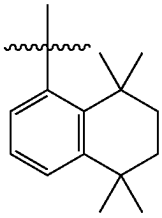
R143	
R144	
R145	
R146	
R147	
R148	

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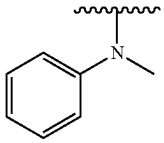
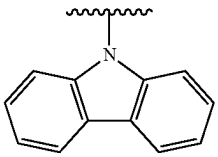
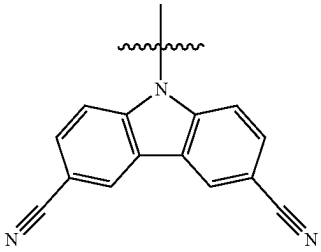
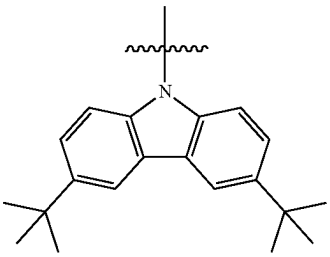
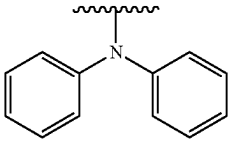
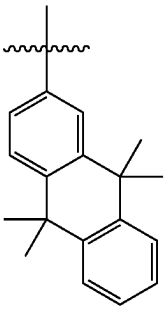
R149	
R150	
R151	
R152	
R153	
R154	

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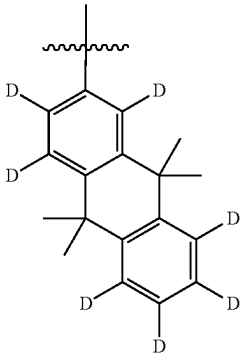
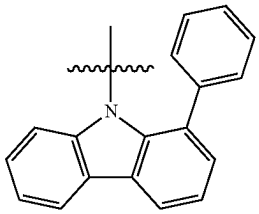
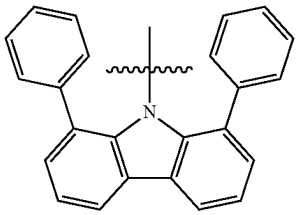
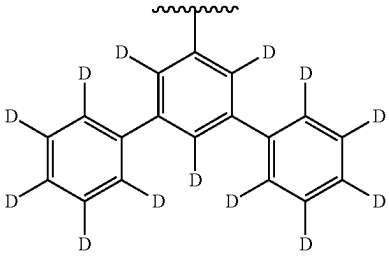
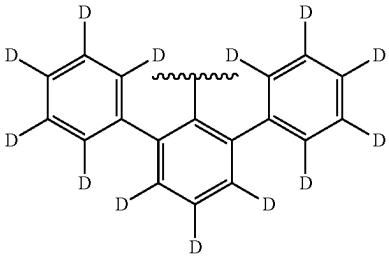
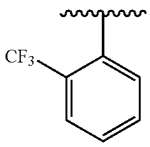
R155	
R156	
R157	
R158	
R159	
R160	

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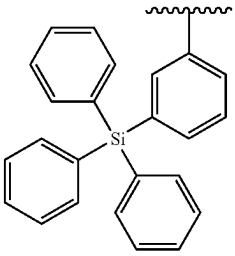
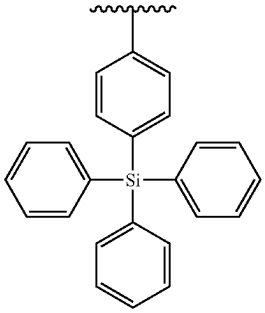
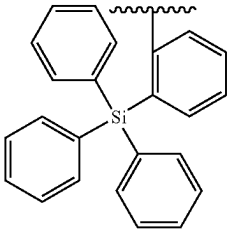
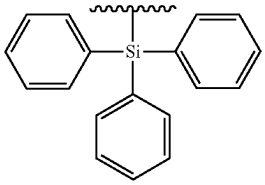
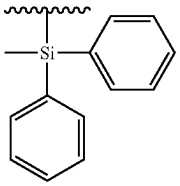
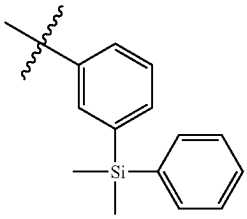
R161	
R162	
R163	
R164	
R165	
R166	

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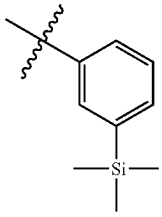
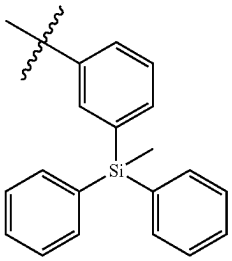
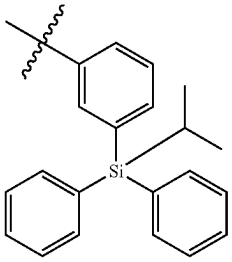
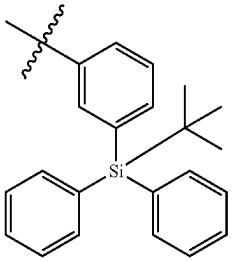
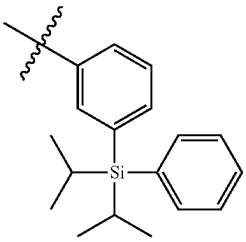
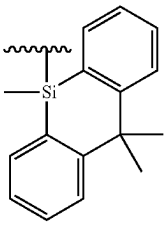
R167	
R168	
R169	
R170	
R171	
R172	

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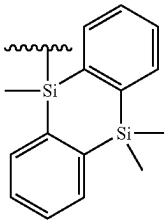
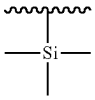
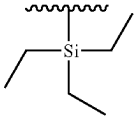
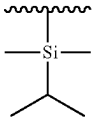
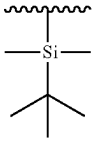
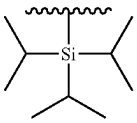
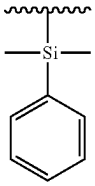
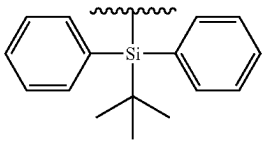
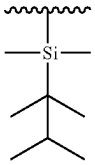
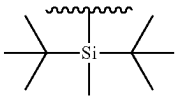
R173	
R174	
R175	
R176	
R177	
R178	
R179	
R180	
R181	
R182	

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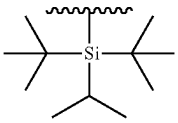
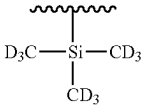
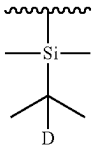
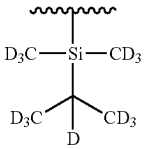
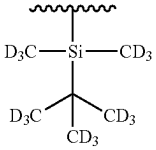
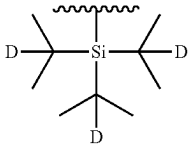
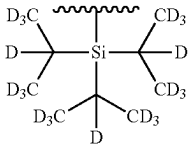
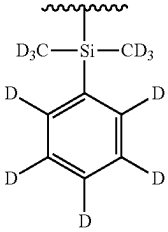
R183	
R184	
R185	
R186	
R187	
R188	
R189	
R190	

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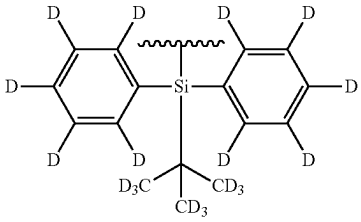
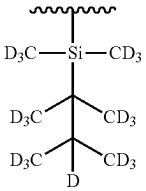
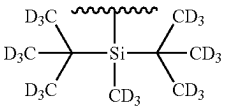
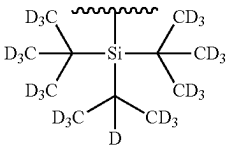
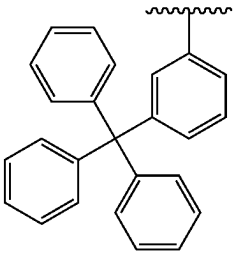
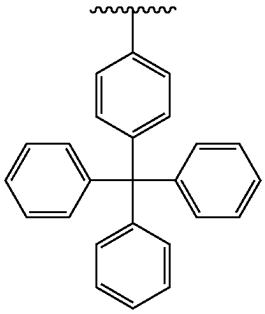
R191	
R192	
R193	
R194	
R195	
R196	

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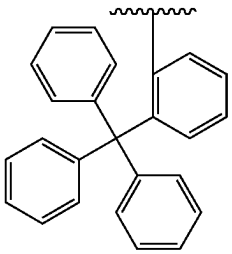
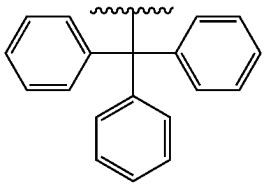
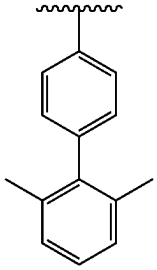
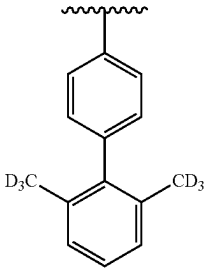
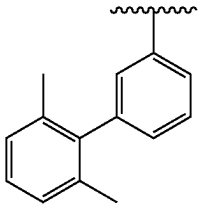
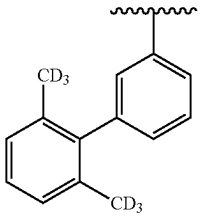
R197	
R198	
R199	
R200	
R201	
R202	

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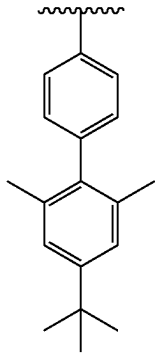
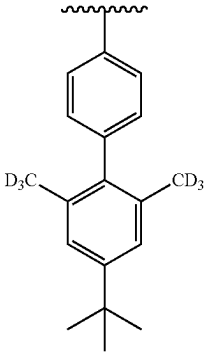
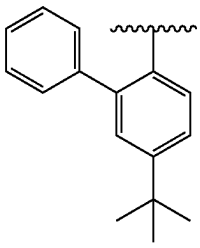
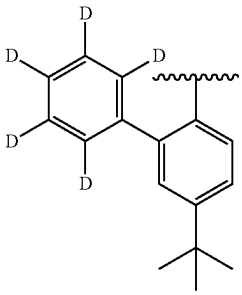
R203	
R204	
R205	
R206	

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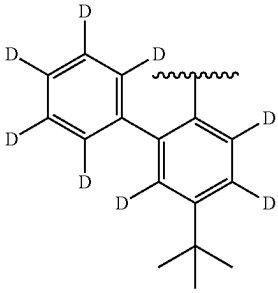
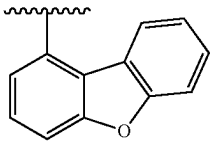
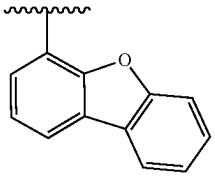
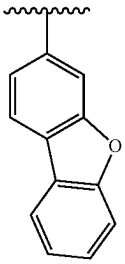
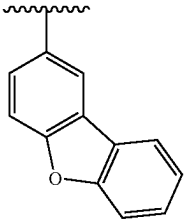
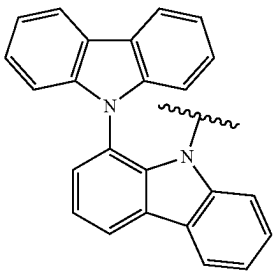
R207	
R208	
R209	
R210	
R211	
R212	

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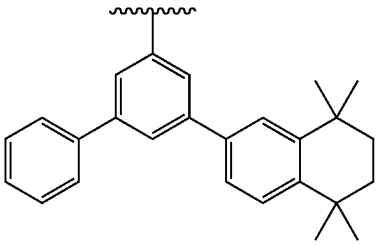
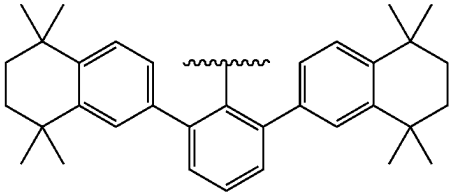
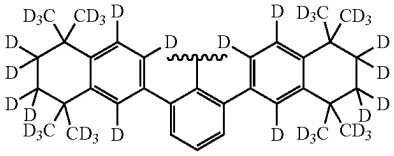
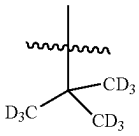
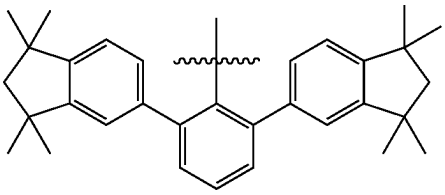
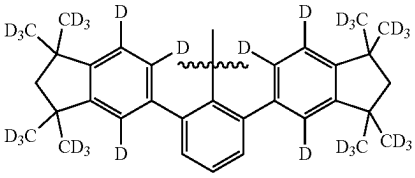
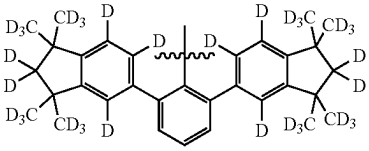
R213	
R214	
R215	
R216	
R217	
R218	
R219	

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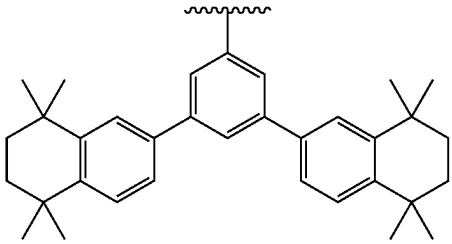
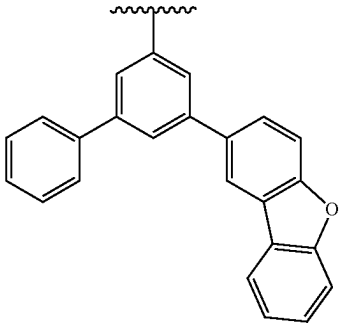
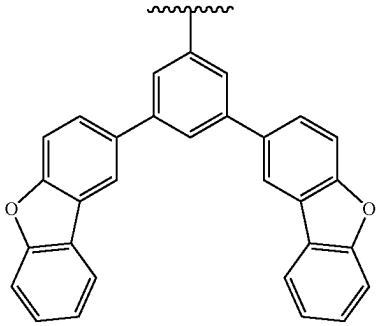
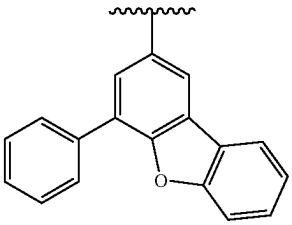
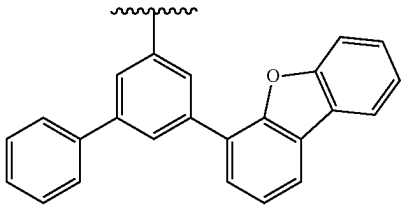
R220	
R221	
R222	
R223	
R224	

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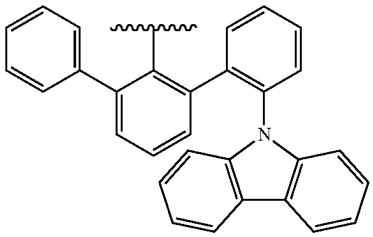
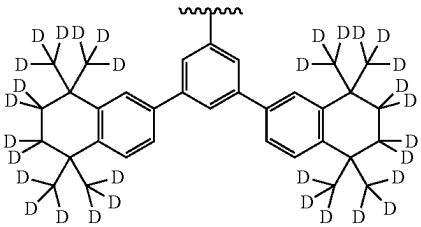
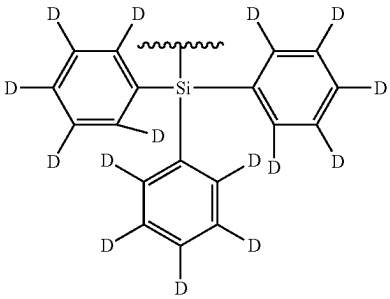
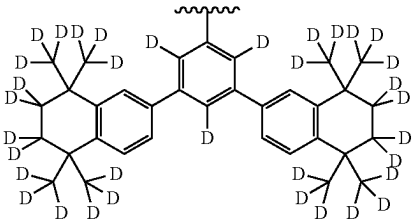
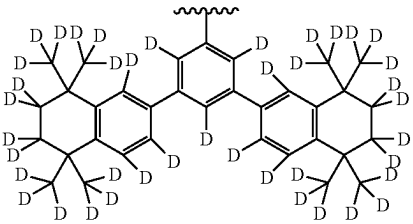
R225	
R226	
R227	
R228	
R229	

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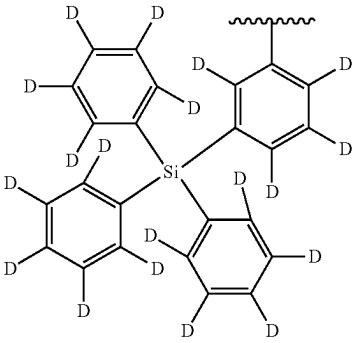
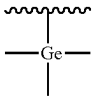
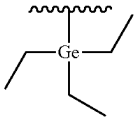
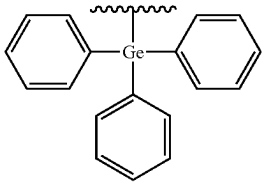
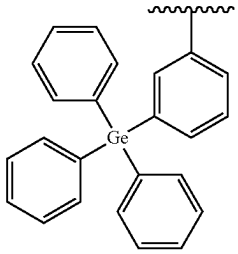
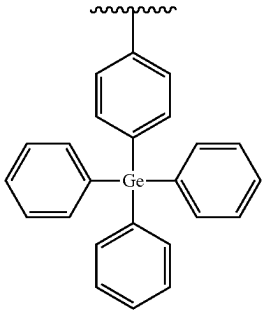
R230	
R231	
R232	
R233	
R234	
R235	

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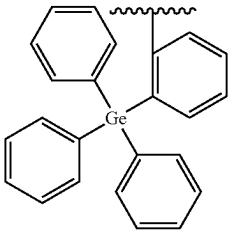
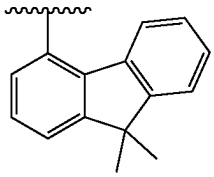
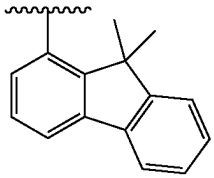
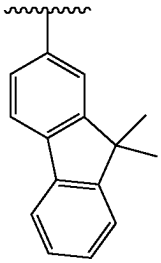
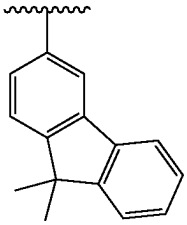
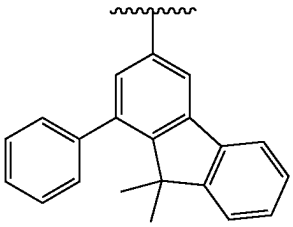
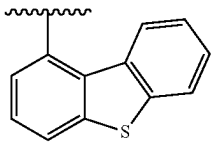
R236	
R237	
R238	
R239	
R240	
R241	
R242	

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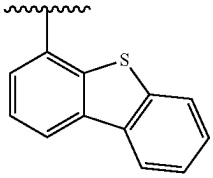
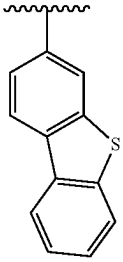
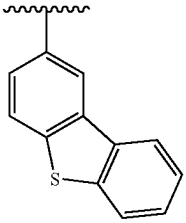
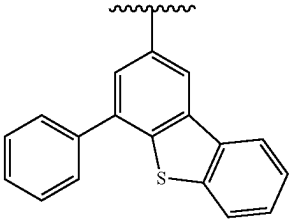
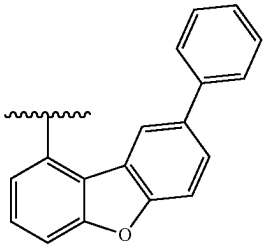
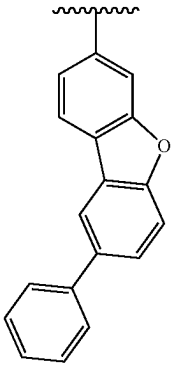
R243	
R244	
R245	
R246	
R247	
R248	

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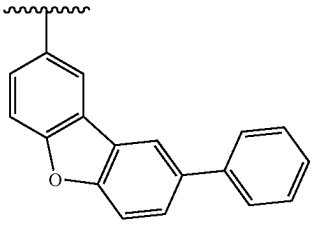
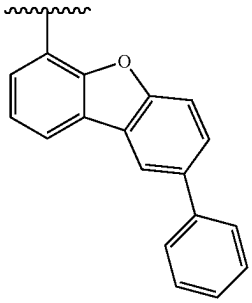
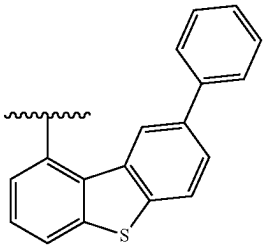
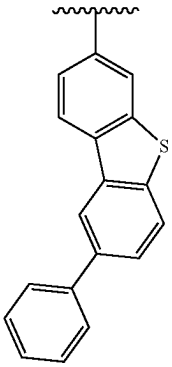
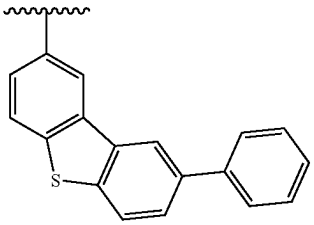
R249	
R250	
R251	
R252	
R253	

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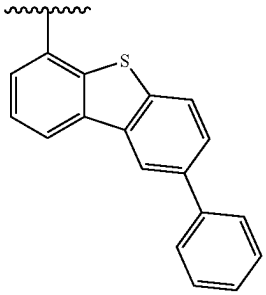
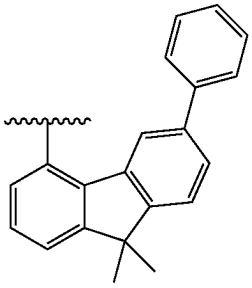
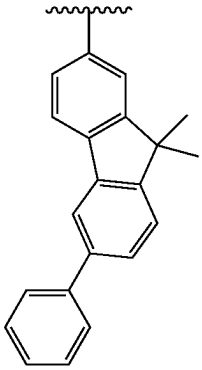
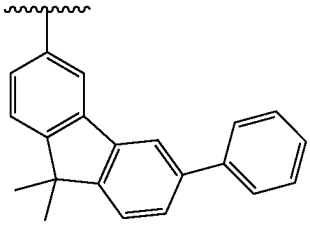
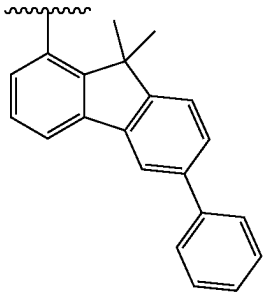
R254	
R255	
R256	
R257	
R258	

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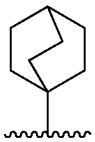
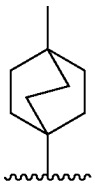
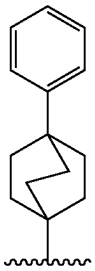
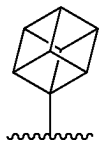
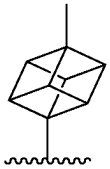
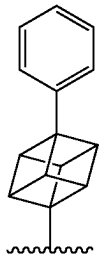
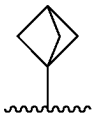
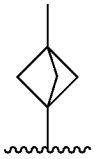
R259	
R260	
R261	
R262	
R263	
R264	
R265	
R266	

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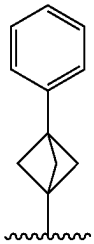
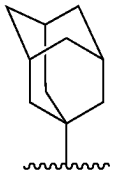
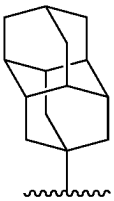
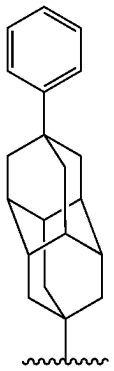
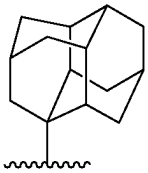
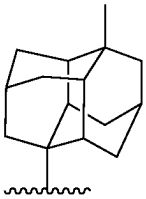
R267	
R268	
R269	
R270	
R271	
R272	

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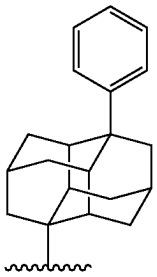
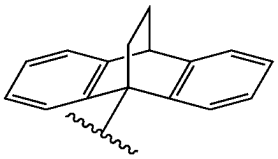
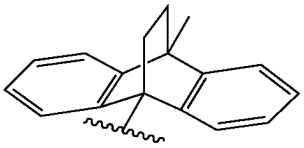
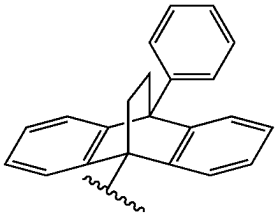
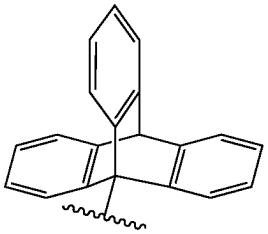
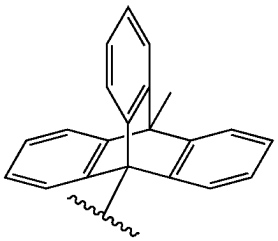
R273 
R274 
R275 
R276 
R277 
R278 

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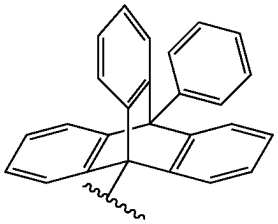
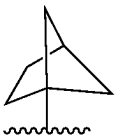
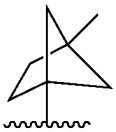
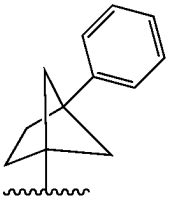
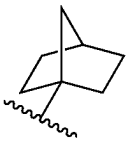
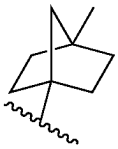
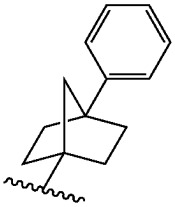
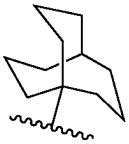
R279 
R280 
R281 
R282 
R283 
R284 
R285 
R286 

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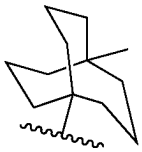
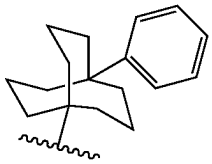
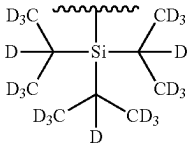
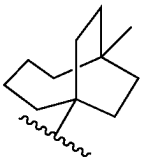
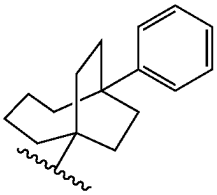
R287 
R288 
R289 
R290 
R291 
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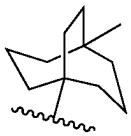
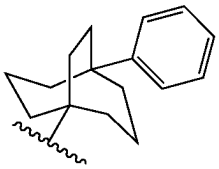
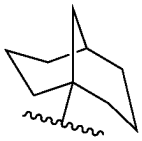
R293 
R294 
R295 

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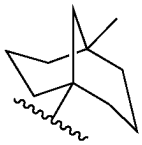
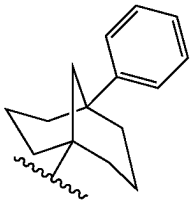
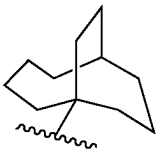
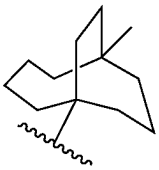
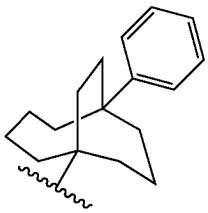
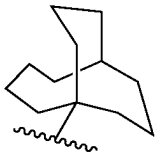
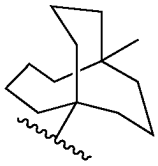
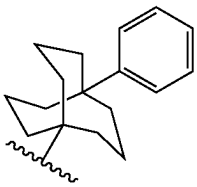
R296 
R297 
R298 
R299 
R300 
R301 
R302 
R303 

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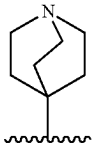
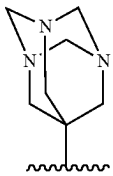
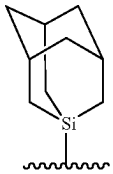
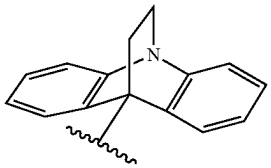
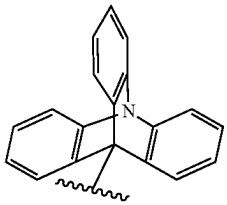
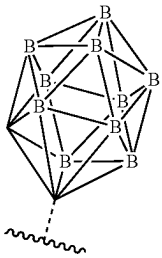
R305 
R306 
R307 
R308 
R309 
R310 

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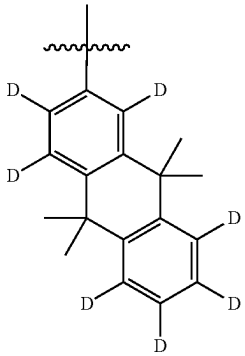
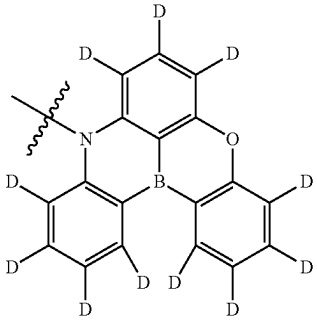
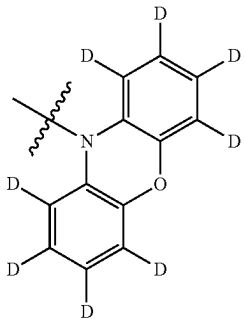
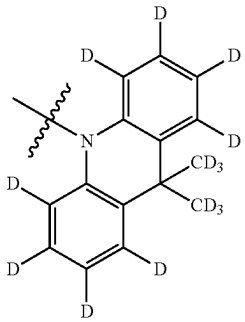
R311 
R312 
R313 
R314 

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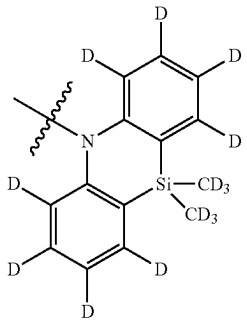
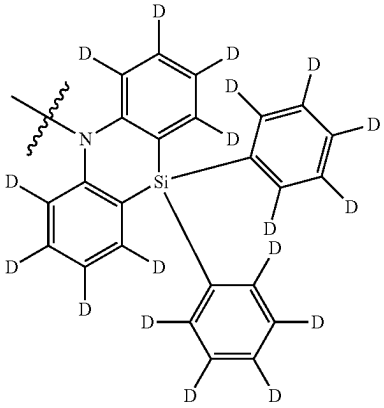
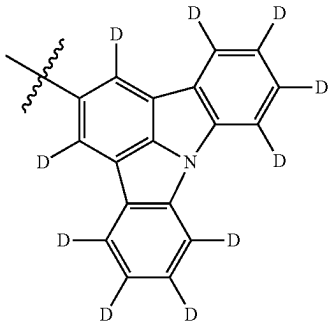
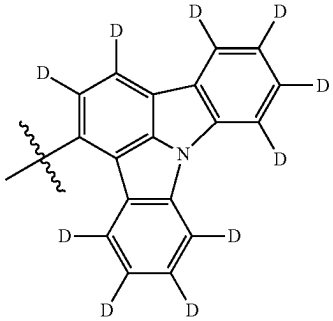
R315 
R316 
R317 
R318 

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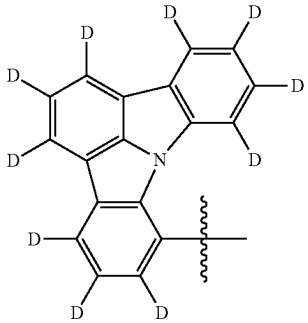
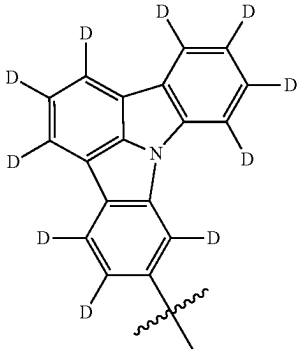
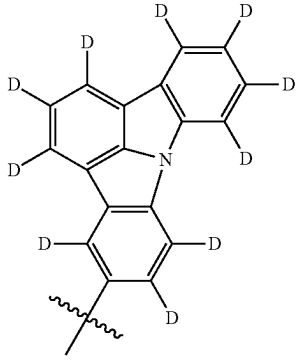
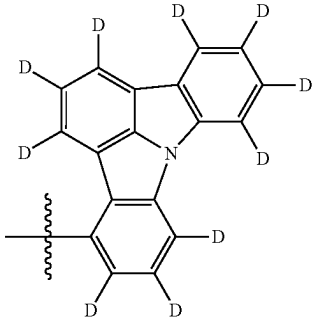
R319 
R320 
R321 
R322 

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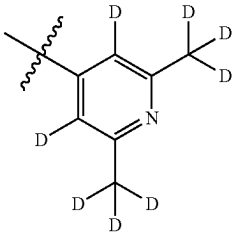
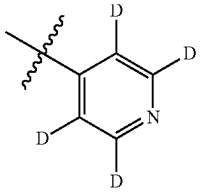
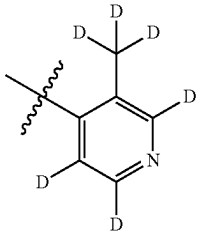
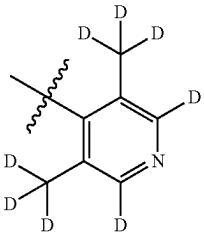
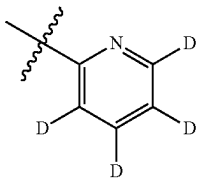
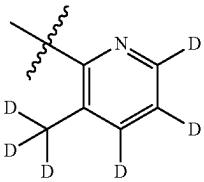
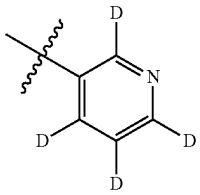
R323 
R324 
R325 
R326 
R327 
R328 
R329 

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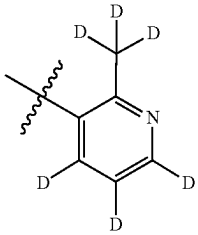
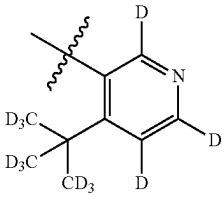
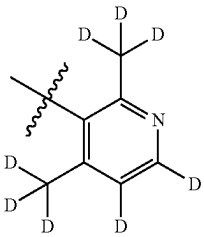
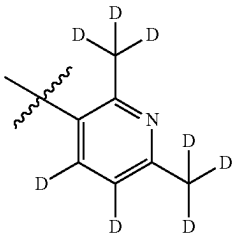
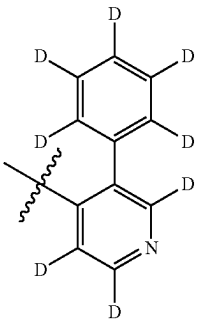
R330 
R331 
R332 
R333 
R334 

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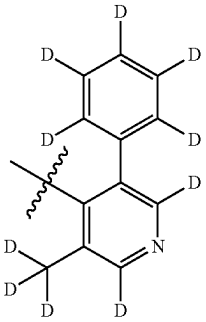
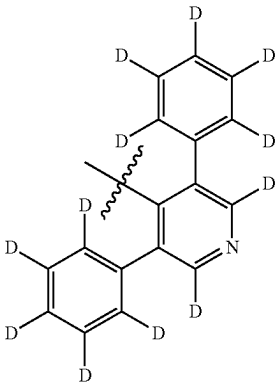
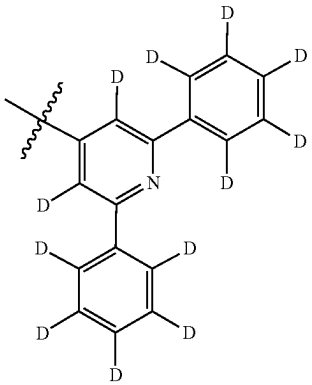
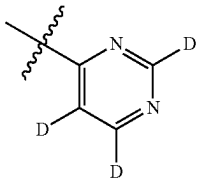
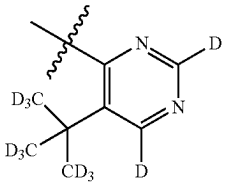
R335 
R336 
R337 
R338 
R339 

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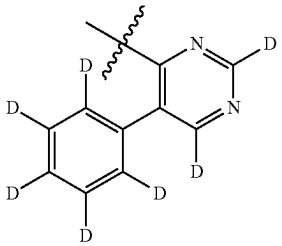
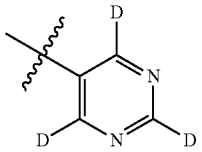
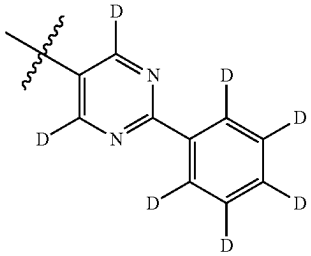
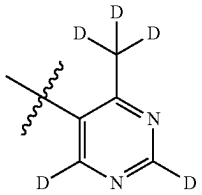
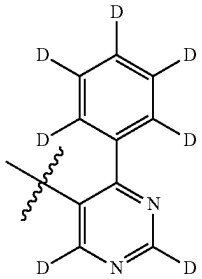
R340 
R341 
R342 
R343 
R344 

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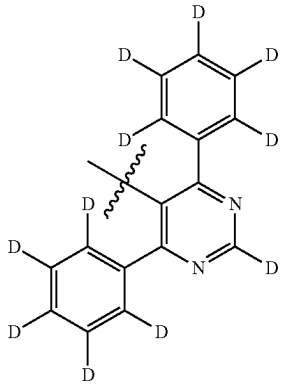
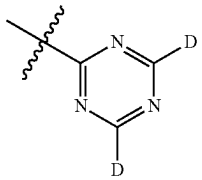
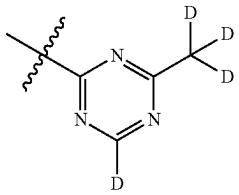
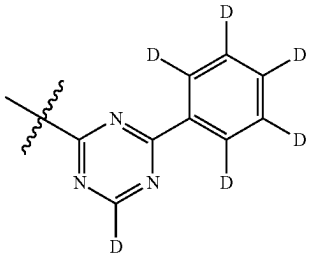
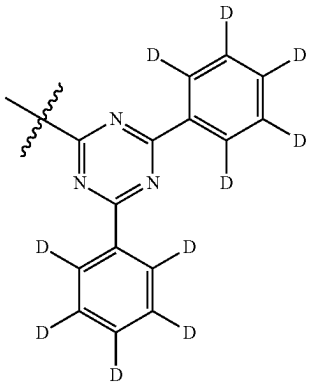
R345	
R346	
R347	
R348	
R349	

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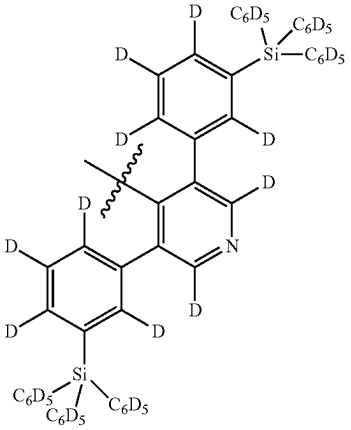
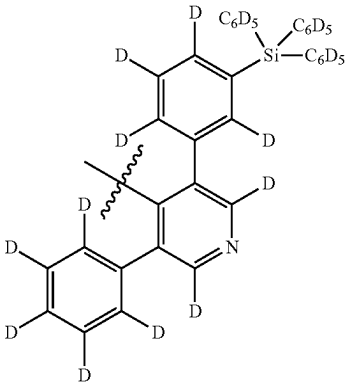
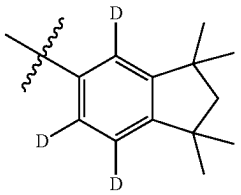
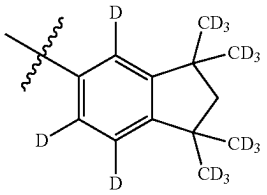
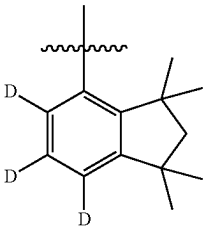
R350	
R351	
R352	
R353	
R354	

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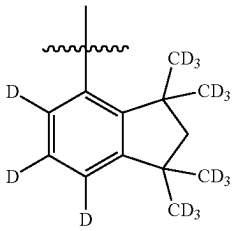
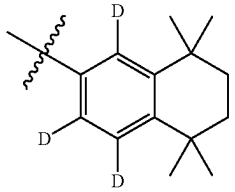
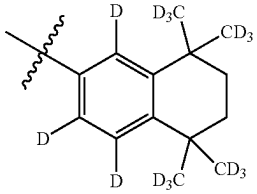
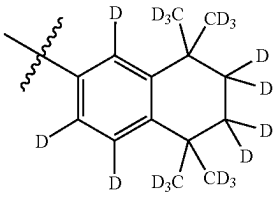
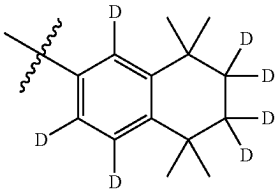
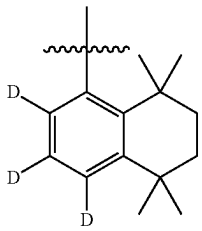
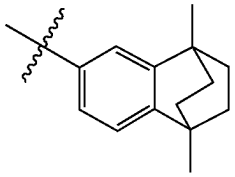
R355	
R356	
R357	
R358	
R359	
R360	
R361	

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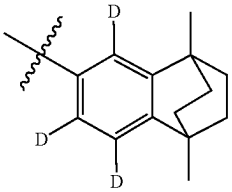
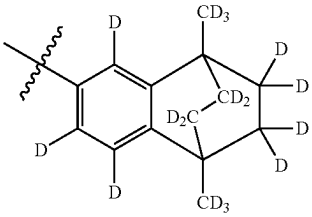
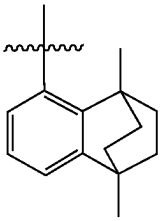
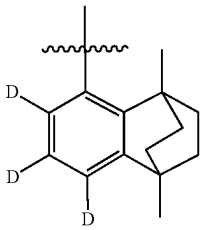
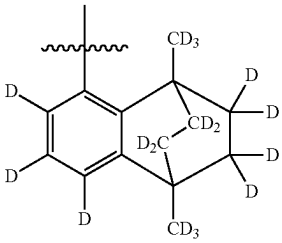
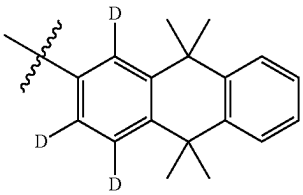
R362	
R363	
R364	
R365	
R366	
R367	

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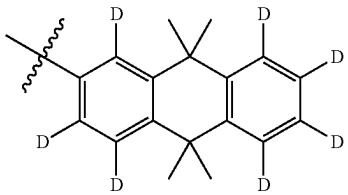
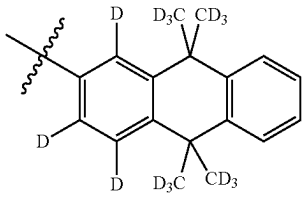
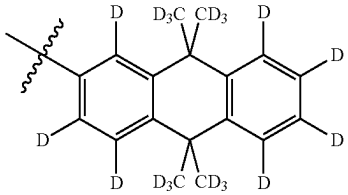
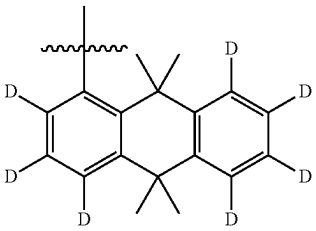
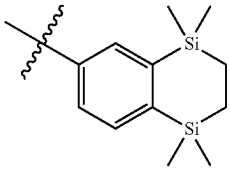
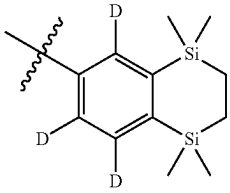
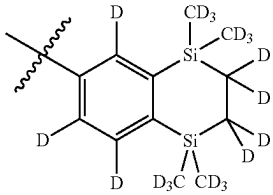
R368	
R369	
R370	
R371	
R372	
R373	
R374	

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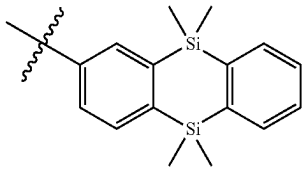
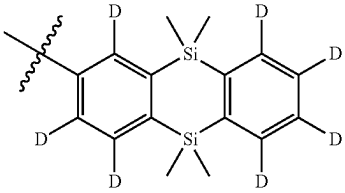
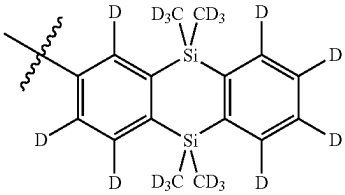
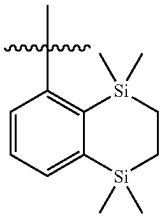
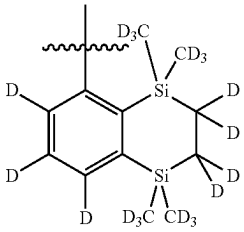
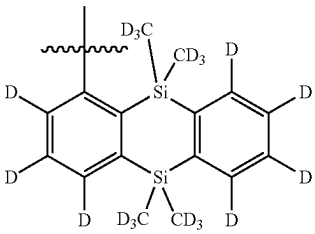
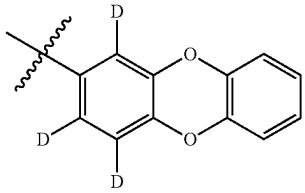
R375	
R376	
R377	
R378	
R379	
R380	
R381	

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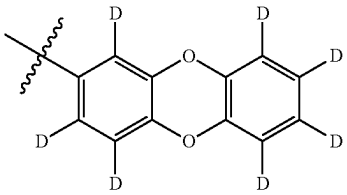
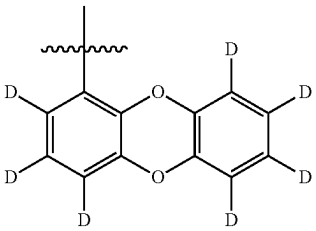
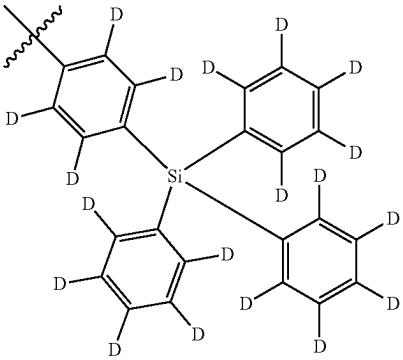
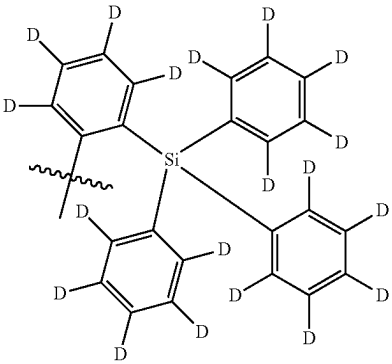
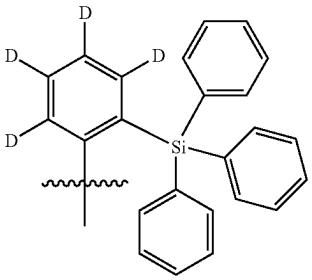
R382	
R383	
R384	
R385	
R386	

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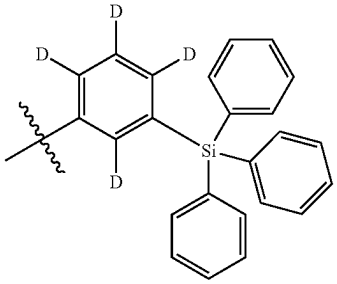
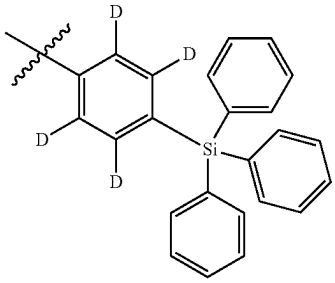
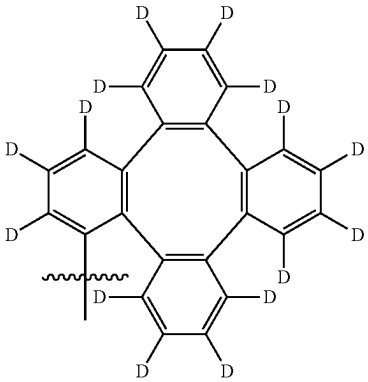
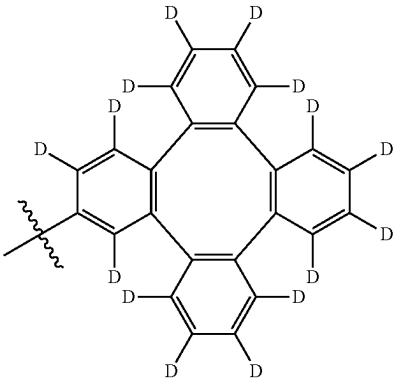
R387	
R388	
R389	
R390	

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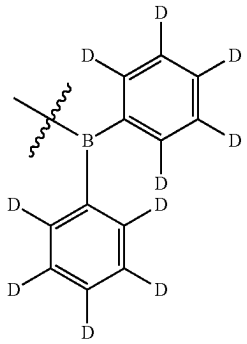
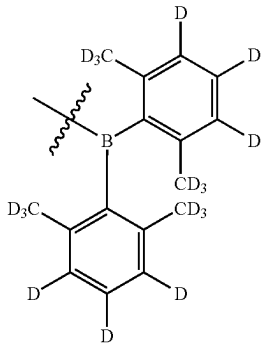
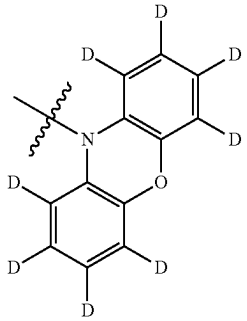
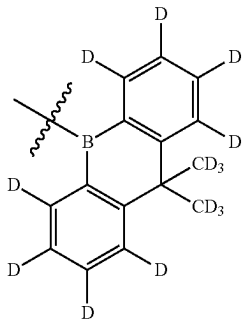
R391	
R392	
R393	
R394	

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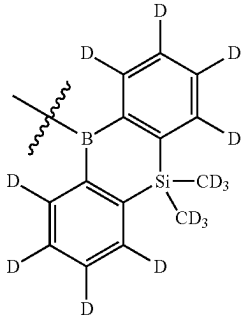
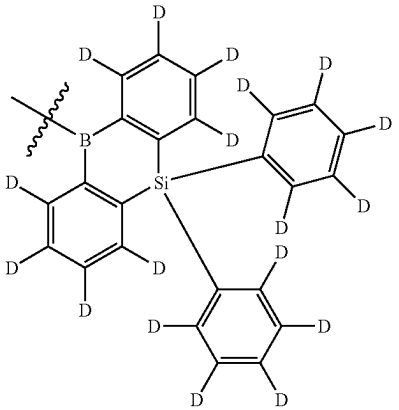
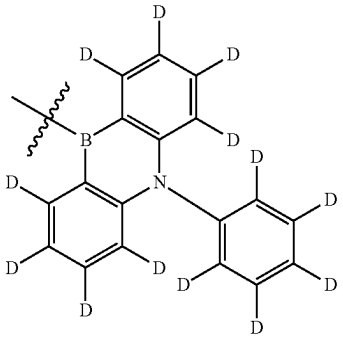
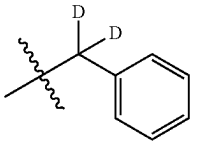
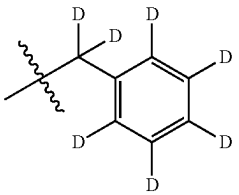
R395	
R396	
R397	
R398	
R399	

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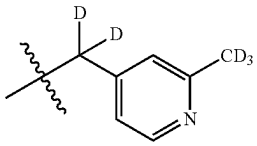
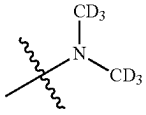
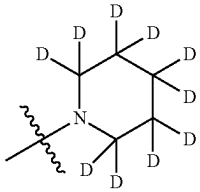
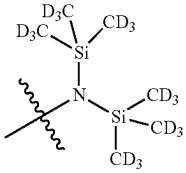
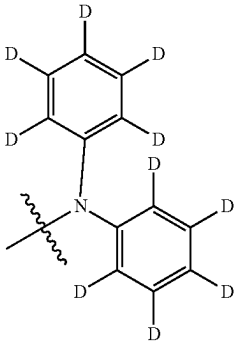
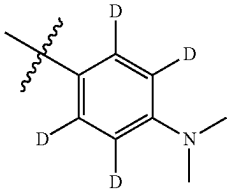
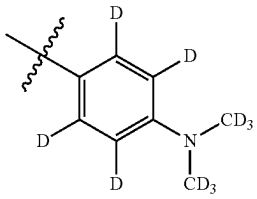
R400	
R401	
R402	
R403	
R404	
R405	
R406	

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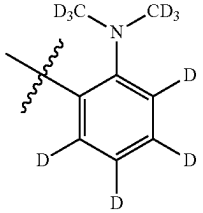
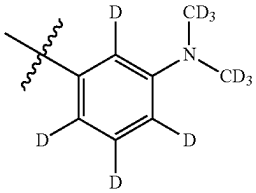
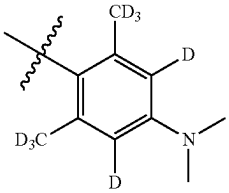
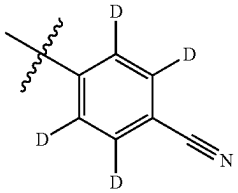
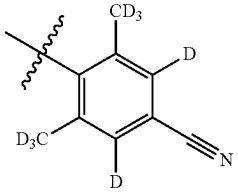
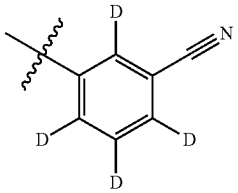
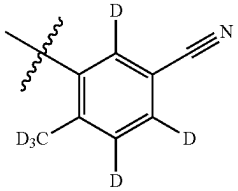
R407	
R408	
R409	
R410	
R411	
R412	
R413	

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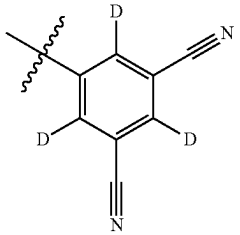
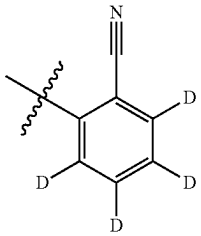
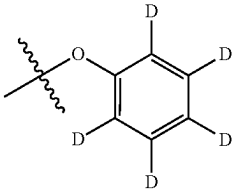
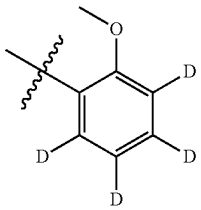
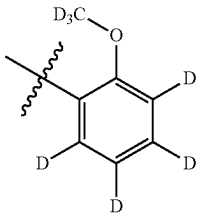
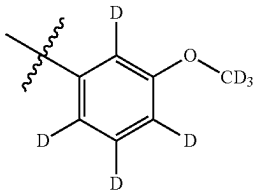
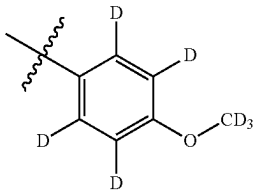
R414 
R415 
R416 
R417 
R418 
R419 
R420 

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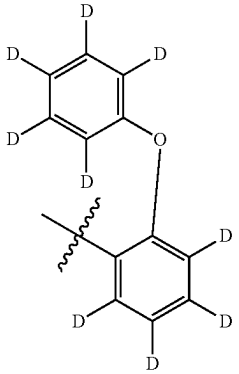
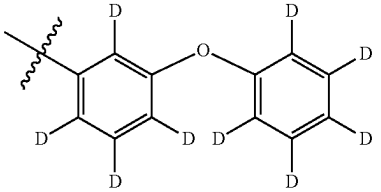
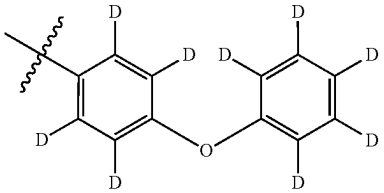
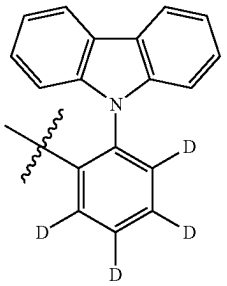
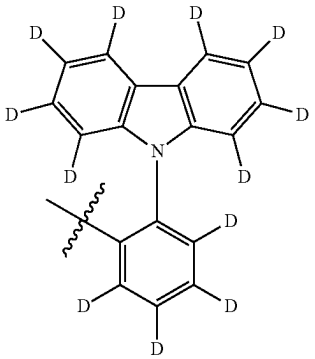
R421 
R422 
R423 
R424 
R425 

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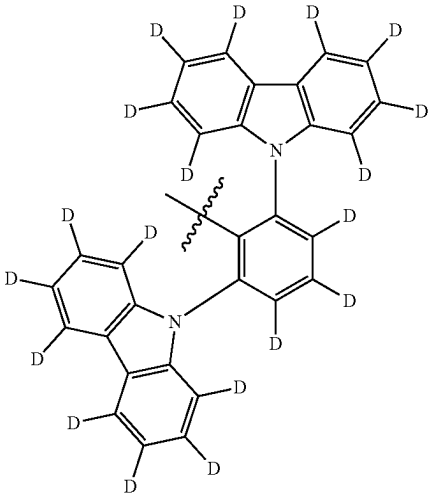
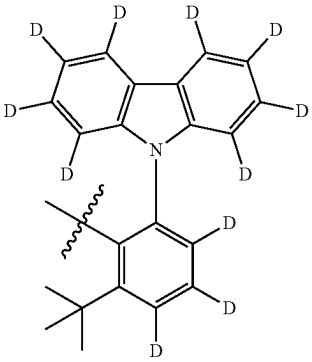
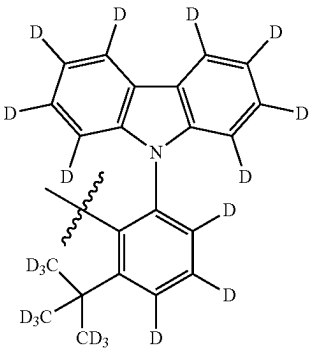
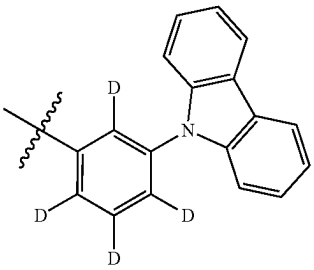
R426 
R427 
R428 
R429 

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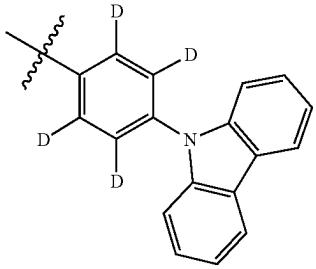
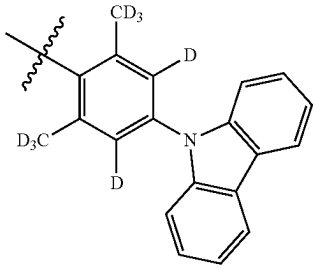
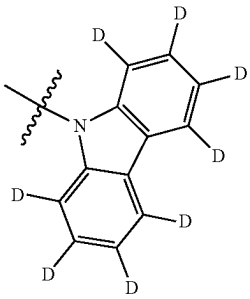
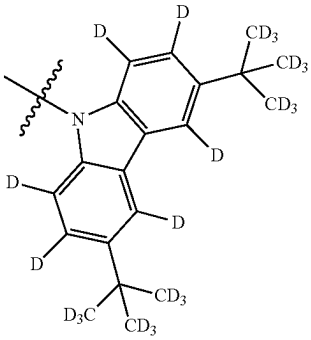
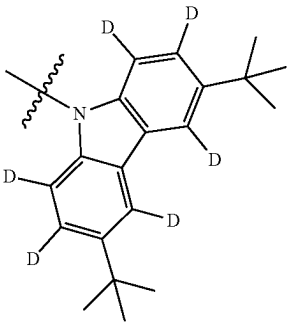
R430 
R431 
R432 
R433 
R434 

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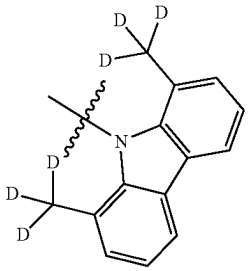
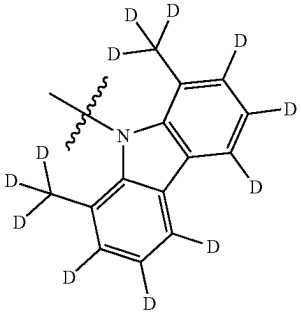
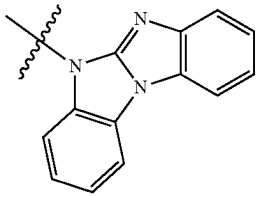
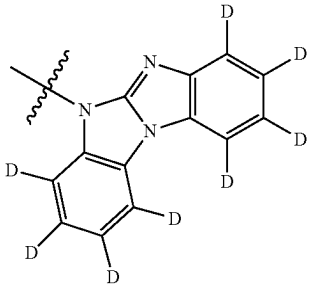
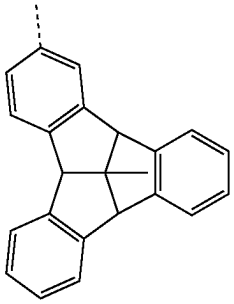
	Structure
R435	
R436	
R437	
R438	
R439	

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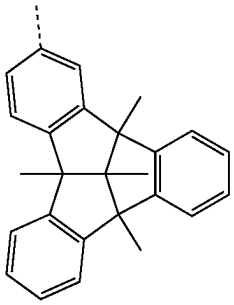
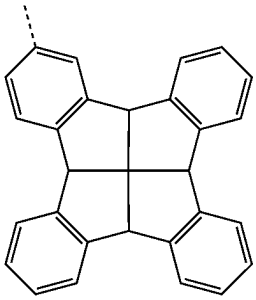
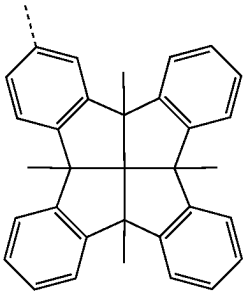
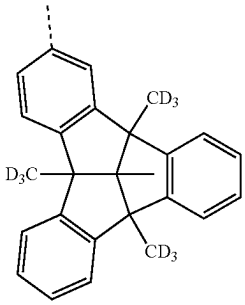
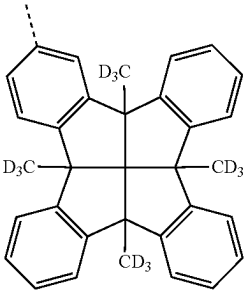
R440	
R441	
R442	
R443	
R444	

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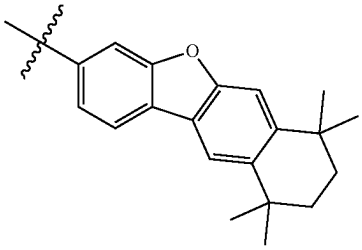
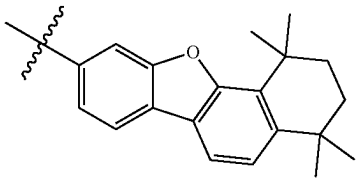
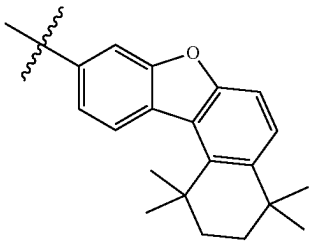
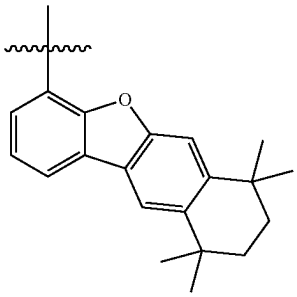
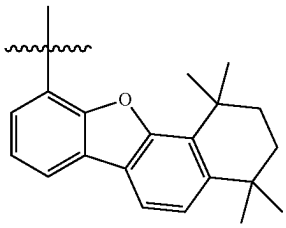
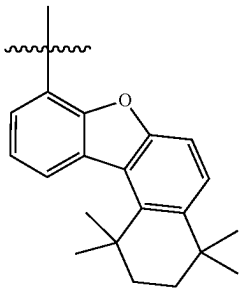
R445	
R446	
R447	
R448	
R449	
R450	

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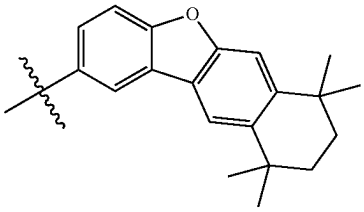
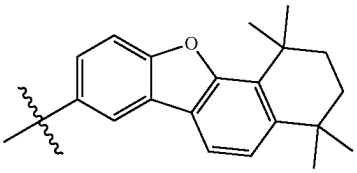
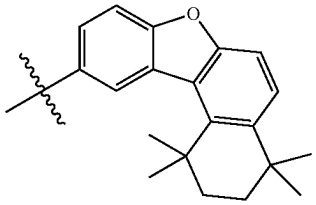
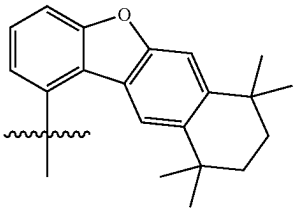
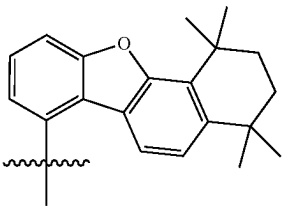
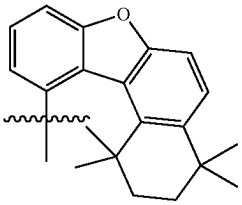
R451	
R452	
R453	
R454	
R455	
R456	

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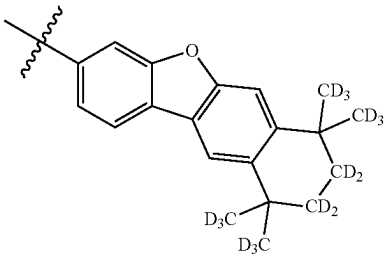
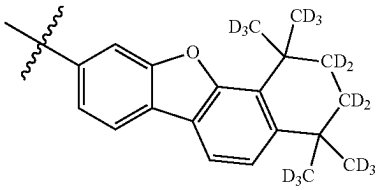
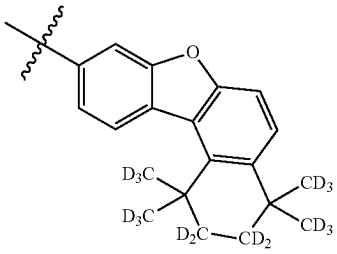
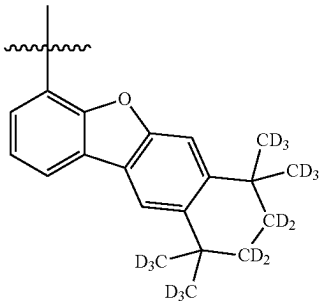
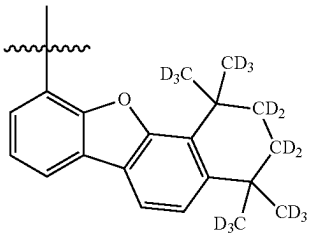
R457	
R458	
R459	
R460	
R461	

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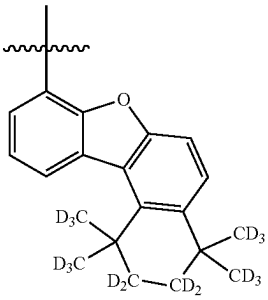
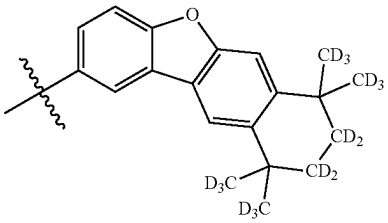
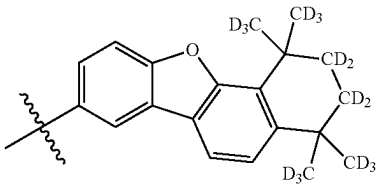
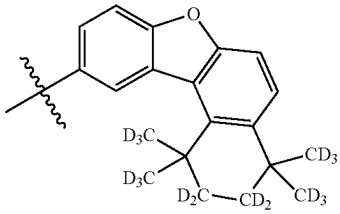
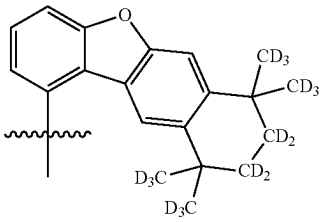
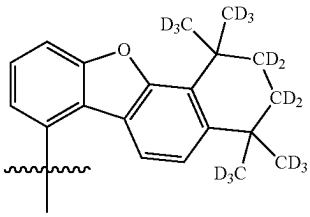
R462	
R463	
R464	
R465	
R466	
R467	

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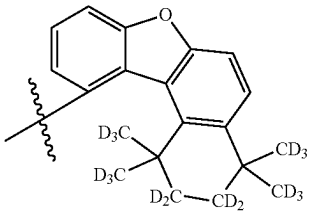
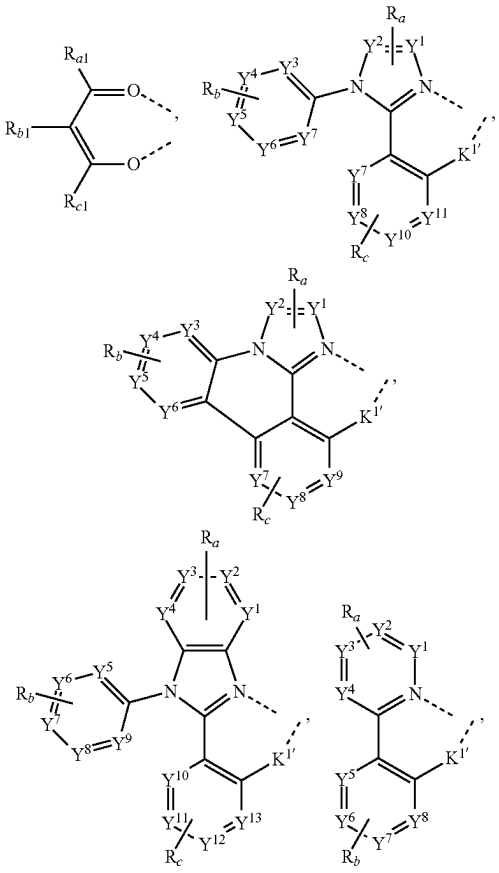
R468 

10. The compound of claim **1**, wherein the compound has a formula of $M(L_A)_p(L_B)_q(L_C)_r$ wherein L_B and L_C are each a bidentate ligand; and wherein p is 1, 2, or 3; q is 0, 1, or 2; r is 0, 1, or 2; and p+q+r is the oxidation state of the metal M.

11. The compound of claim **10**, wherein the compound has a formula selected from the group consisting of $Ir(L_A)_3$, $Ir(L_A)(L_B)_2$, $Ir(L_A)_2(L_B)$, $Ir(L_A)_2(L_C)$, and $Ir(L_A)(L_B)(L_C)$; and wherein L_A, L_B, and L_C are different from each other; or a formula of $Pt(L_A)(L_B)$; and wherein L_A and L_B can be the same or different.

12. The compound of claim **10**, wherein L_B and L_C are each independently selected from the group consisting of:



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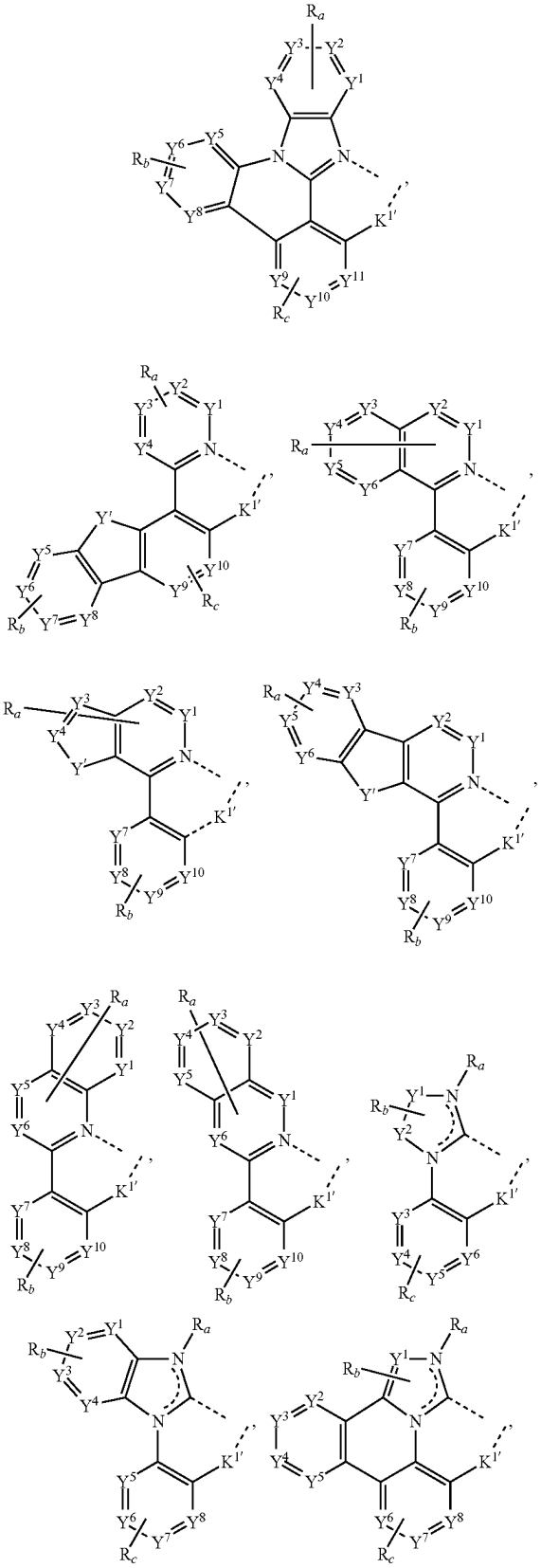

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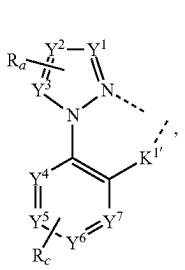

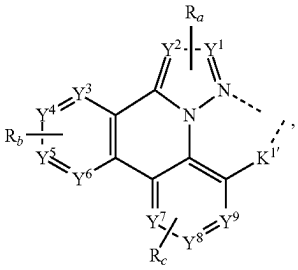

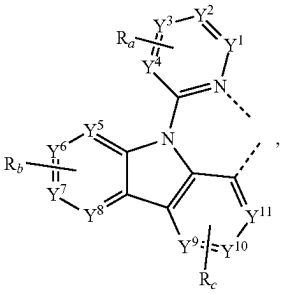

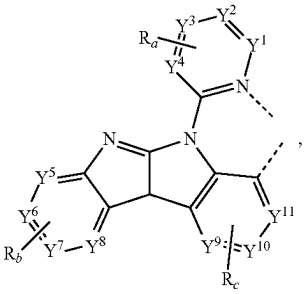

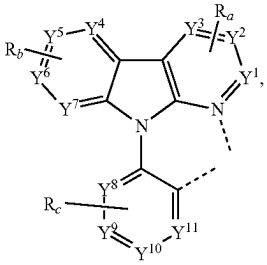

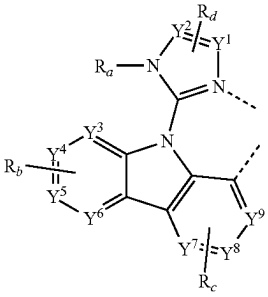

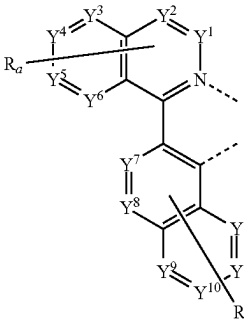

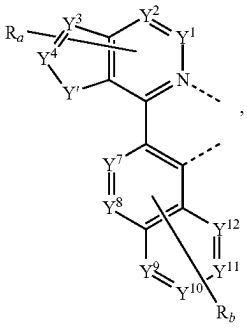

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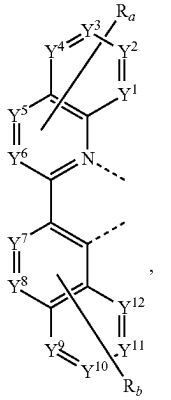

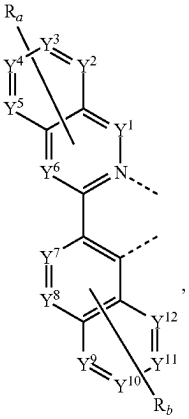

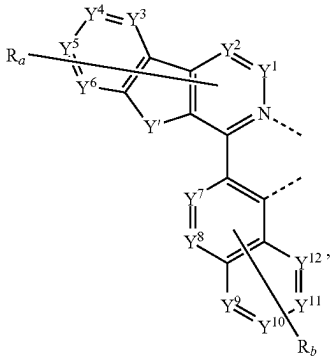

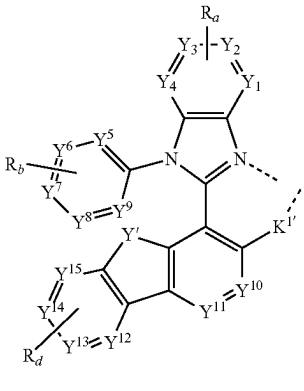

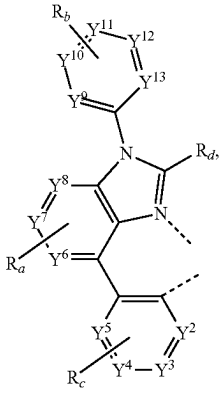

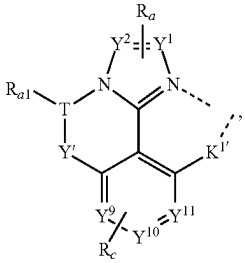

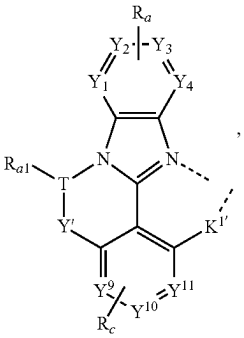

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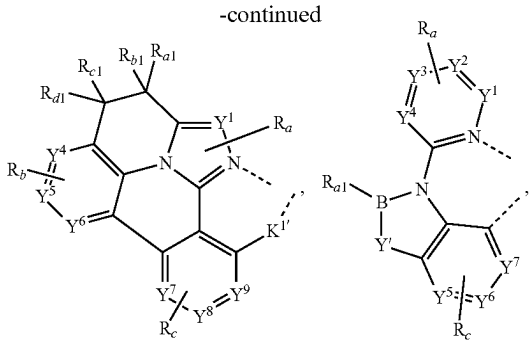

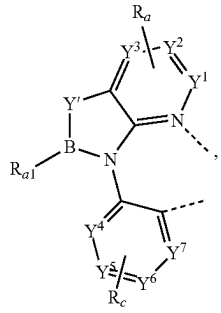

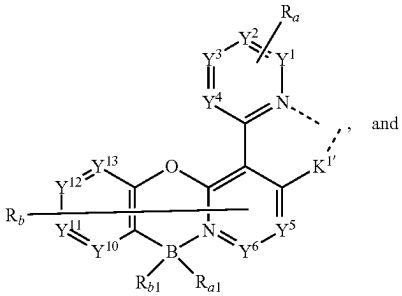

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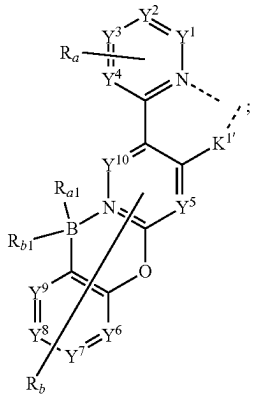


wherein:

T is selected from the group consisting of B, Al, Ga, and In;

$K^{1'}$ is selected from the group consisting of a single bond, O, S, NR_e, PR_e, BR_e, CR_eR_f, and SiR_eR_f, each of Y^1 to Y^{13} is independently selected from the group consisting of C and N;

Y' is selected from the group consisting of BR_e, BR_eR_f, NR_e, PR_e, $P(O)R_e$, O, S, Se, C═O, C═S, C═Se, C═NR_e, C═CR_eR_f, S═O, SO_2, CR_eR_f, SiR_eR_f, and GeR_eR_f;

each R_a, R_b, R_c, and R_d independently represents from mono to the maximum allowed number of substitutions, or no substitution;

each of R_{a1}, R_{b1}, R_{c1}, R_{d1}, R_a, R_b, R_c, R_d, R_e, and R_f is independently a hydrogen or a subsituent selected from the group consisting of deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acid, ester, nitrile, isonitrile, sulfanyl, selenyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

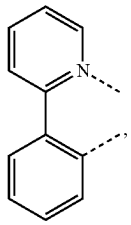
any two substituents of R_{a1}, R_{b1}, R_{c1}, R_{d1}, R_a, R_b, R_c, R_d, R_e, and R_f can be fused or joined to form a ring or form a multidentate ligand.

13. The compound of claim **10**, wherein the compound has formula $Ir(L_A)_3$, formula $Ir(L_A)(L_{Bk})_2$, formula $Ir(L_A)_2(L_{Bk})$, formula $Ir(L_A)_2(L_{Cj\text{-}I})$, or formula $Ir(L_A)_2(L_{Cj\text{-}II})$,

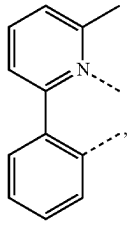
wherein L_A is according to Formula I;

wherein k is an integer from 1 to 530, and each L_{Bk} has the structure defined as follows:

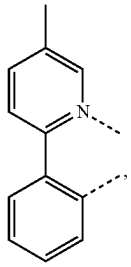
L_{B1}



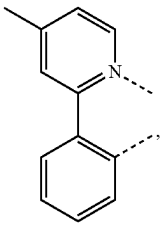
L_{B2}



L_{B3}



L_{B4}



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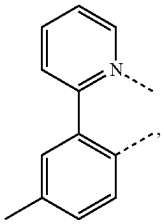
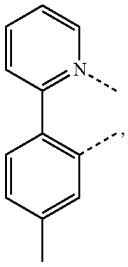
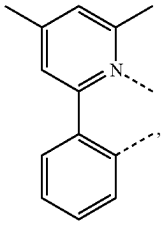
L_{B5}



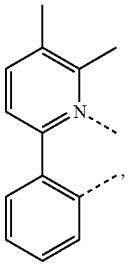
L_{B6}



L_{B7}



L_{B8}



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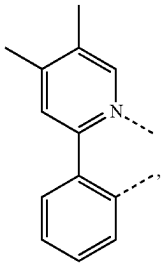
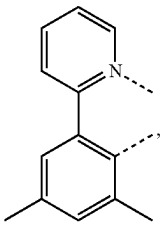


L_{B10}



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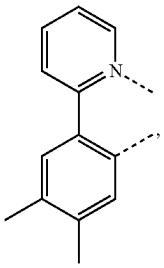
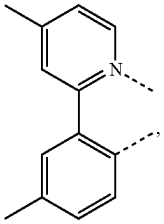
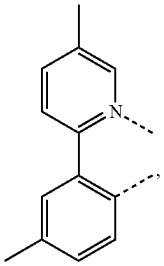


L_{B12}



L_{B13}



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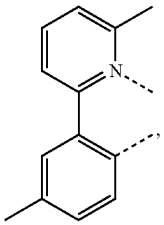

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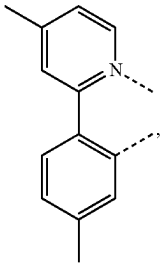

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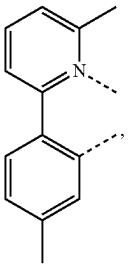

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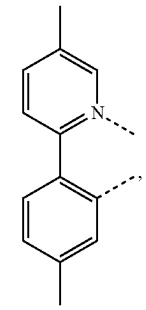

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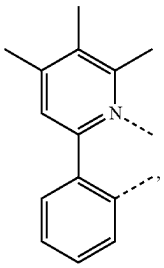

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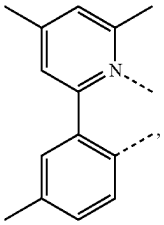

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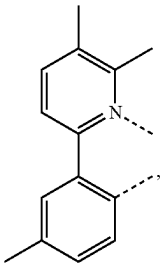

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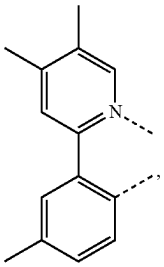

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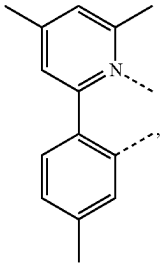

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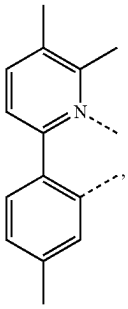

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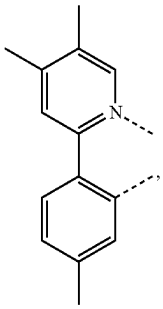

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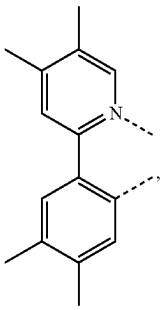

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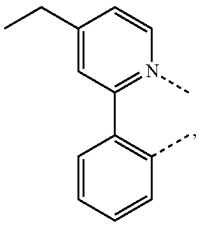

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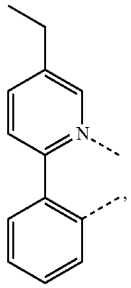

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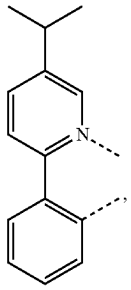

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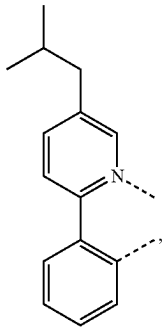
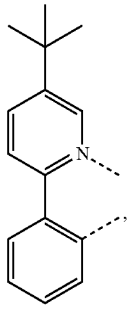


L_{B30}



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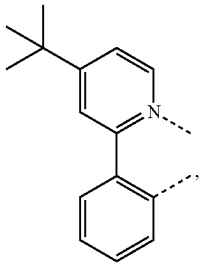

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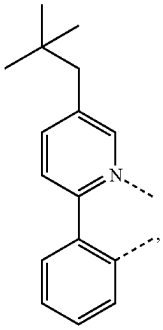

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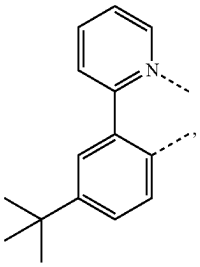
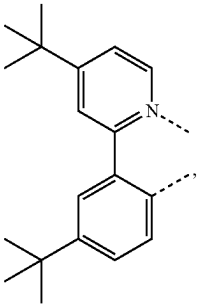


L_{B34}



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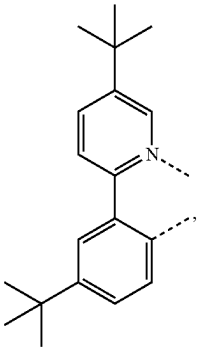

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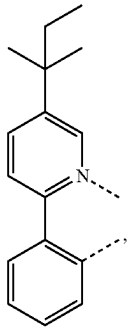
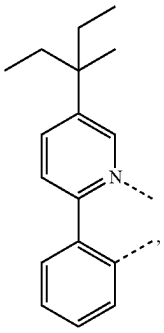
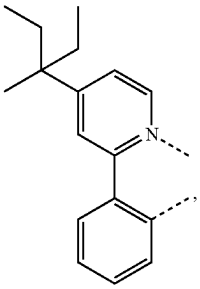
L_{B36}



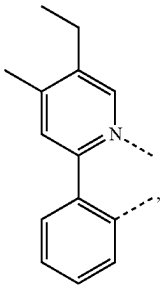
L_{B37}



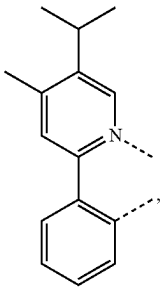
L_{B38}



L_{B39}



L_{B40}



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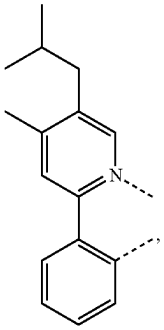
L_{B41}



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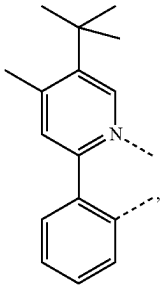

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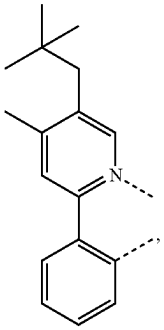
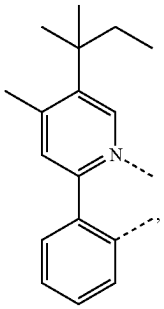


L_{B44}



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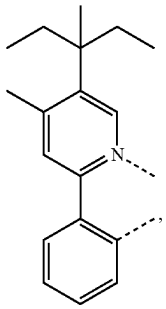

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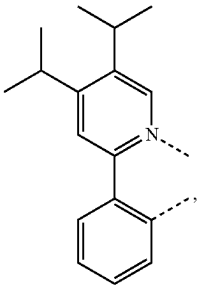

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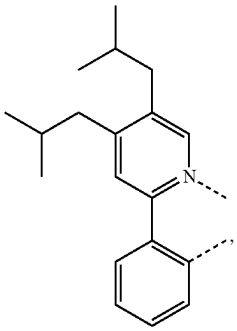

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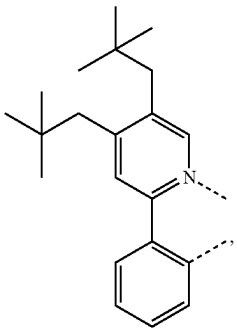

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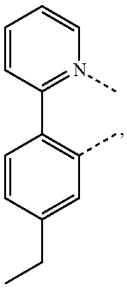

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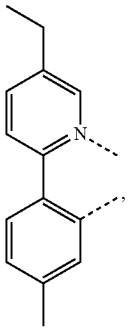

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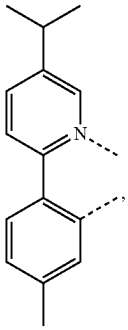

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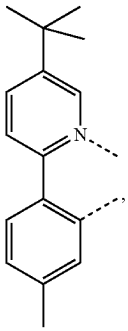

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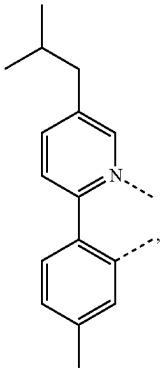

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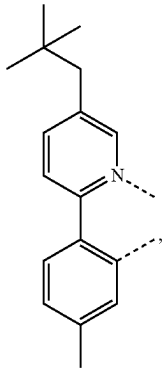

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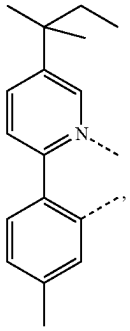

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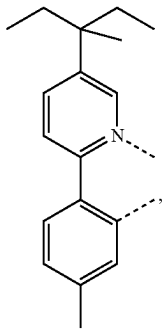

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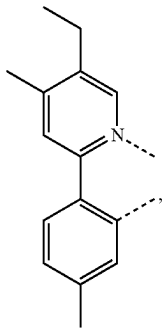

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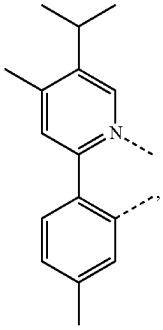

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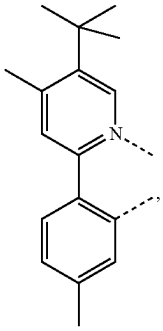

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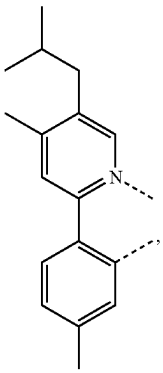

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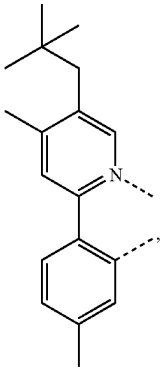

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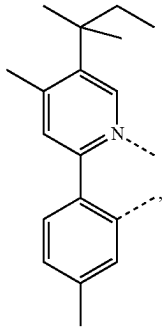

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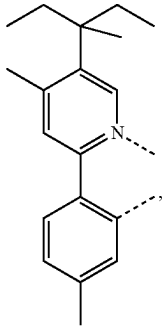

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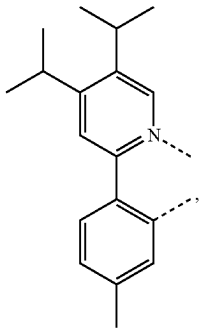

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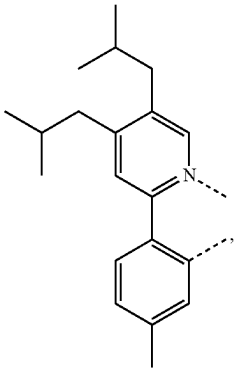

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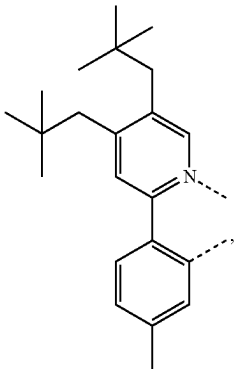

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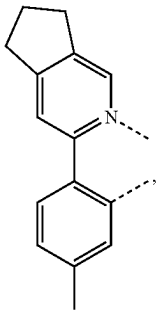

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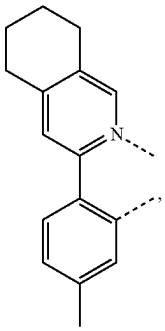

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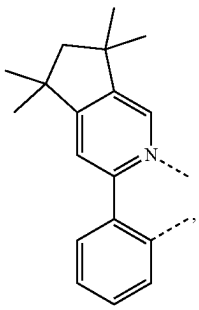

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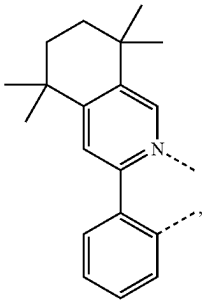

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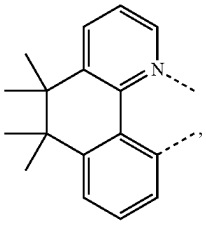

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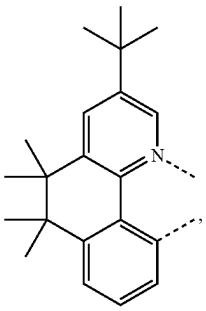

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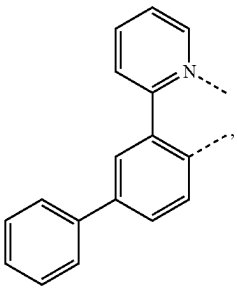

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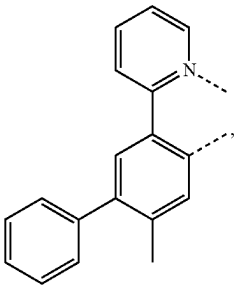

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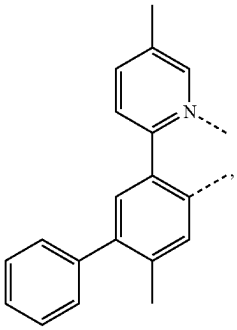

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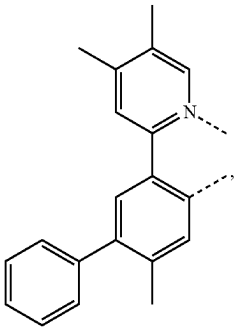

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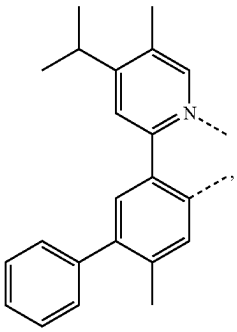

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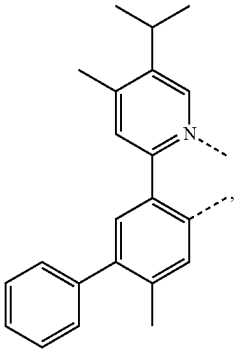

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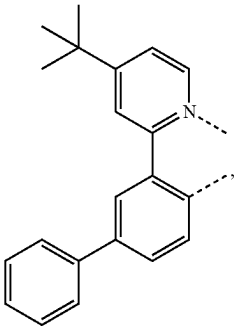

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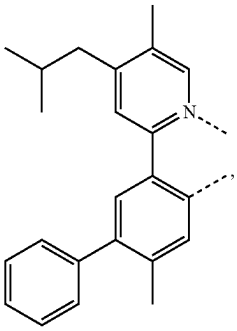

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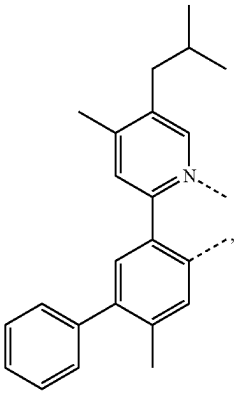

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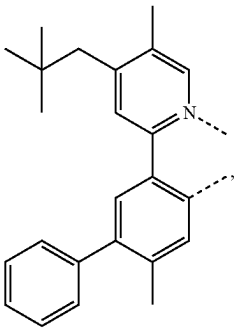

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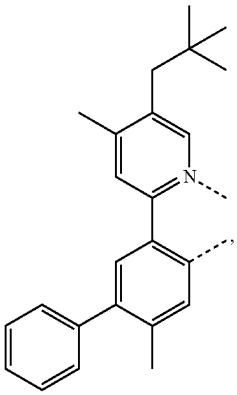

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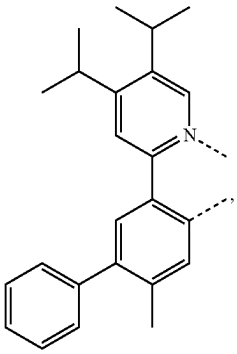

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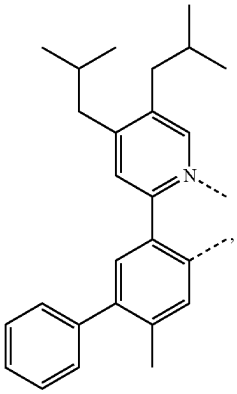

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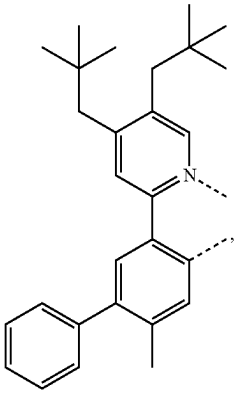

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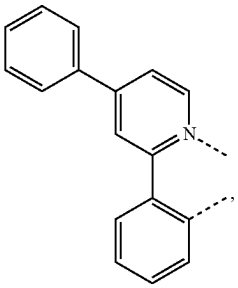

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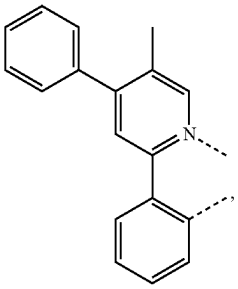

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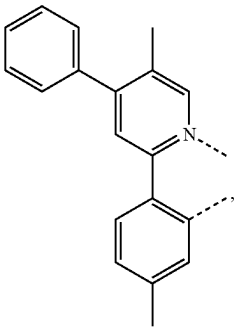

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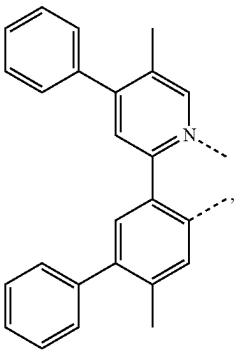

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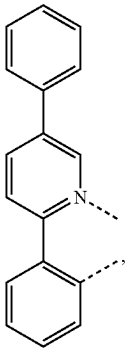

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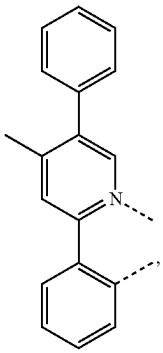

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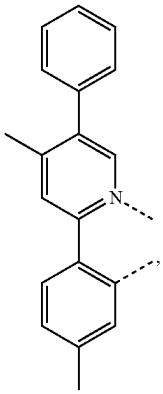

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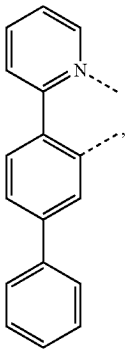

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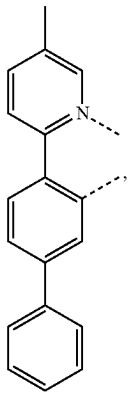

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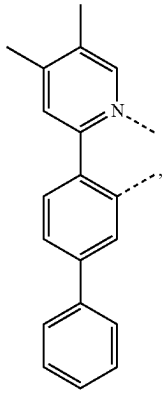

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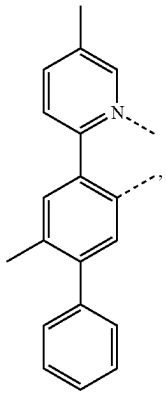

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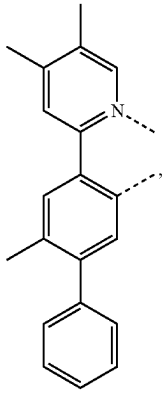

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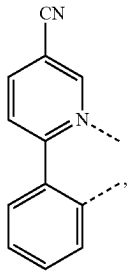

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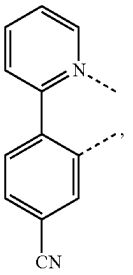

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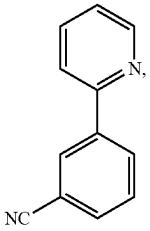

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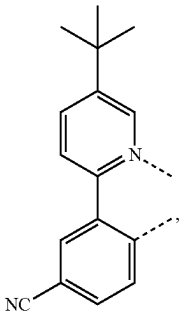

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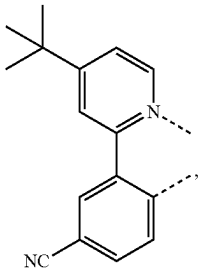

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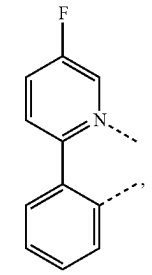

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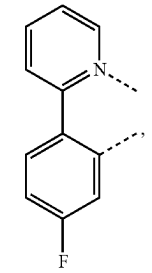

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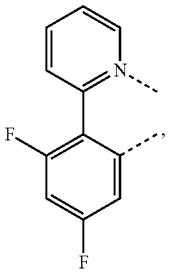

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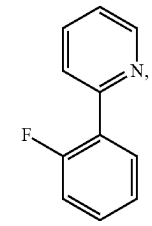

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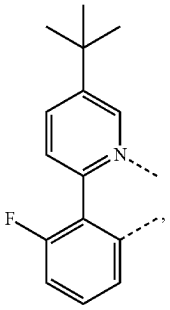

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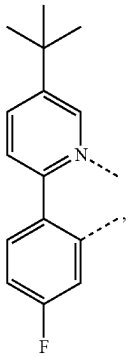

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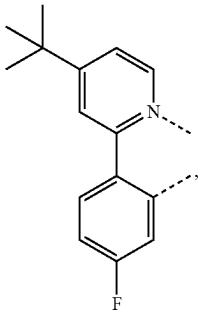

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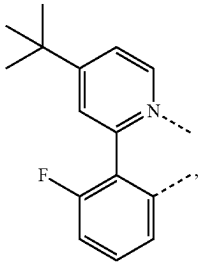

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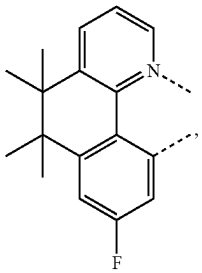

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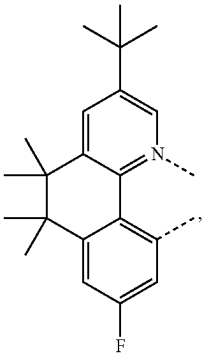

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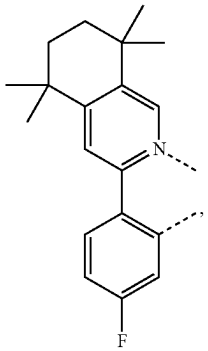

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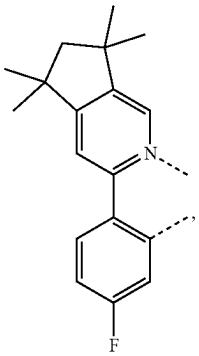

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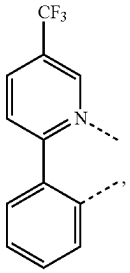

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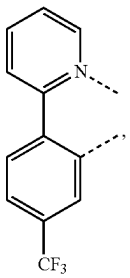

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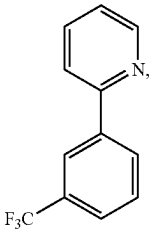

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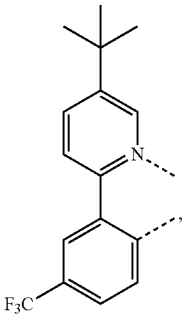

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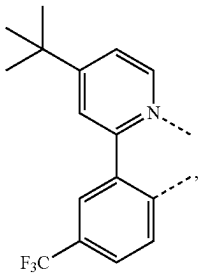

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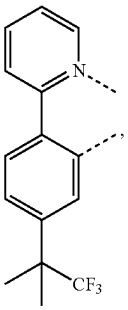

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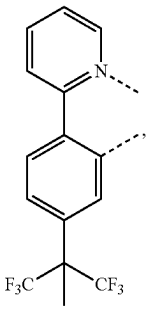

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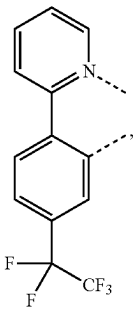

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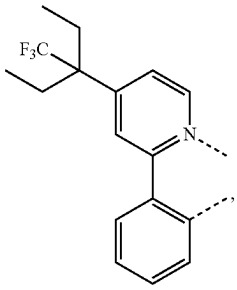

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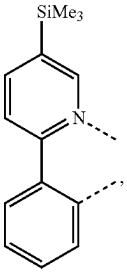

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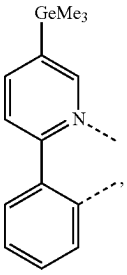

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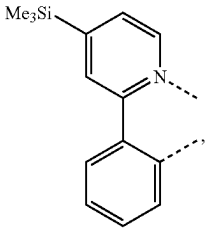

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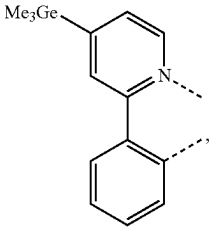

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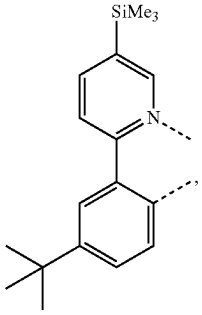

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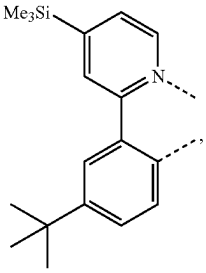

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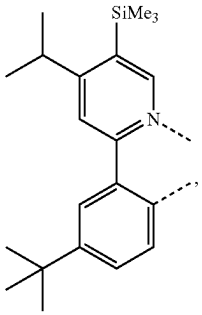

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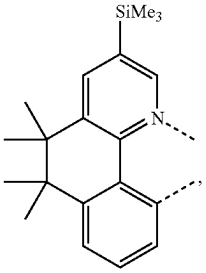

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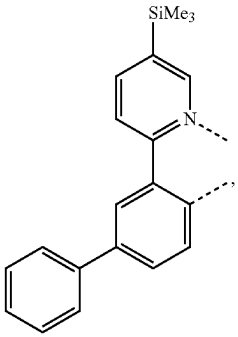

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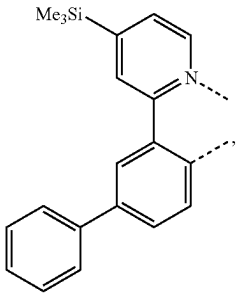

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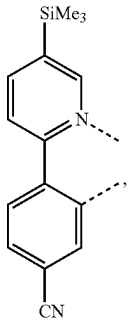

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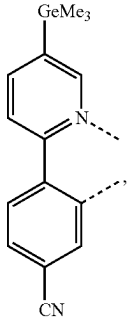

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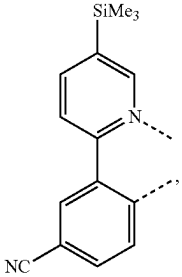

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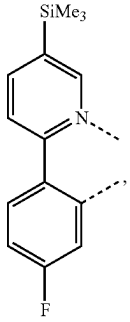

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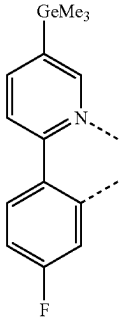

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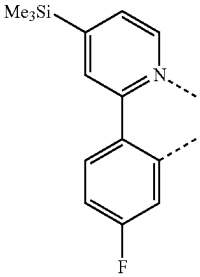

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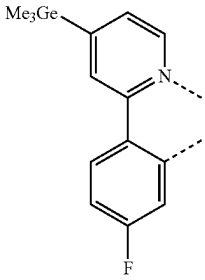

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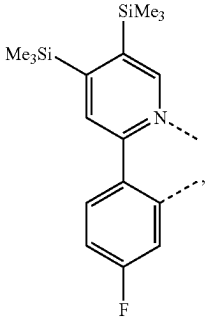

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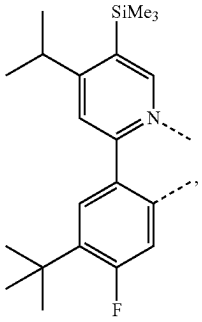

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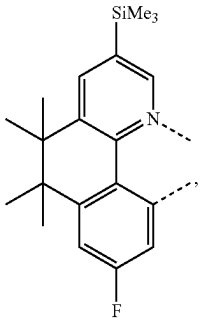

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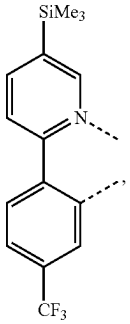

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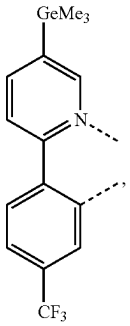

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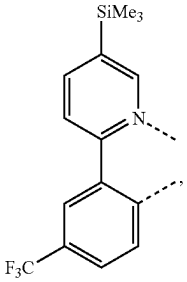

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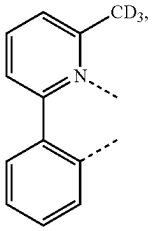

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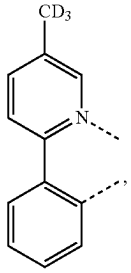

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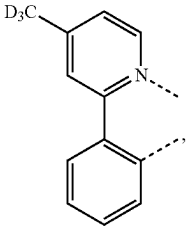

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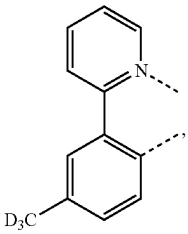

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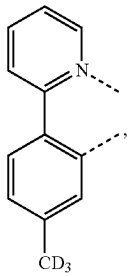

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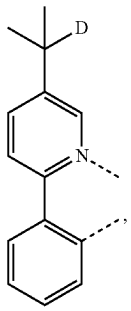

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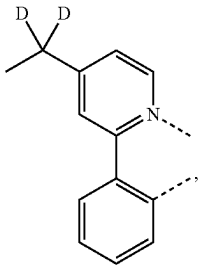

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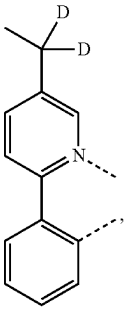

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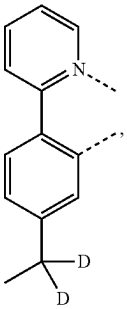

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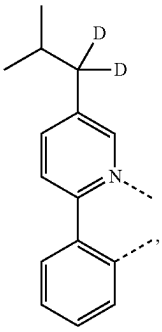

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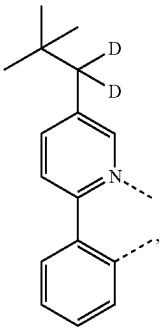

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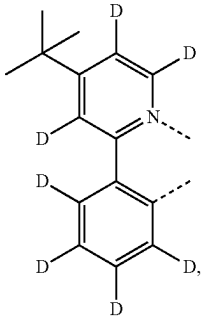

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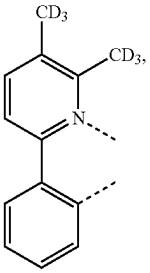

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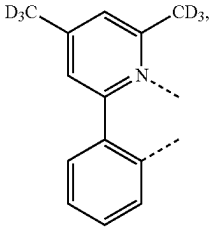

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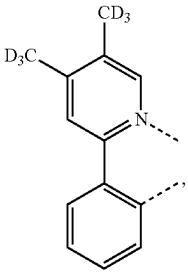

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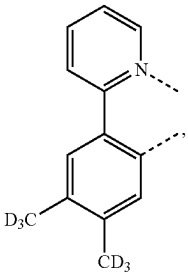

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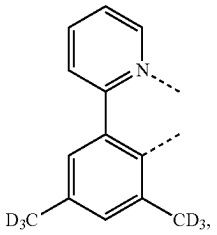

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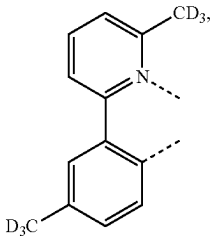

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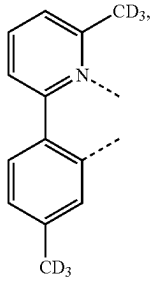

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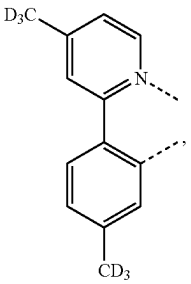

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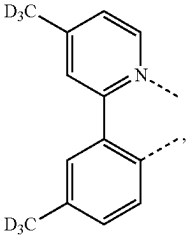

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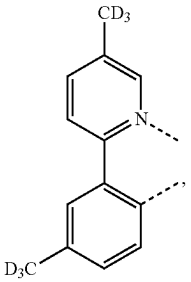

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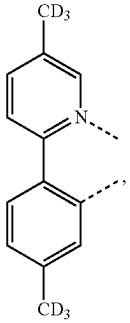

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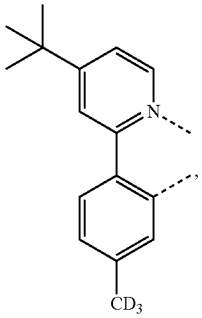

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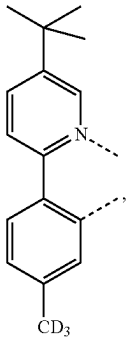

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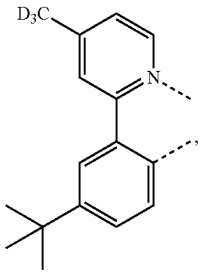

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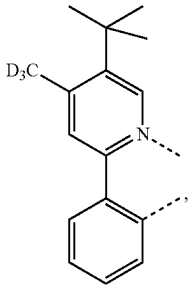

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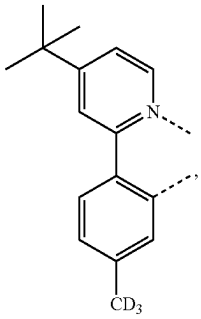

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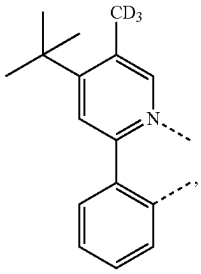

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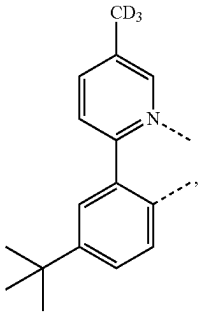

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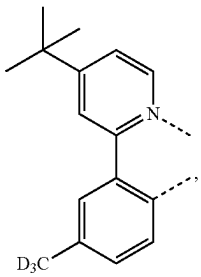

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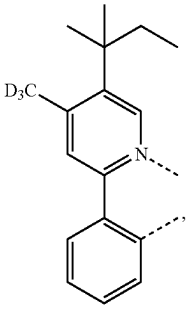

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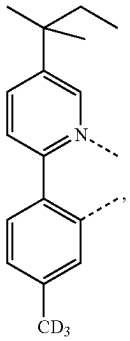

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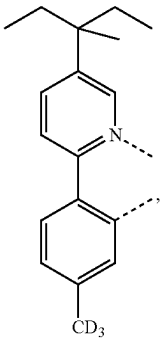

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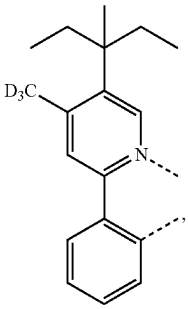

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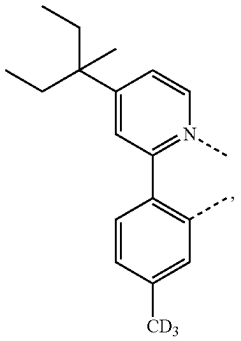

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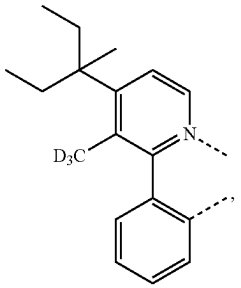

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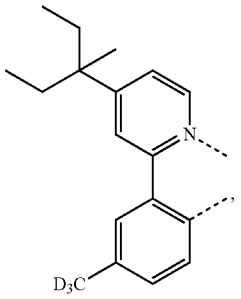

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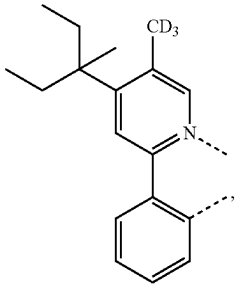

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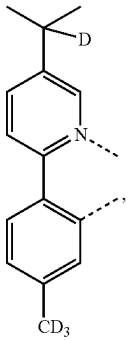

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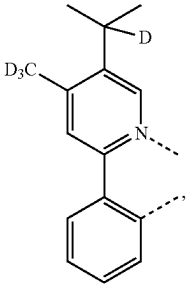

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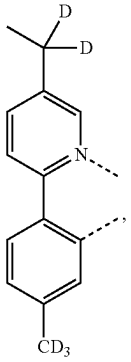

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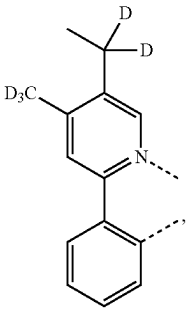

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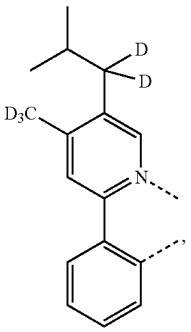

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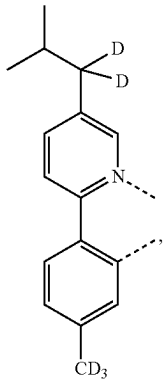

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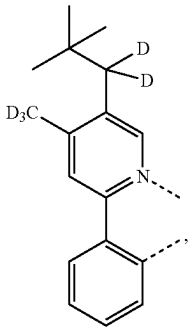

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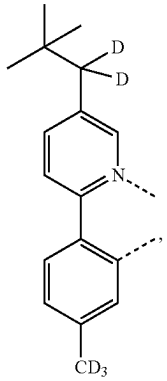

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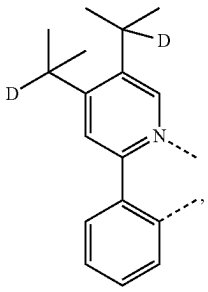

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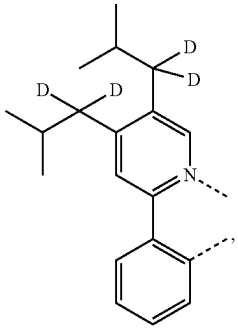

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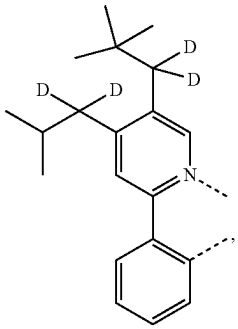

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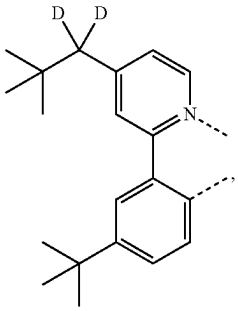

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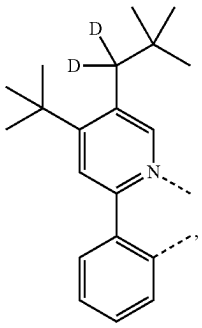

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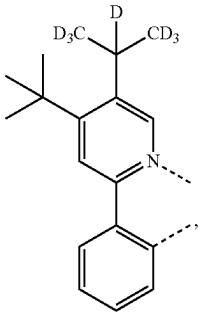

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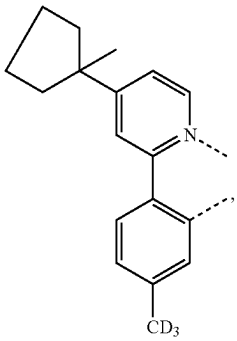

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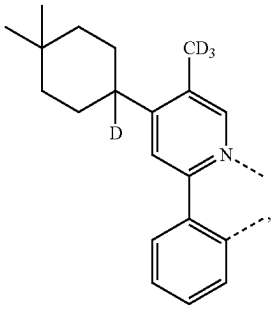

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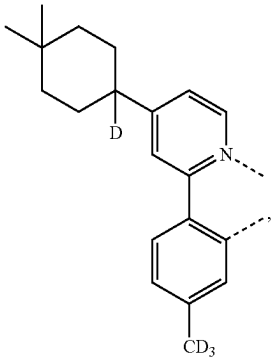

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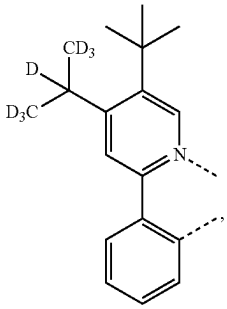

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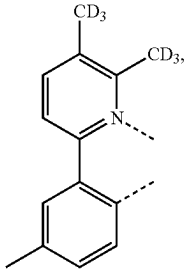

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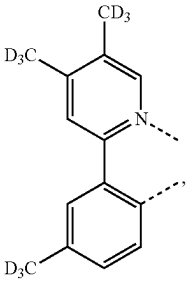

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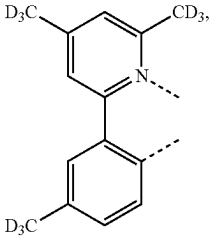

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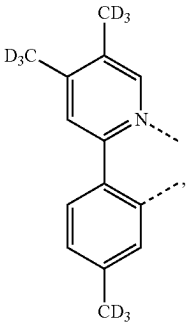

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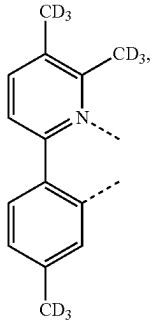

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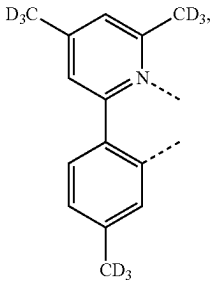

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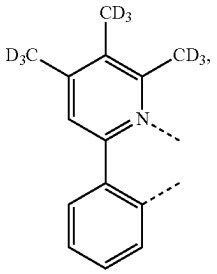

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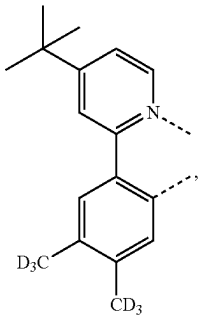

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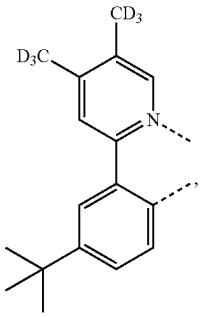

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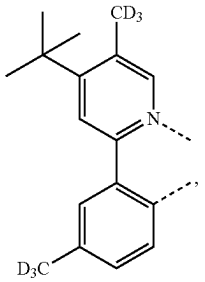

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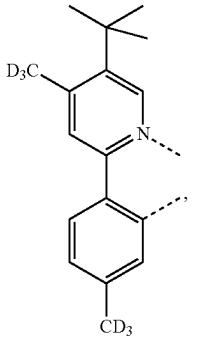

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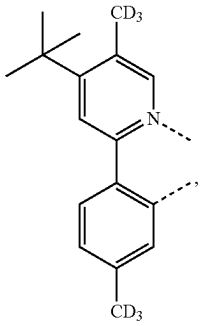

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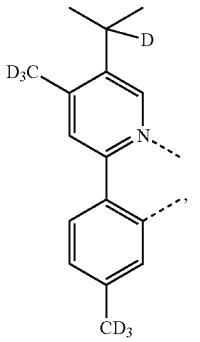

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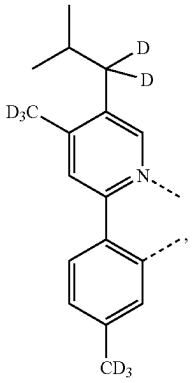

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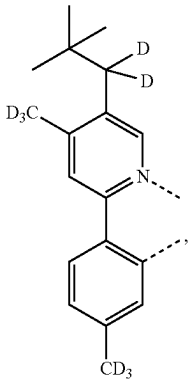

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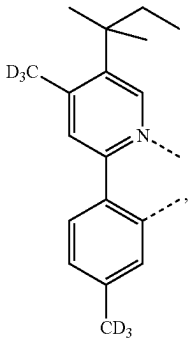

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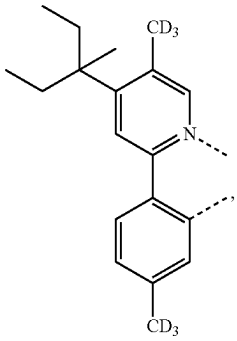

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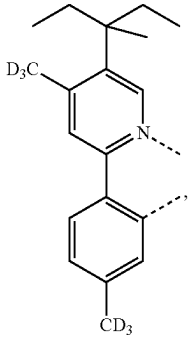

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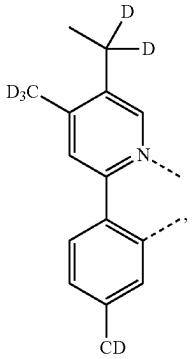

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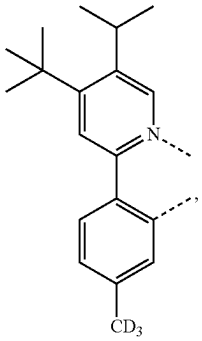

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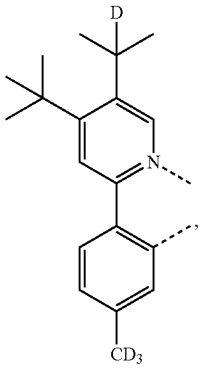

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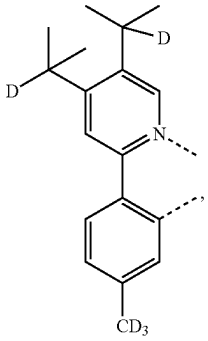

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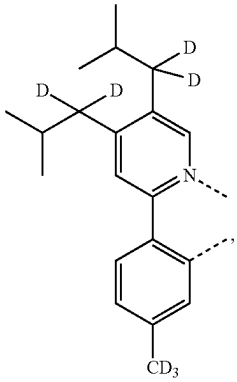

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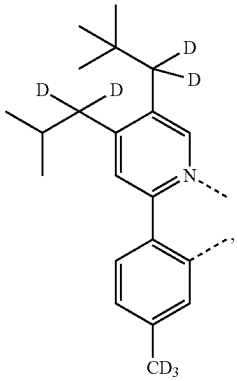

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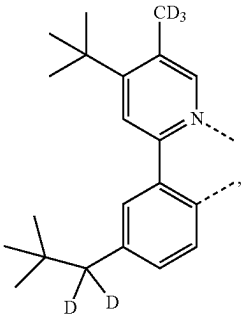

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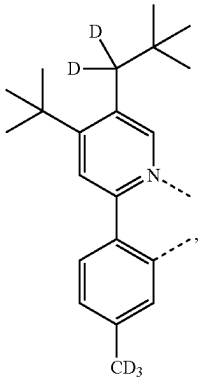

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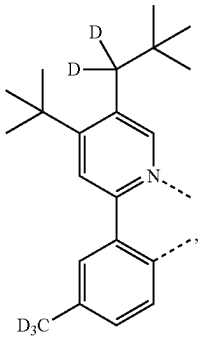

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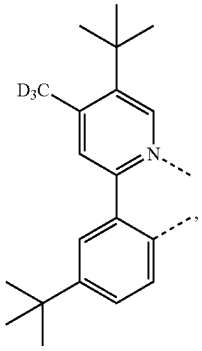

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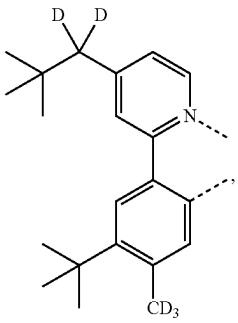

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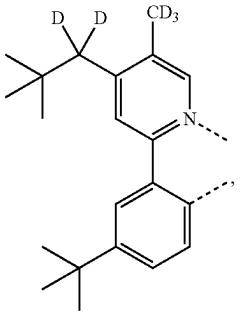

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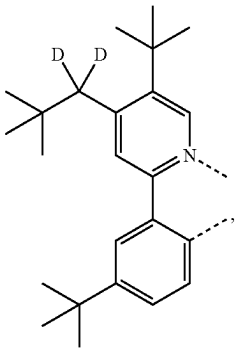

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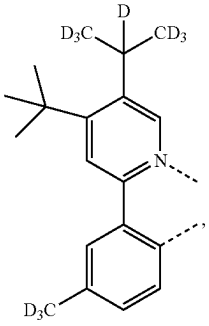

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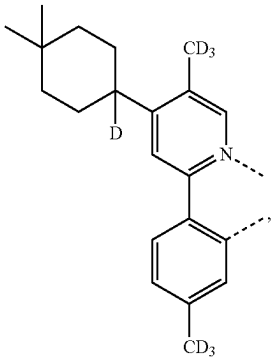

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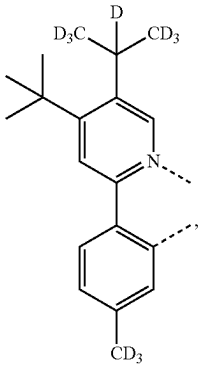

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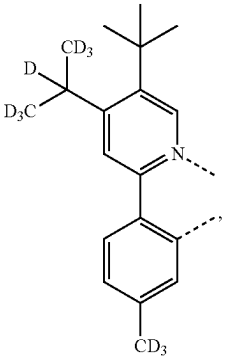

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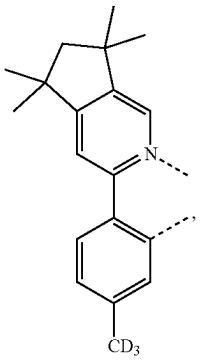

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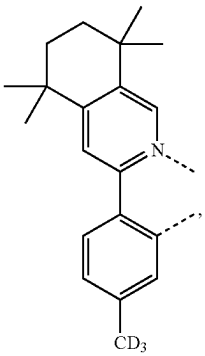

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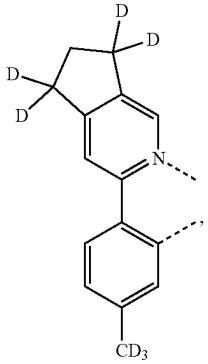

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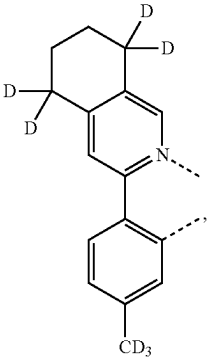

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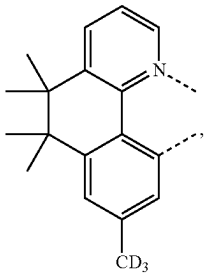

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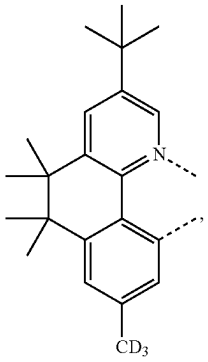

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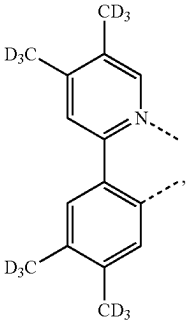

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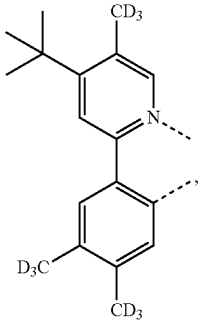

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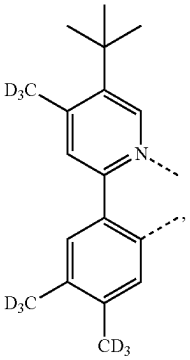

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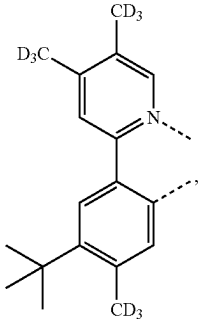

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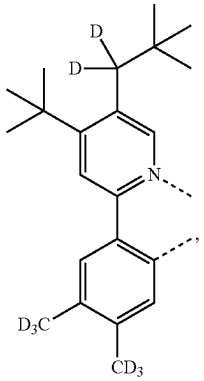

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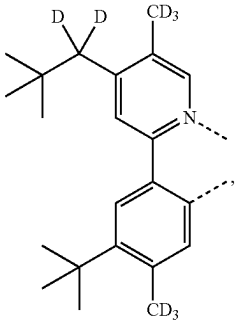

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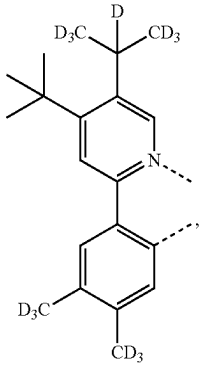

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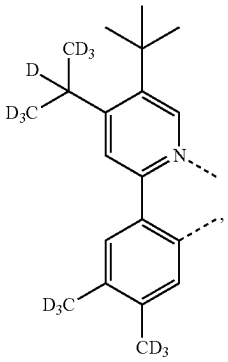

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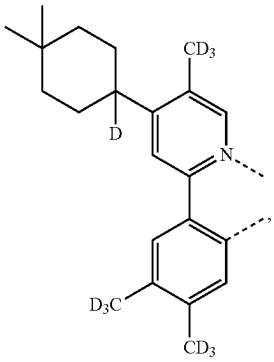

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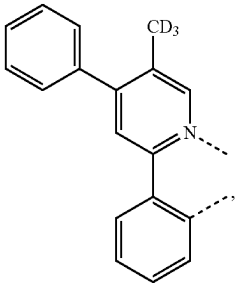

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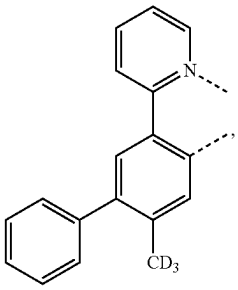

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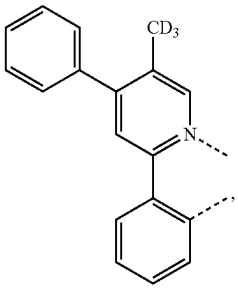

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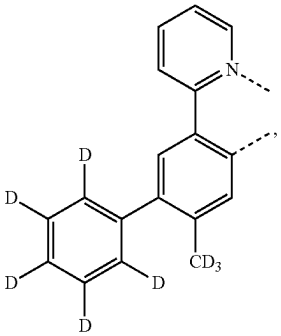

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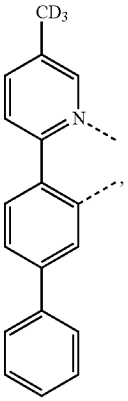

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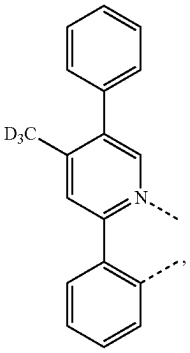

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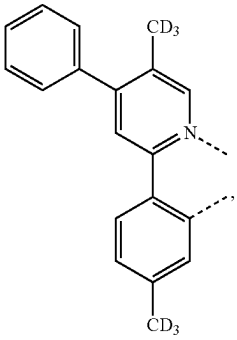

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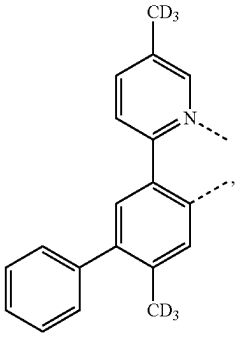

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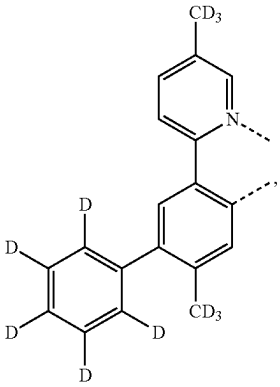

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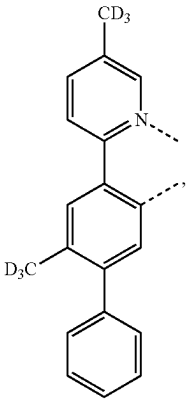

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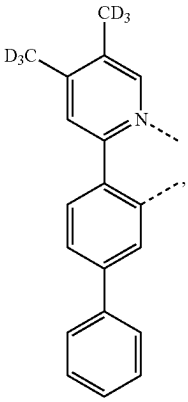

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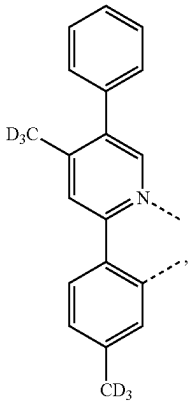

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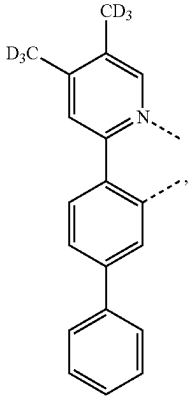

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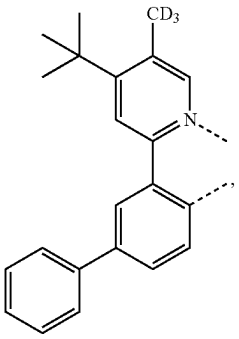

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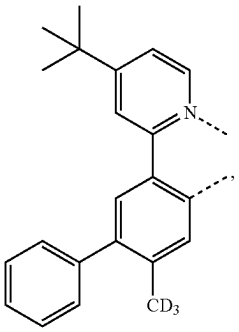

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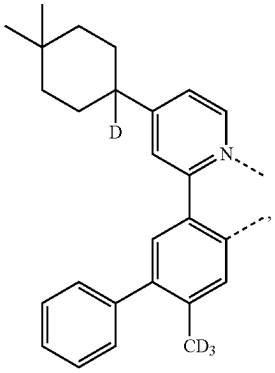

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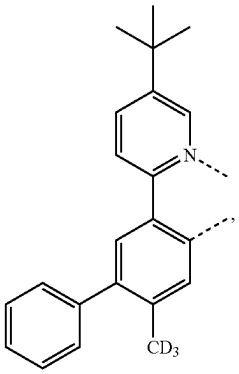

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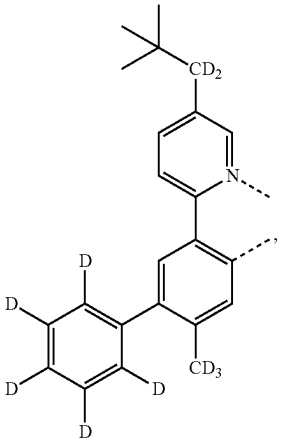

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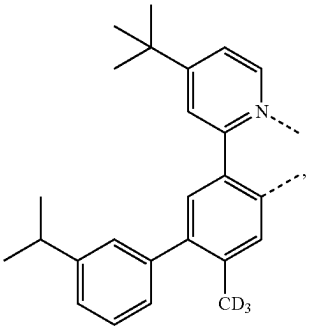

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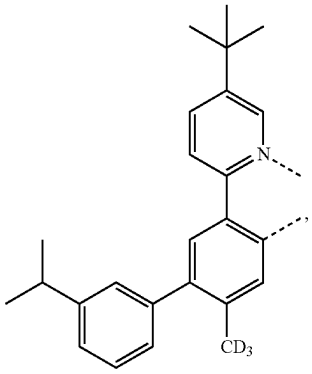

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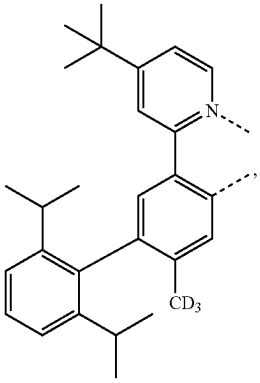

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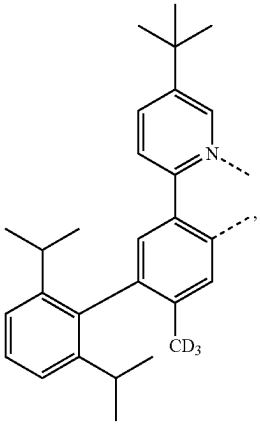

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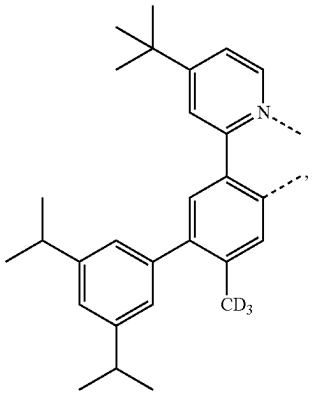

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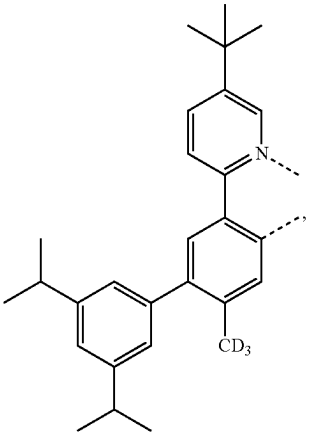

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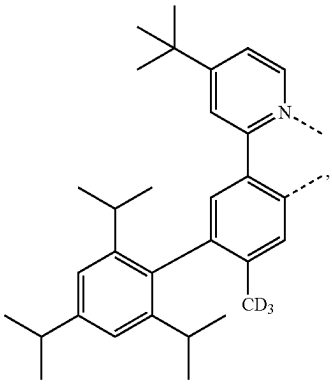

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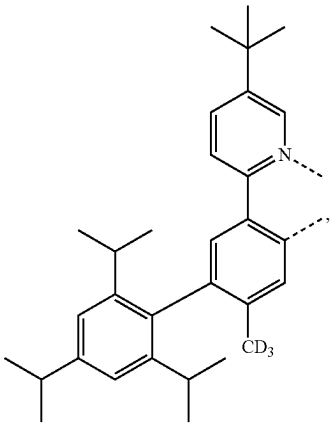

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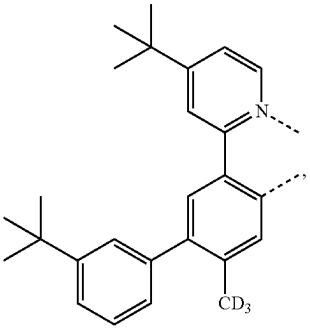

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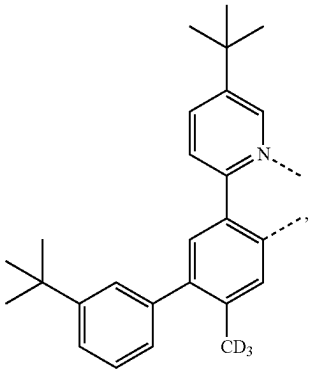

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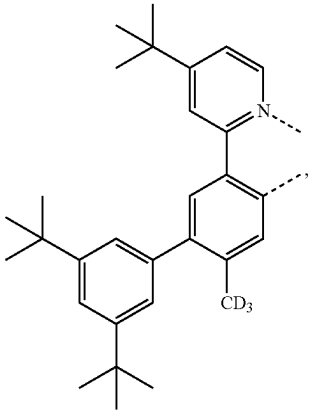

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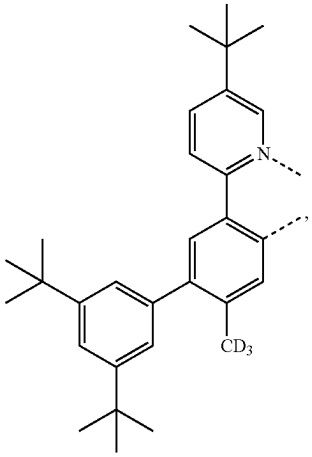

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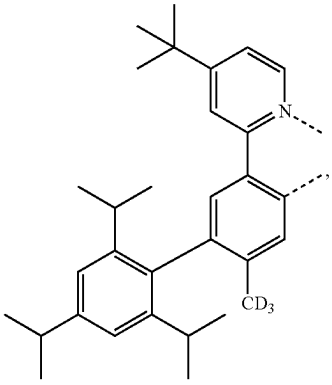

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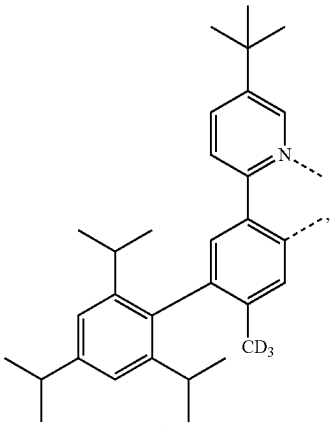

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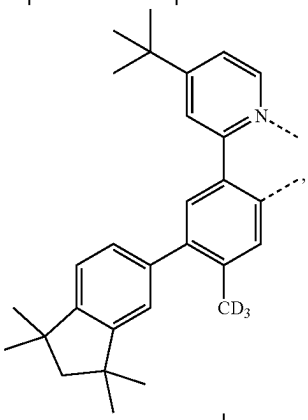

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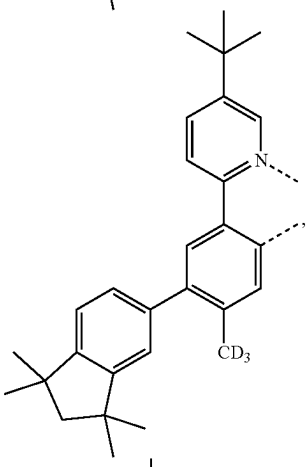

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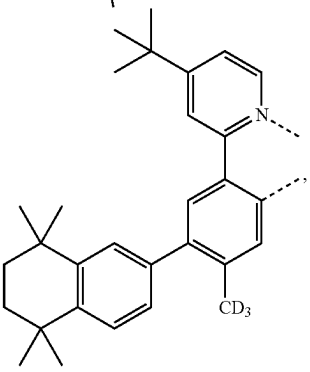

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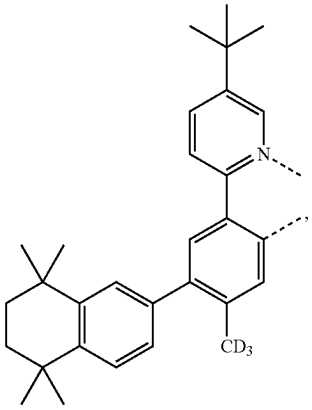

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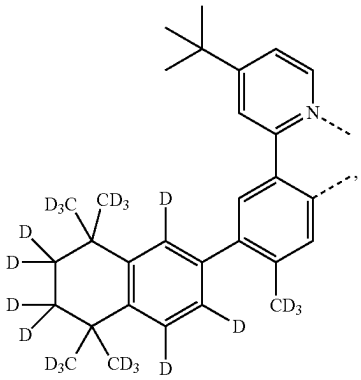

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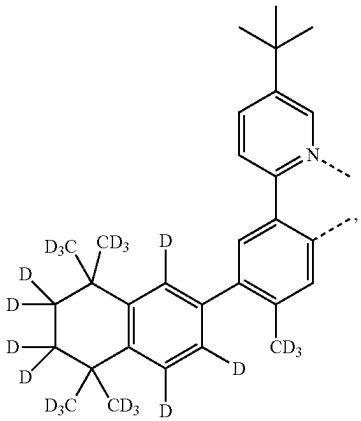

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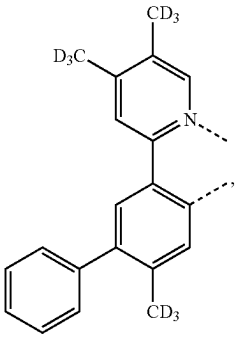

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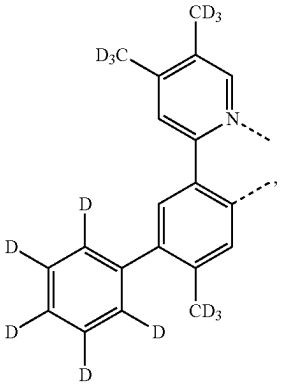

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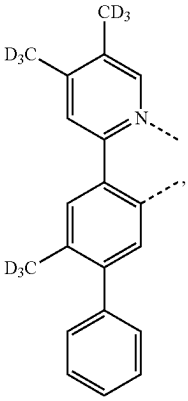

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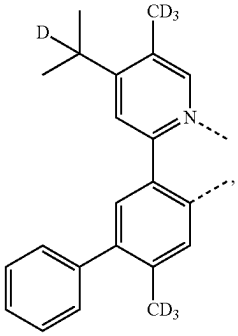

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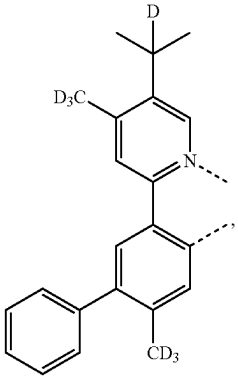

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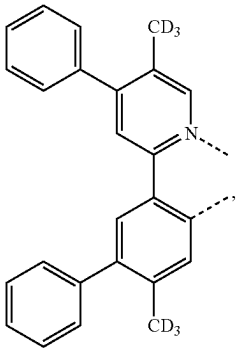

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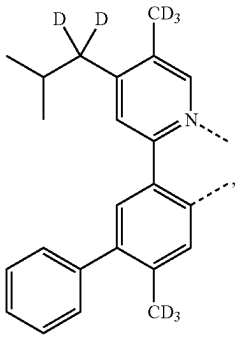

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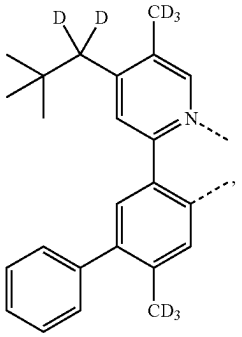

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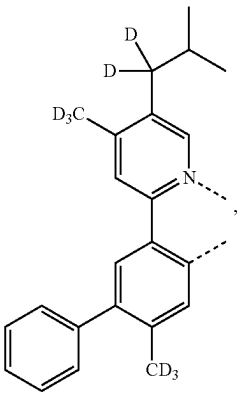

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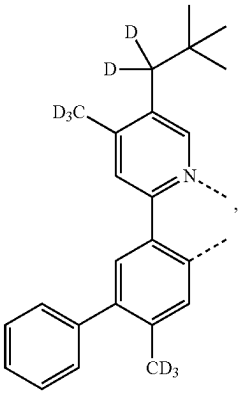

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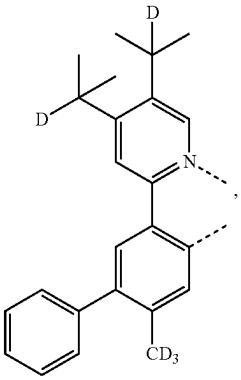

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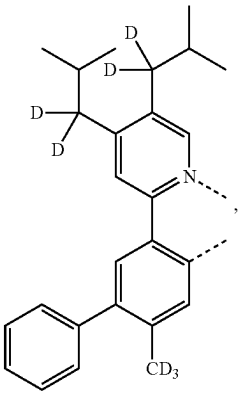

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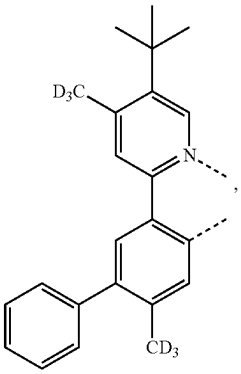

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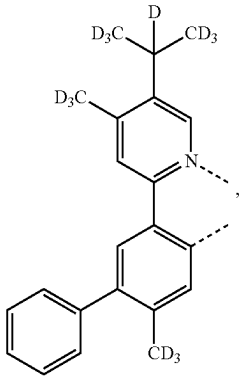

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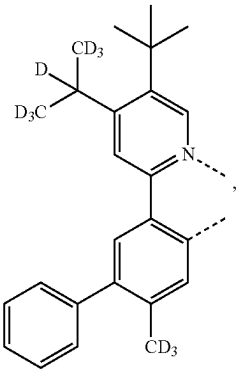

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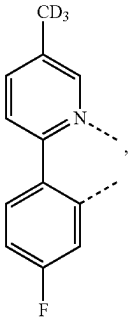

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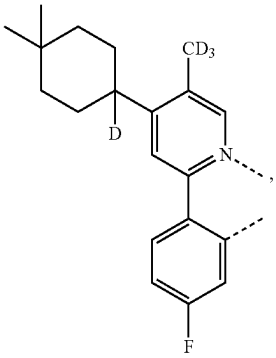

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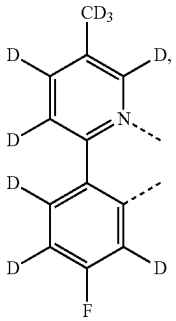

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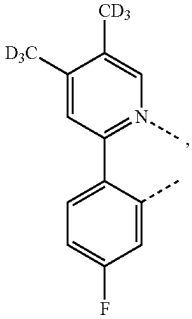

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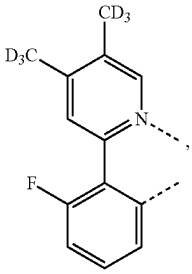

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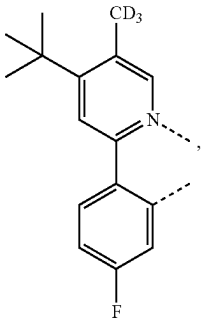

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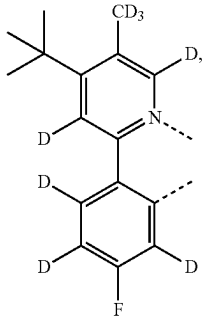

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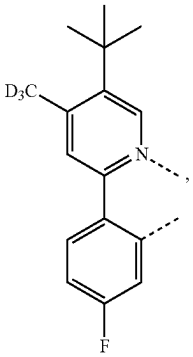

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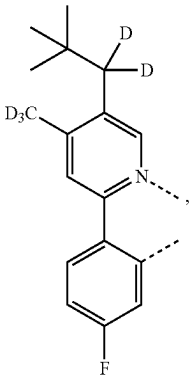

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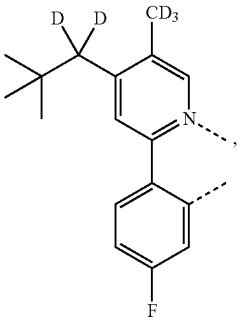

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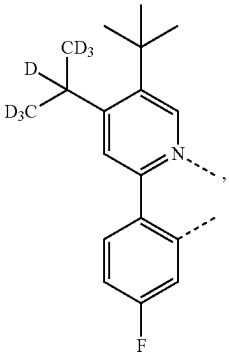

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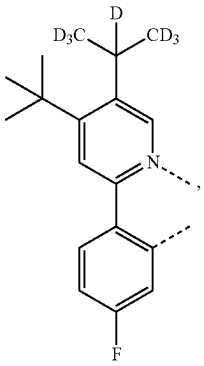

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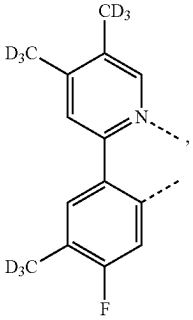

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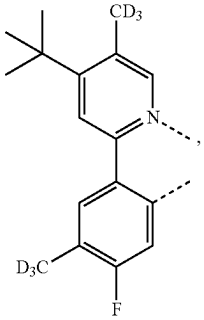

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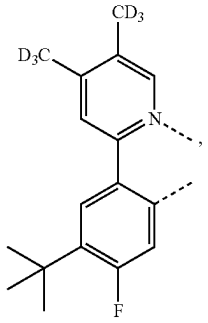

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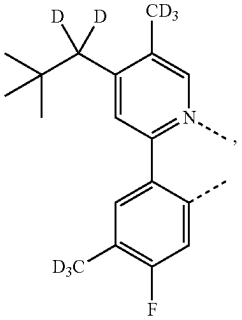

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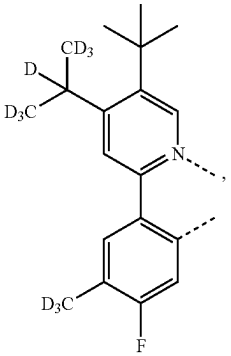

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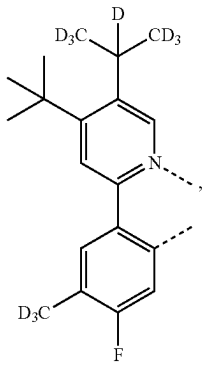

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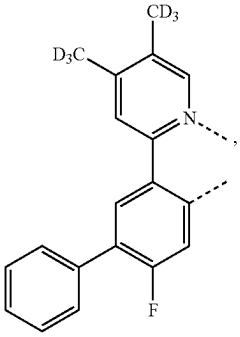

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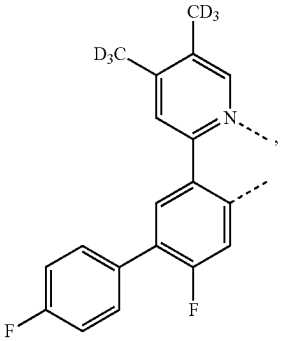

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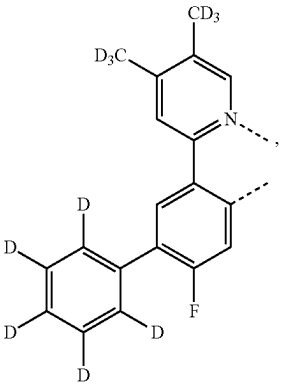

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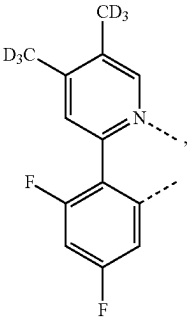

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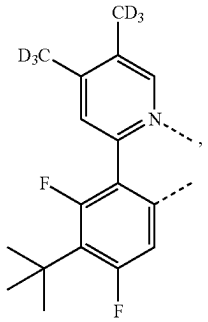

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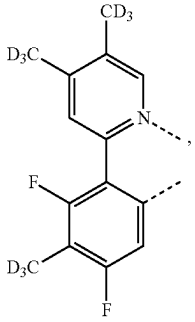

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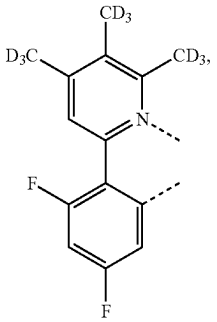

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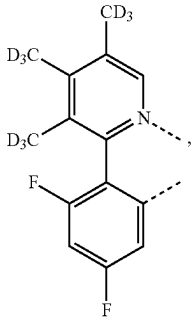

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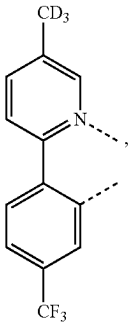

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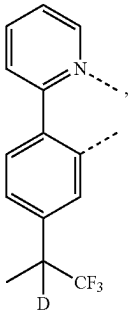

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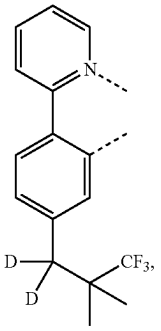

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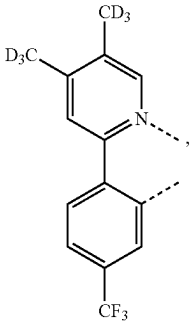

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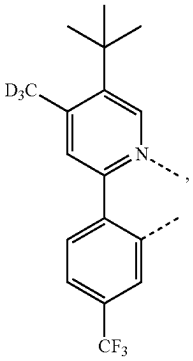

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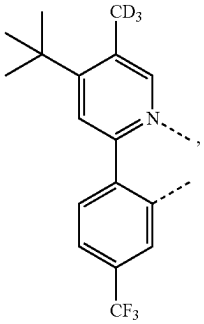

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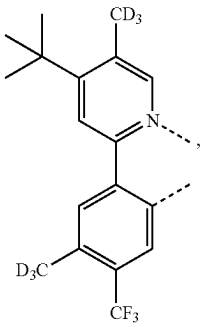

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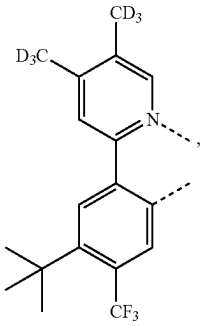

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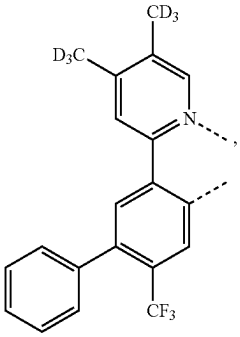

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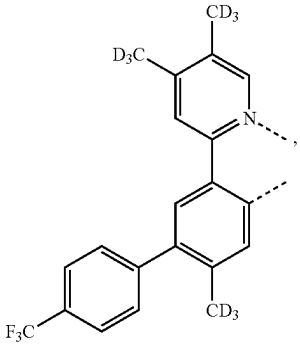

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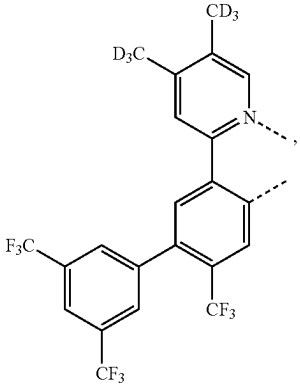

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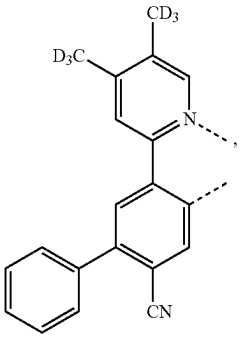

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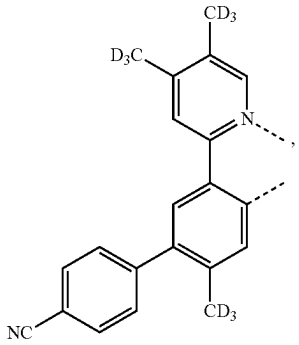

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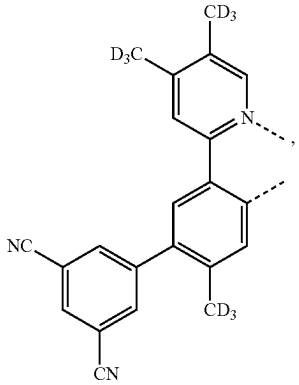

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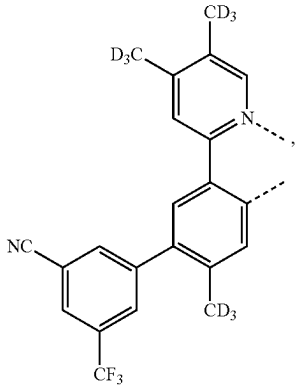

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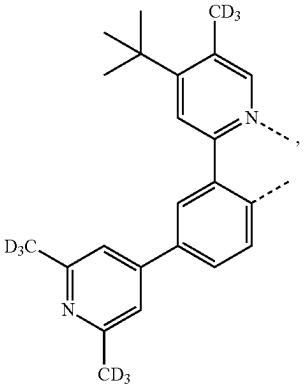

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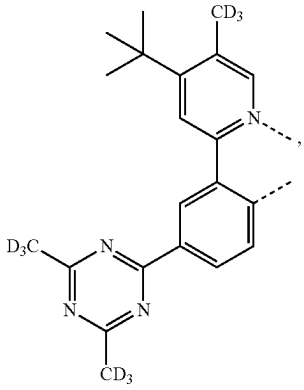

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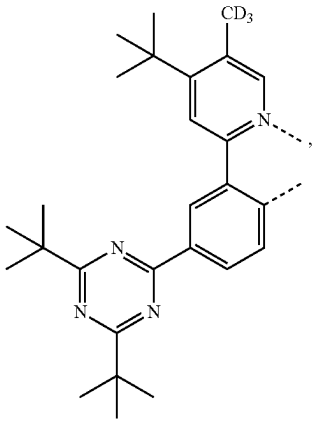

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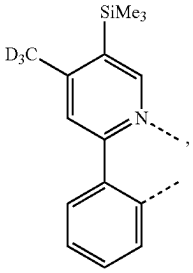

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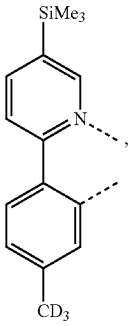

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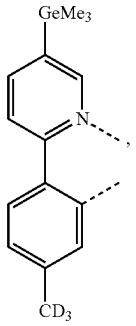

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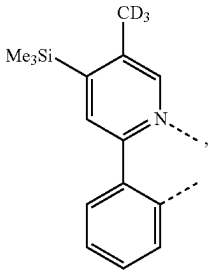

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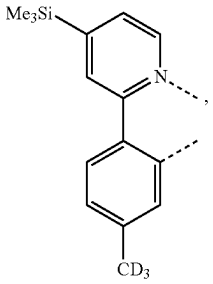

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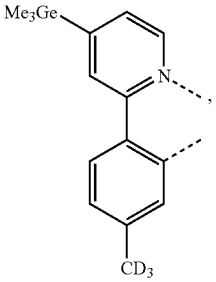

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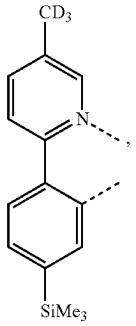

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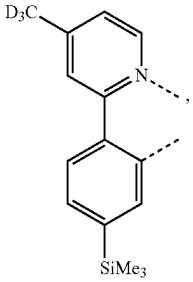

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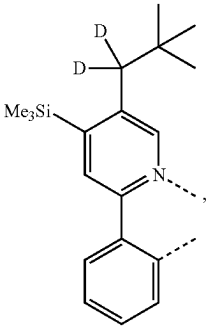

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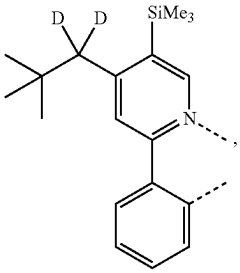

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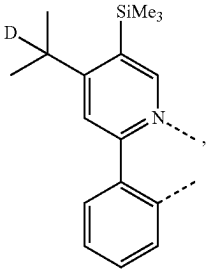

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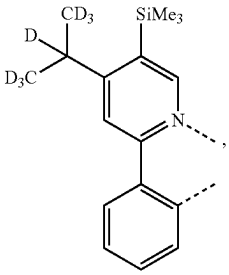

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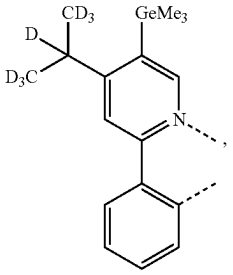

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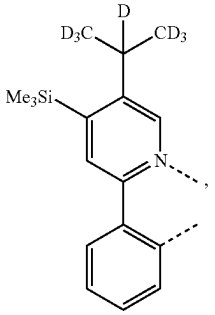

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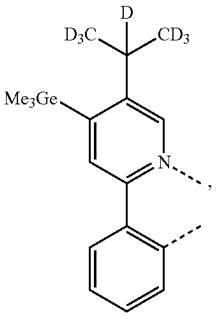

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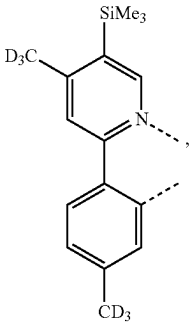

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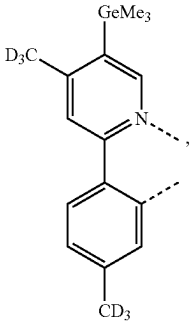

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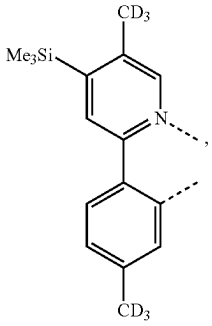

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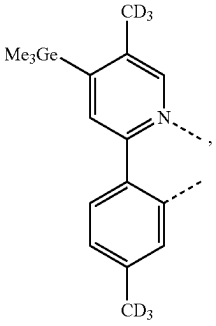

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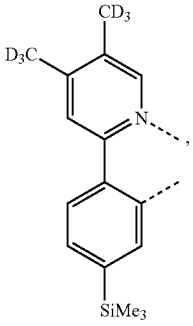

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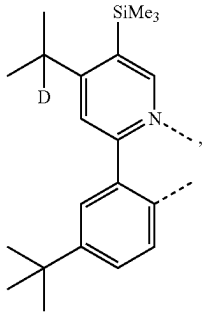

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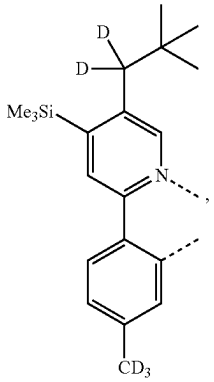

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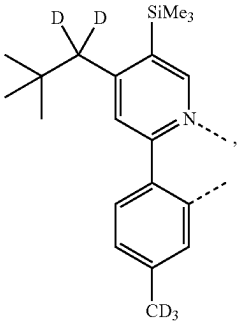

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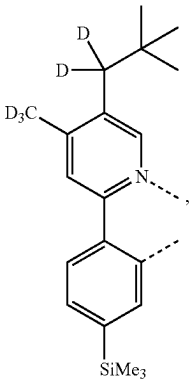

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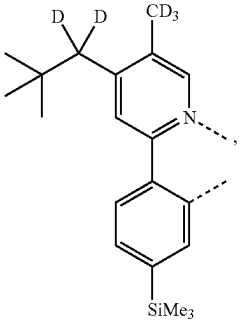

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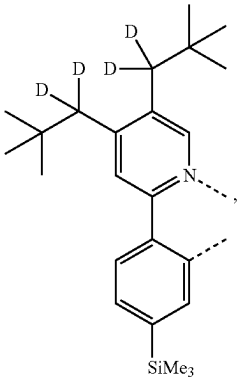

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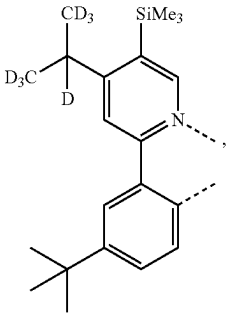

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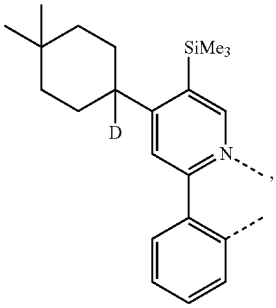

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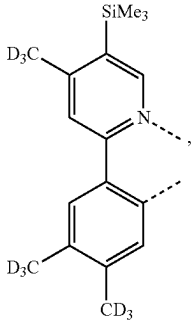

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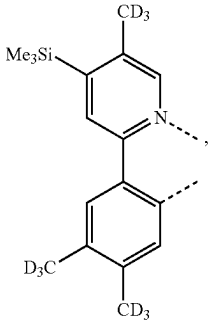

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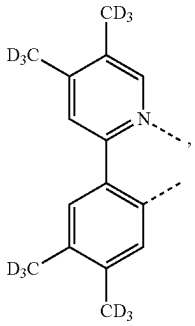

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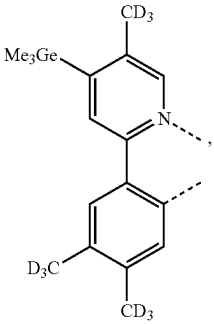

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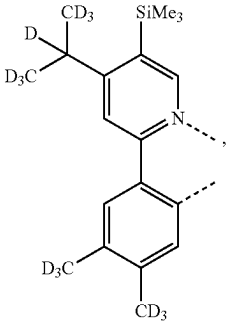

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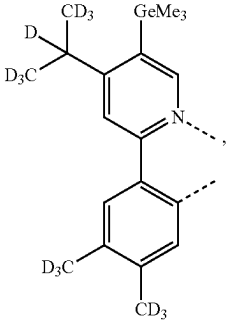

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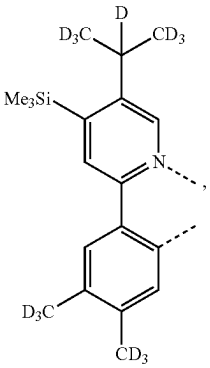

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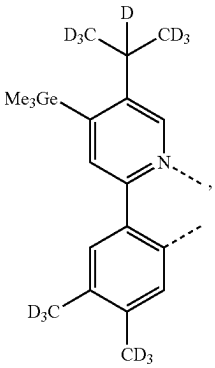

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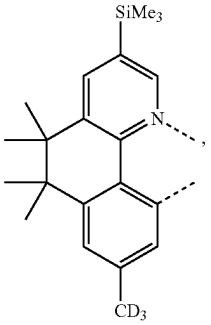

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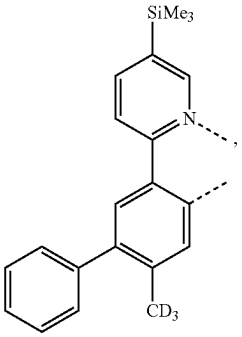

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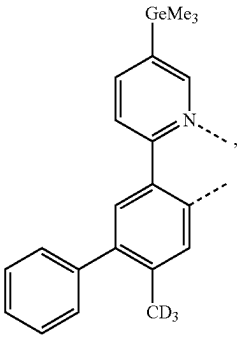

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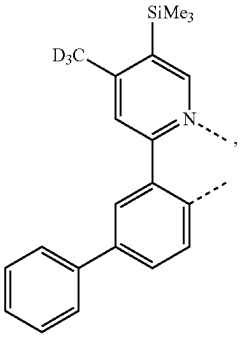

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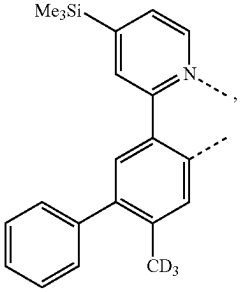

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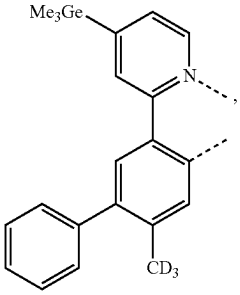

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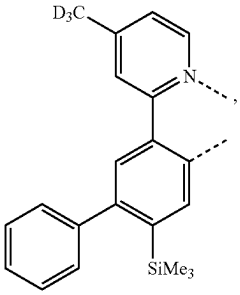

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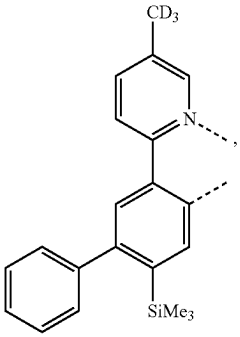

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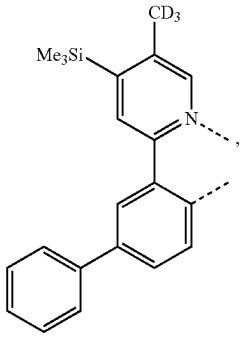

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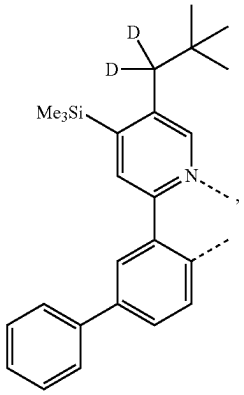

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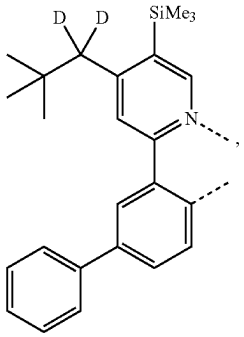

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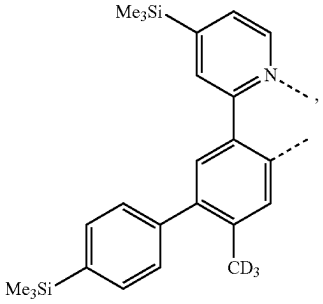

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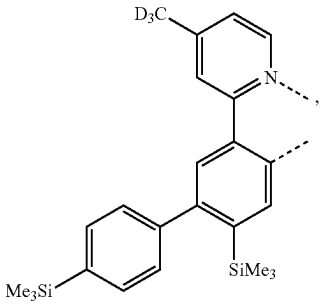

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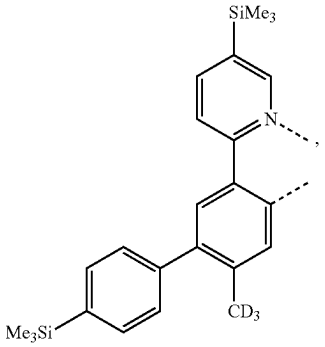

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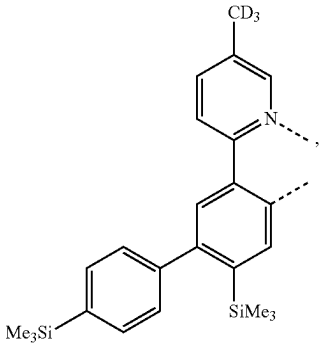

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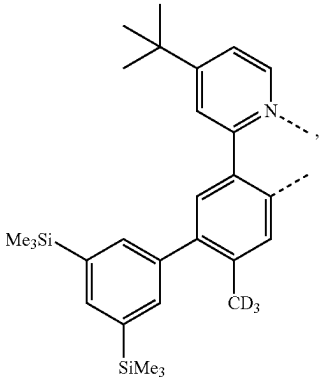

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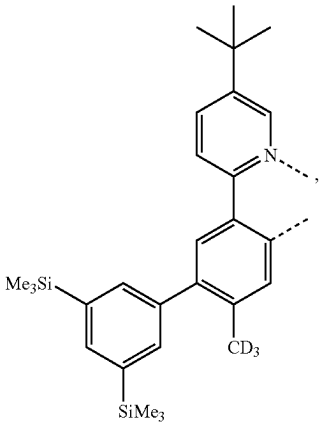

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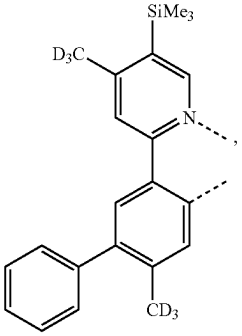

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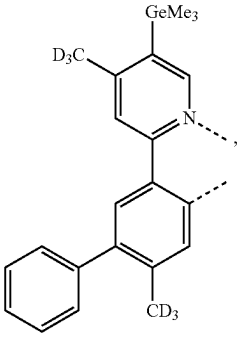

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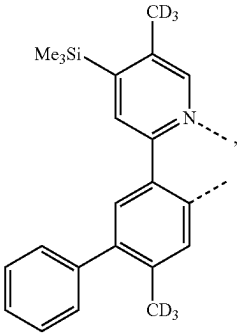

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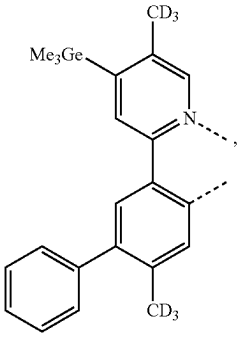

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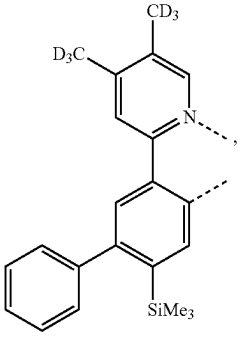

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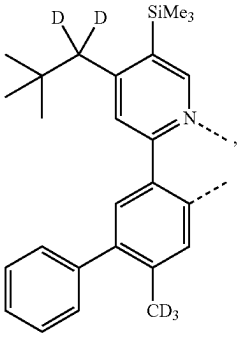

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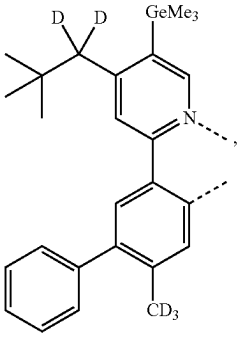

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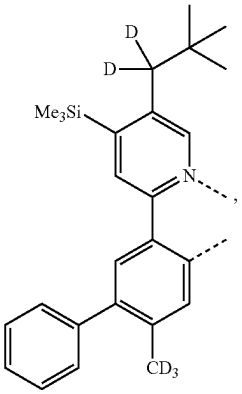

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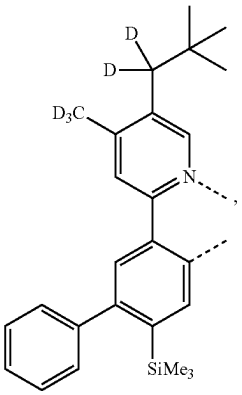

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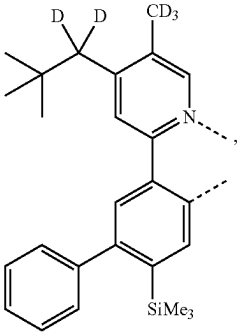

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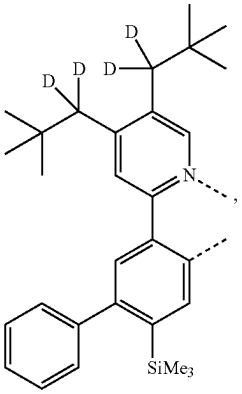

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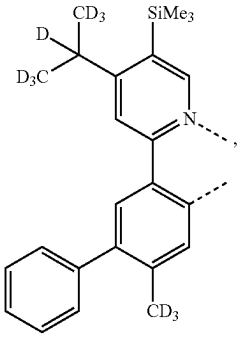

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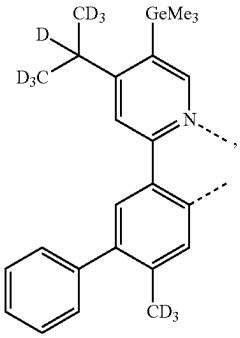

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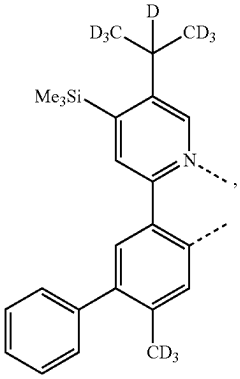

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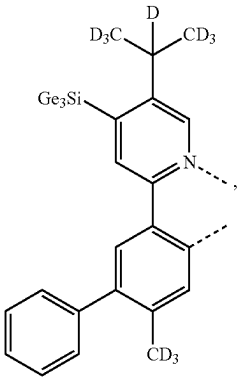

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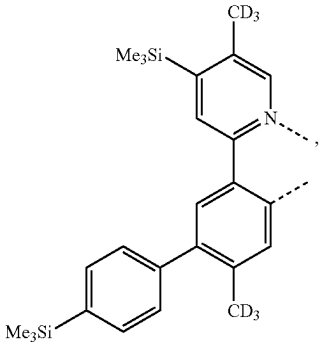

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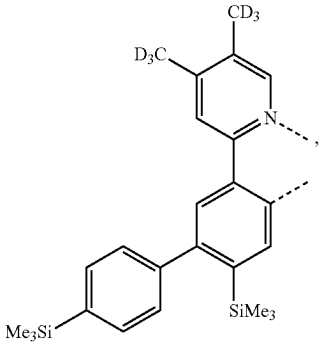

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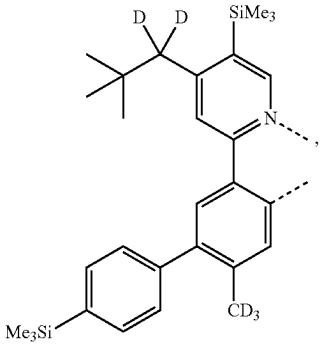

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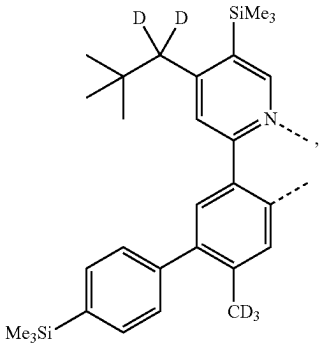

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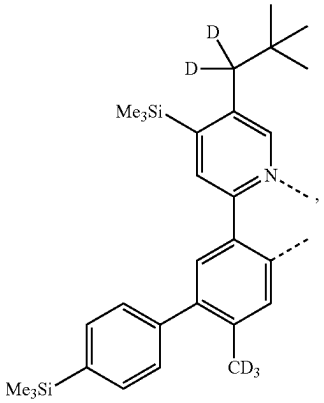

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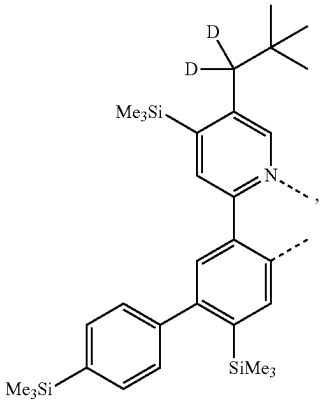

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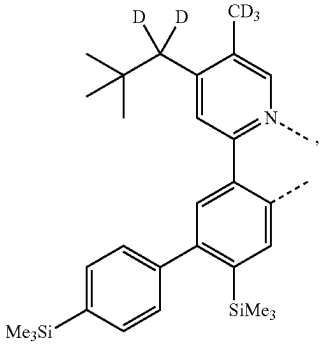

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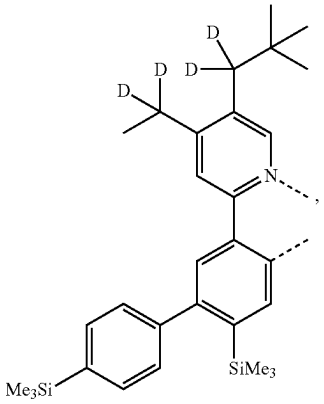

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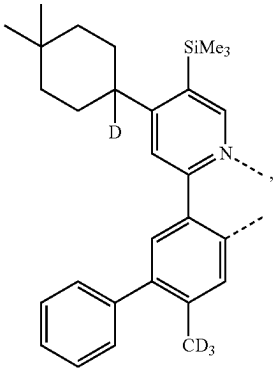

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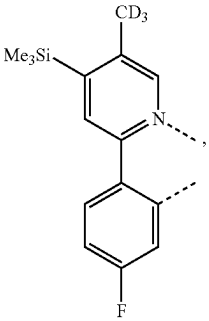

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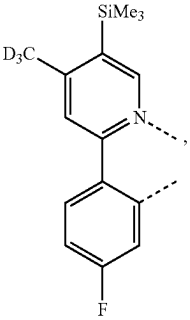

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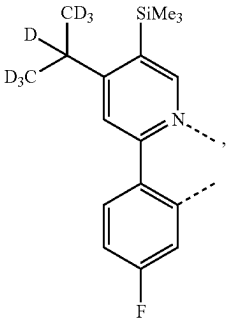

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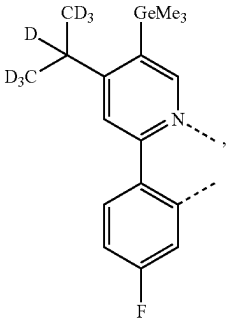

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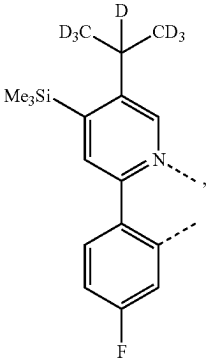

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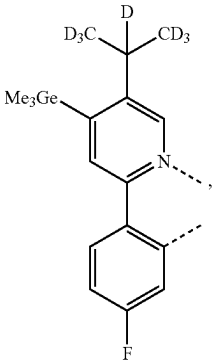

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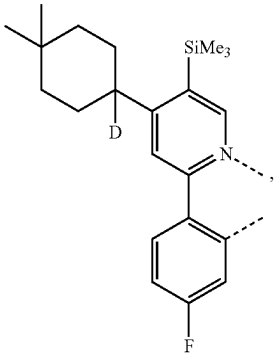

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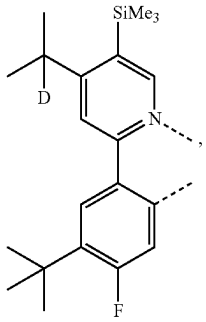

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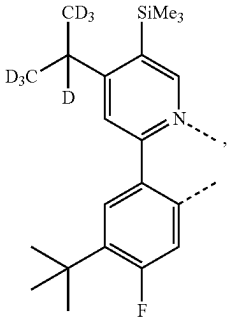

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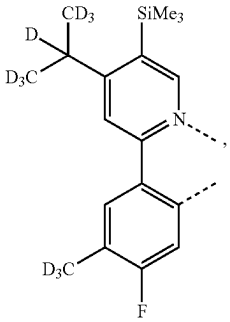

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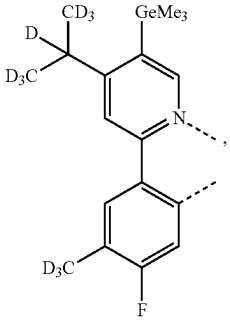

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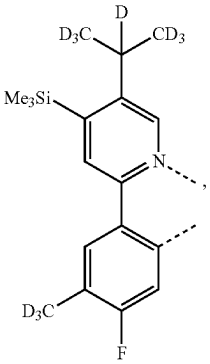

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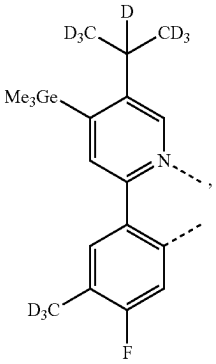

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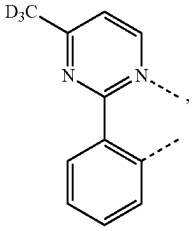

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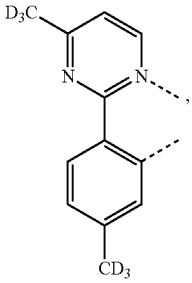

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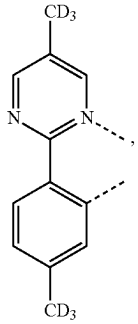

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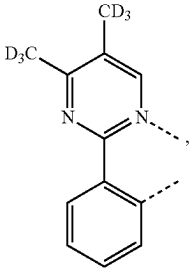

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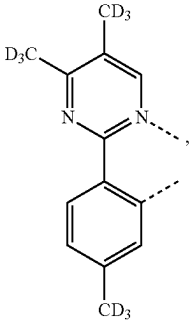

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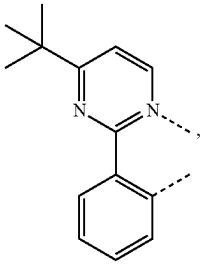

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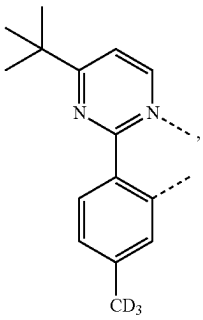

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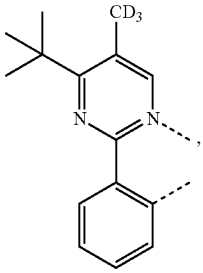

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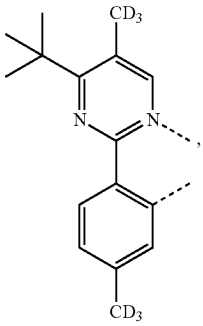

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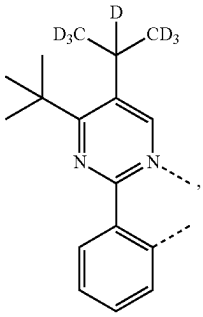

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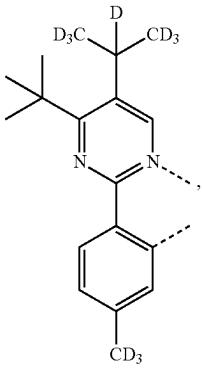

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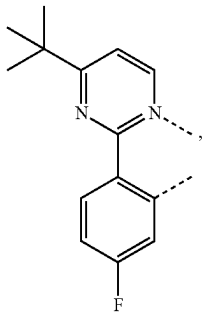

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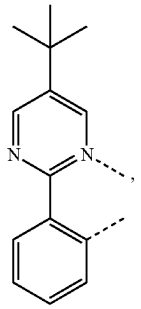

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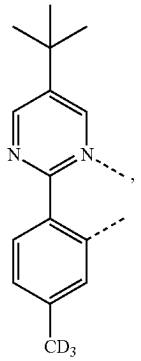

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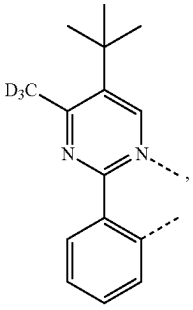

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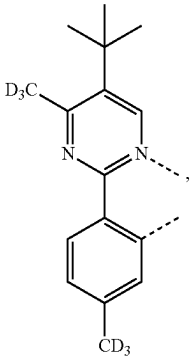

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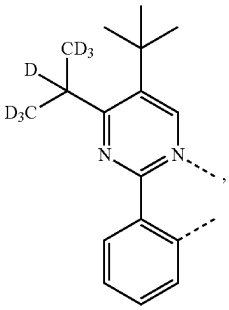

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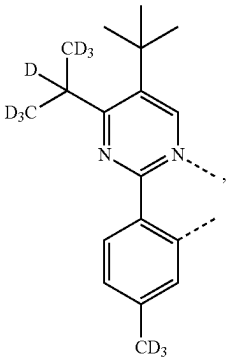

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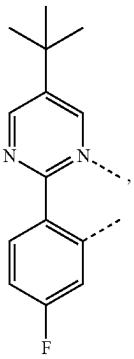

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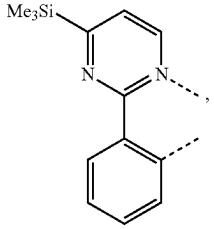

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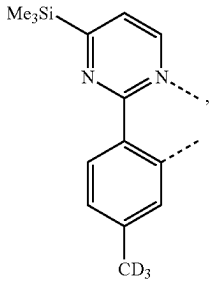

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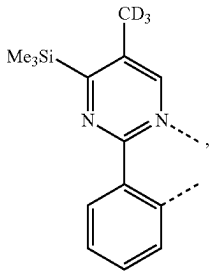

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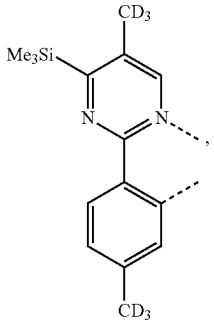

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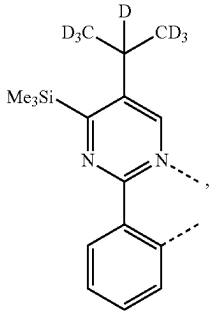

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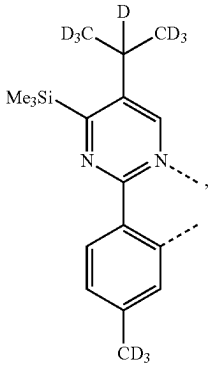

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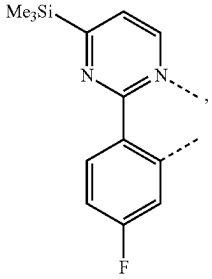

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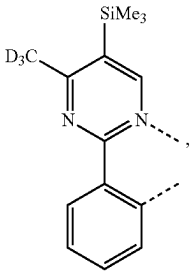

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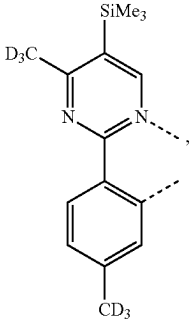

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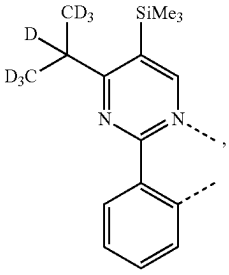

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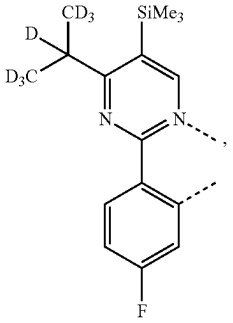

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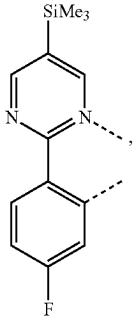

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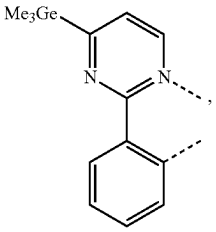

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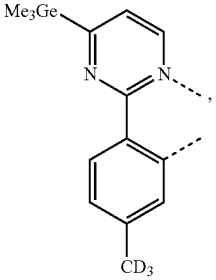

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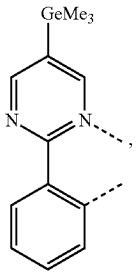

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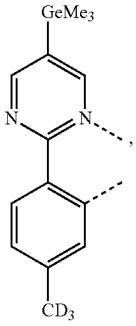

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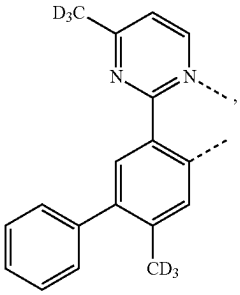

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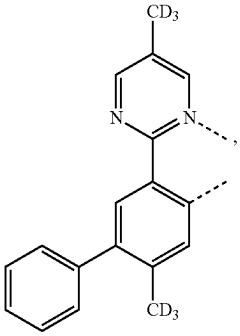

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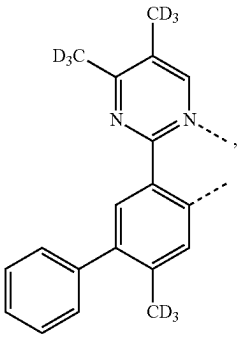

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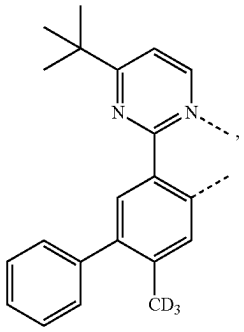

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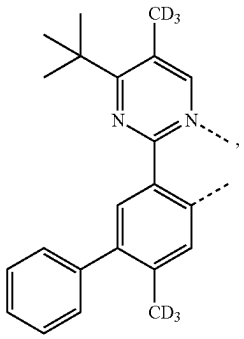

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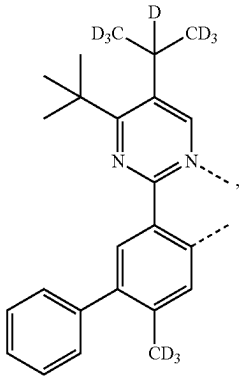

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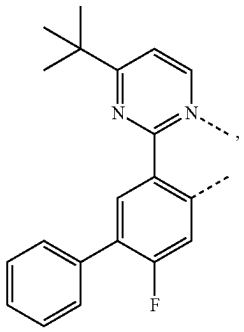

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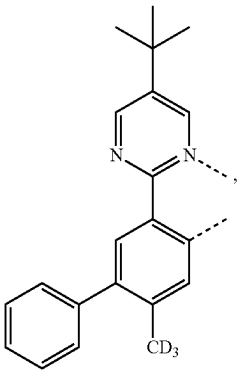

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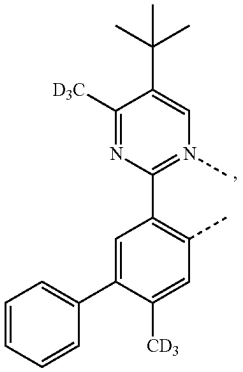

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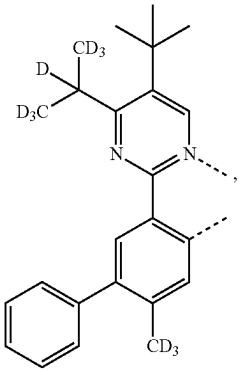

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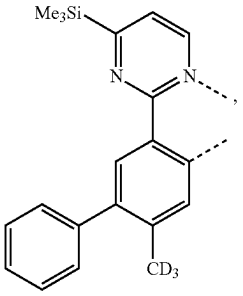

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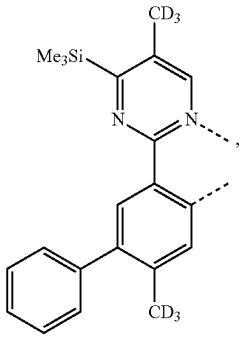

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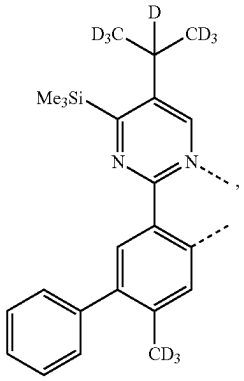

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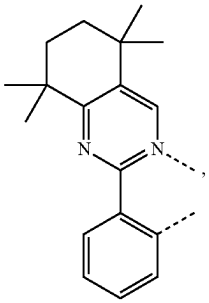

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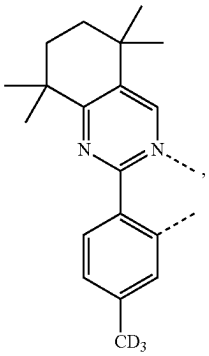

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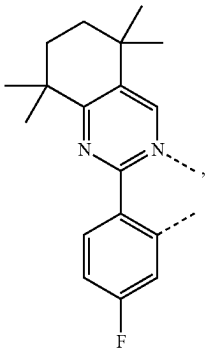

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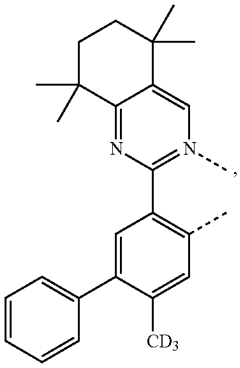

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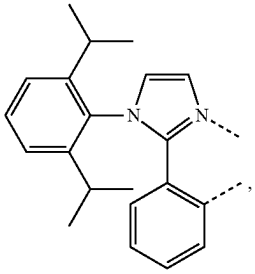

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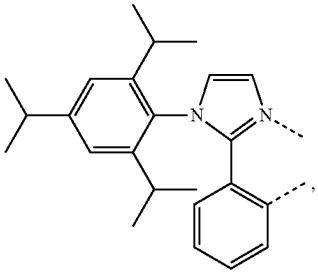

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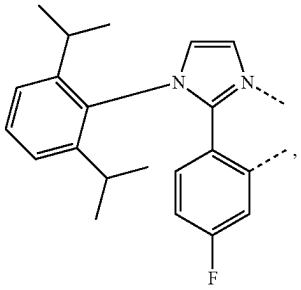

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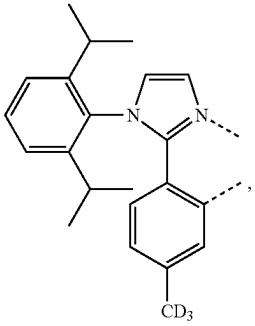

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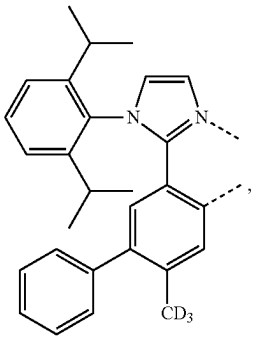

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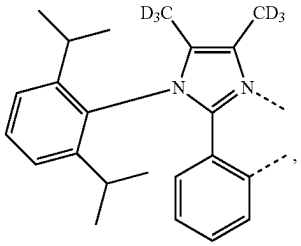

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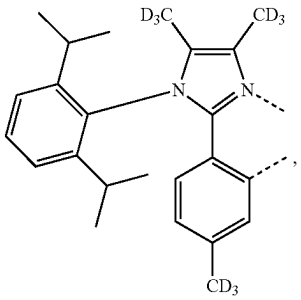

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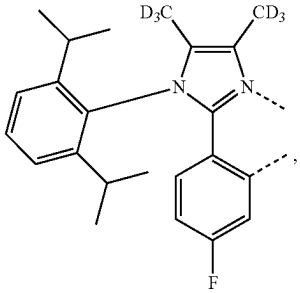

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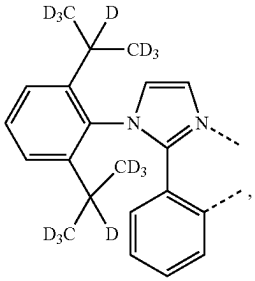

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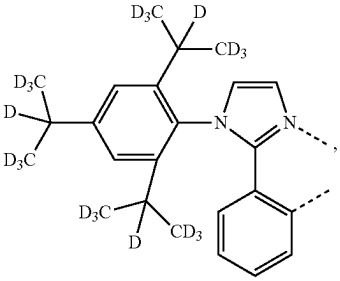

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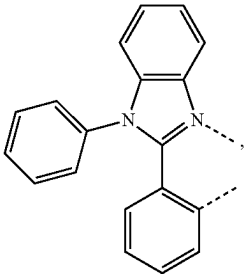

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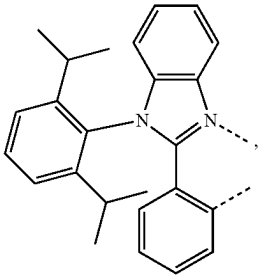

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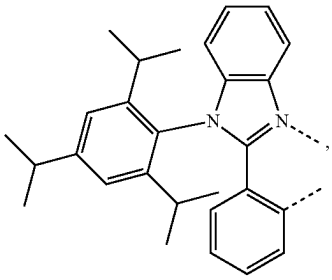

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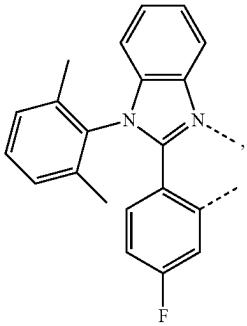

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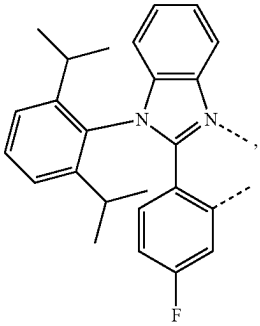

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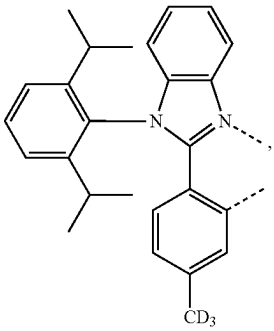

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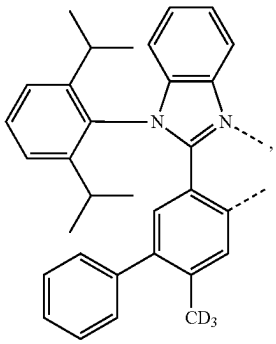

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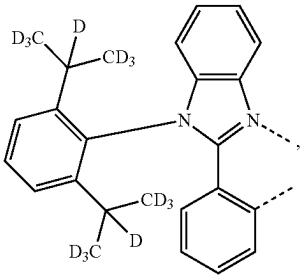

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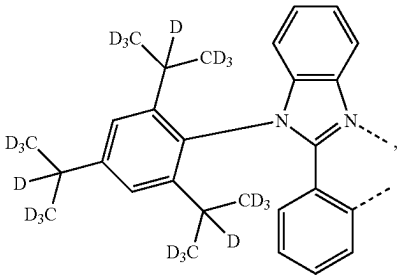

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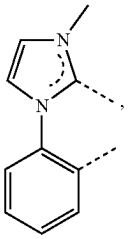

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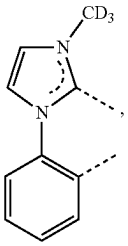

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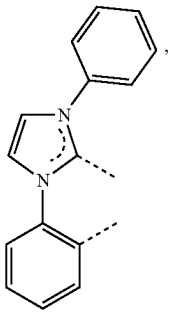
L_{B525}



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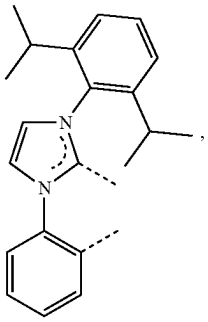

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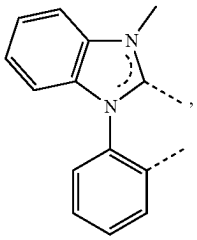

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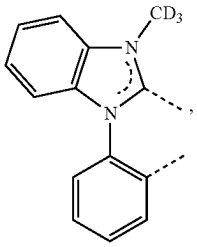

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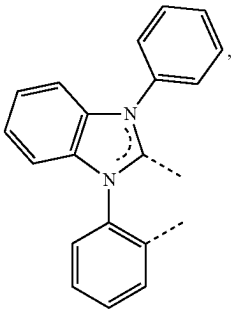
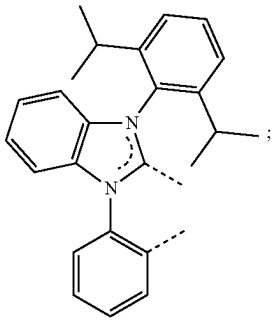
L_{B531}

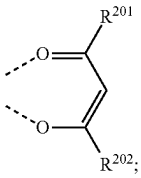


and

L_{B532}

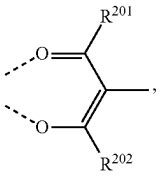


wherein each $L_{Cj\text{-}I}$ has a structure based on formula



and

each $L_{Cj\text{-}II}$ has a structure based on formula



wherein for each L_{Cj} in $L_{Cj\text{-}I}$ and $L_{Cj\text{-}II}$, R^{201} and R^{202} are defined as follows:

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C1}	R^{D1}	R^{D1}	L_{C193}	R^{D1}	R^{D3}	L_{C385}	R^{D17}	R^{D40}	L_{C577}	R^{D143}	R^{D120}
L_{C2}	R^{D2}	R^{D2}	L_{C194}	R^{D1}	R^{D4}	L_{C386}	R^{D17}	R^{D41}	L_{C578}	R^{D143}	R^{D133}
L_{C3}	R^{D3}	R^{D3}	L_{C195}	R^{D1}	R^{D5}	L_{C387}	R^{D17}	R^{D42}	L_{C579}	R^{D143}	R^{D134}
L_{C4}	R^{D4}	R^{D4}	L_{C196}	R^{D1}	R^{D9}	L_{C388}	R^{D17}	R^{D43}	L_{C580}	R^{D143}	R^{D135}
L_{C5}	R^{D5}	R^{D5}	L_{C197}	R^{D1}	R^{D10}	L_{C389}	R^{D17}	R^{D48}	L_{C581}	R^{D143}	R^{D136}
L_{C6}	R^{D6}	R^{D6}	L_{C198}	R^{D1}	R^{D17}	L_{C390}	R^{D17}	R^{D49}	L_{C582}	R^{D143}	R^{D144}
L_{C7}	R^{D7}	R^{D7}	L_{C199}	R^{D1}	R^{D18}	L_{C391}	R^{D17}	R^{D50}	L_{C583}	R^{D143}	R^{D145}
L_{C8}	R^{D8}	R^{D8}	L_{C200}	R^{D1}	R^{D20}	L_{C392}	R^{D17}	R^{D54}	L_{C584}	R^{D143}	R^{D146}
L_{C9}	R^{D9}	R^{D9}	L_{C201}	R^{D1}	R^{D22}	L_{C393}	R^{D17}	R^{D55}	L_{C585}	R^{D143}	R^{D147}
L_{C10}	R^{D10}	R^{D10}	L_{C202}	R^{D1}	R^{D37}	L_{C394}	R^{D17}	R^{D58}	L_{C586}	R^{D143}	R^{D149}
L_{C11}	R^{D11}	R^{D11}	L_{C203}	R^{D1}	R^{D40}	L_{C395}	R^{D17}	R^{D59}	L_{C587}	R^{D143}	R^{D151}
L_{C12}	R^{D12}	R^{D12}	L_{C204}	R^{D1}	R^{D41}	L_{C396}	R^{D17}	R^{D78}	L_{C588}	R^{D143}	R^{D154}
L_{C13}	R^{D13}	R^{D13}	L_{C205}	R^{D1}	R^{D42}	L_{C397}	R^{D17}	R^{D79}	L_{C589}	R^{D143}	R^{D155}
L_{C14}	R^{D14}	R^{D14}	L_{C206}	R^{D1}	R^{D43}	L_{C398}	R^{D17}	R^{D81}	L_{C590}	R^{D143}	R^{D161}
L_{C15}	R^{D15}	R^{D15}	L_{C207}	R^{D1}	R^{D48}	L_{C399}	R^{D17}	R^{D87}	L_{C591}	R^{D143}	R^{D175}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C16}	R^{D16}	R^{D16}	L_{C208}	R^{D1}	R^{D49}	L_{C400}	R^{D17}	R^{D88}	L_{C592}	R^{D144}	R^{D3}
L_{C17}	R^{D17}	R^{D17}	L_{C209}	R^{D1}	R^{D50}	L_{C401}	R^{D17}	R^{D89}	L_{C593}	R^{D144}	R^{D5}
L_{C18}	R^{D18}	R^{D18}	L_{C210}	R^{D1}	R^{D54}	L_{C402}	R^{D17}	R^{D93}	L_{C594}	R^{D144}	R^{D17}
L_{C19}	R^{D19}	R^{D19}	L_{C211}	R^{D1}	R^{D55}	L_{C403}	R^{D17}	R^{D116}	L_{C595}	R^{D144}	R^{D18}
L_{C20}	R^{D20}	R^{D20}	L_{C212}	R^{D1}	R^{D58}	L_{C404}	R^{D17}	R^{D117}	L_{C596}	R^{D144}	R^{D20}
L_{C21}	R^{D21}	R^{D21}	L_{C213}	R^{D1}	R^{D59}	L_{C405}	R^{D17}	R^{D118}	L_{C597}	R^{D144}	R^{D22}
L_{C22}	R^{D22}	R^{D22}	L_{C214}	R^{D1}	R^{D78}	L_{C406}	R^{D17}	R^{D119}	L_{C598}	R^{D144}	R^{D37}
L_{C23}	R^{D23}	R^{D23}	L_{C215}	R^{D1}	R^{D79}	L_{C407}	R^{D17}	R^{D120}	L_{C599}	R^{D144}	R^{D40}
L_{C24}	R^{D24}	R^{D24}	L_{C216}	R^{D1}	R^{D81}	L_{C408}	R^{D17}	R^{D133}	L_{C600}	R^{D144}	R^{D41}
L_{C25}	R^{D25}	R^{D25}	L_{C217}	R^{D1}	R^{D87}	L_{C409}	R^{D17}	R^{D134}	L_{C601}	R^{D144}	R^{D42}
L_{C26}	R^{D26}	R^{D26}	L_{C218}	R^{D1}	R^{D88}	L_{C410}	R^{D17}	R^{D135}	L_{C602}	R^{D144}	R^{D43}
L_{C27}	R^{D27}	R^{D27}	L_{C219}	R^{D1}	R^{D89}	L_{C411}	R^{D17}	R^{D136}	L_{C603}	R^{D144}	R^{D48}
L_{C28}	R^{D28}	R^{D28}	L_{C220}	R^{D1}	R^{D93}	L_{C412}	R^{D17}	R^{D143}	L_{C604}	R^{D144}	R^{D49}
L_{C29}	R^{D29}	R^{D29}	L_{C221}	R^{D1}	R^{D116}	L_{C413}	R^{D17}	R^{D144}	L_{C605}	R^{D144}	R^{D54}
L_{C30}	R^{D30}	R^{D30}	L_{C222}	R^{D1}	R^{D117}	L_{C414}	R^{D17}	R^{D145}	L_{C606}	R^{D144}	R^{D58}
L_{C31}	R^{D31}	R^{D31}	L_{C223}	R^{D1}	R^{D118}	L_{C415}	R^{D17}	R^{D146}	L_{C607}	R^{D144}	R^{D59}
L_{C32}	R^{D32}	R^{D32}	L_{C224}	R^{D1}	R^{D119}	L_{C416}	R^{D17}	R^{D147}	L_{C608}	R^{D144}	R^{D78}
L_{C33}	R^{D33}	R^{D33}	L_{C225}	R^{D1}	R^{D120}	L_{C417}	R^{D17}	R^{D149}	L_{C609}	R^{D144}	R^{D79}
L_{C34}	R^{D34}	R^{D34}	L_{C226}	R^{D1}	R^{D133}	L_{C418}	R^{D17}	R^{D151}	L_{C610}	R^{D144}	R^{D81}
L_{C35}	R^{D35}	R^{D35}	L_{C227}	R^{D1}	R^{D134}	L_{C419}	R^{D17}	R^{D154}	L_{C611}	R^{D144}	R^{D87}
L_{C36}	R^{D36}	R^{D36}	L_{C228}	R^{D1}	R^{D135}	L_{C420}	R^{D17}	R^{D155}	L_{C612}	R^{D144}	R^{D88}
L_{C37}	R^{D37}	R^{D37}	L_{C229}	R^{D1}	R^{D136}	L_{C421}	R^{D17}	R^{D161}	L_{C613}	R^{D144}	R^{D89}
L_{C38}	R^{D38}	R^{D38}	L_{C230}	R^{D1}	R^{D143}	L_{C422}	R^{D17}	R^{D175}	L_{C614}	R^{D144}	R^{D93}
L_{C39}	R^{D39}	R^{D39}	L_{C231}	R^{D1}	R^{D144}	L_{C423}	R^{D50}	R^{D3}	L_{C615}	R^{D144}	R^{D116}
L_{C40}	R^{D40}	R^{D40}	L_{C232}	R^{D1}	R^{D145}	L_{C424}	R^{D50}	R^{D5}	L_{C616}	R^{D144}	R^{D117}
L_{C41}	R^{D41}	R^{D41}	L_{C233}	R^{D1}	R^{D146}	L_{C425}	R^{D50}	R^{D18}	L_{C617}	R^{D144}	R^{D118}
L_{C42}	R^{D42}	R^{D42}	L_{C234}	R^{D1}	R^{D147}	L_{C426}	R^{D50}	R^{D20}	L_{C618}	R^{D144}	R^{D119}
L_{C43}	R^{D43}	R^{D43}	L_{C235}	R^{D1}	R^{D149}	L_{C427}	R^{D50}	R^{D22}	L_{C619}	R^{D144}	R^{D120}
L_{C44}	R^{D44}	R^{D44}	L_{C236}	R^{D1}	R^{D151}	L_{C428}	R^{D50}	R^{D37}	L_{C620}	R^{D144}	R^{D133}
L_{C45}	R^{D45}	R^{D45}	L_{C237}	R^{D1}	R^{D154}	L_{C429}	R^{D50}	R^{D40}	L_{C621}	R^{D144}	R^{D134}
L_{C46}	R^{D46}	R^{D46}	L_{C238}	R^{D1}	R^{D155}	L_{C430}	R^{D50}	R^{D41}	L_{C622}	R^{D144}	R^{D135}
L_{C47}	R^{D47}	R^{D47}	L_{C239}	R^{D1}	R^{D161}	L_{C431}	R^{D50}	R^{D42}	L_{C623}	R^{D144}	R^{D136}
L_{C48}	R^{D48}	R^{D48}	L_{C240}	R^{D1}	R^{D175}	L_{C432}	R^{D50}	R^{D43}	L_{C624}	R^{D144}	R^{D145}
L_{C49}	R^{D49}	R^{D49}	L_{C241}	R^{D4}	R^{D3}	L_{C433}	R^{D50}	R^{D48}	L_{C625}	R^{D144}	R^{D146}
L_{C50}	R^{D50}	R^{D50}	L_{C242}	R^{D4}	R^{D5}	L_{C434}	R^{D50}	R^{D49}	L_{C626}	R^{D144}	R^{D147}
L_{C51}	R^{D51}	R^{D51}	L_{C243}	R^{D4}	R^{D9}	L_{C435}	R^{D50}	R^{D54}	L_{C627}	R^{D144}	R^{D149}
L_{C52}	R^{D52}	R^{D52}	L_{C244}	R^{D4}	R^{D10}	L_{C436}	R^{D50}	R^{D55}	L_{C628}	R^{D144}	R^{D151}
L_{C53}	R^{D53}	R^{D53}	L_{C245}	R^{D4}	R^{D17}	L_{C437}	R^{D50}	R^{D58}	L_{C629}	R^{D144}	R^{D154}
L_{C54}	R^{D54}	R^{D54}	L_{C246}	R^{D4}	R^{D18}	L_{C438}	R^{D50}	R^{D59}	L_{C630}	R^{D144}	R^{D155}
L_{C55}	R^{D55}	R^{D55}	L_{C247}	R^{D4}	R^{D20}	L_{C439}	R^{D50}	R^{D78}	L_{C631}	R^{D144}	R^{D161}
L_{C56}	R^{D56}	R^{D56}	L_{C248}	R^{D4}	R^{D22}	L_{C440}	R^{D50}	R^{D79}	L_{C632}	R^{D144}	R^{D175}
L_{C57}	R^{D57}	R^{D57}	L_{C249}	R^{D4}	R^{D37}	L_{C441}	R^{D50}	R^{D81}	L_{C633}	R^{D145}	R^{D3}
L_{C58}	R^{D58}	R^{D58}	L_{C250}	R^{D4}	R^{D40}	L_{C442}	R^{D50}	R^{D87}	L_{C634}	R^{D145}	R^{D5}
L_{C59}	R^{D59}	R^{D59}	L_{C251}	R^{D4}	R^{D41}	L_{C443}	R^{D50}	R^{D88}	L_{C635}	R^{D145}	R^{D17}
L_{C60}	R^{D60}	R^{D60}	L_{C252}	R^{D4}	R^{D42}	L_{C444}	R^{D50}	R^{D89}	L_{C636}	R^{D145}	R^{D18}
L_{C61}	R^{D61}	R^{D61}	L_{C253}	R^{D4}	R^{D43}	L_{C445}	R^{D50}	R^{D93}	L_{C637}	R^{D145}	R^{D20}
L_{C62}	R^{D62}	R^{D62}	L_{C254}	R^{D4}	R^{D48}	L_{C446}	R^{D50}	R^{D116}	L_{C638}	R^{D145}	R^{D22}
L_{C63}	R^{D63}	R^{D63}	L_{C255}	R^{D4}	R^{D49}	L_{C447}	R^{D50}	R^{D117}	L_{C639}	R^{D145}	R^{D37}
L_{C64}	R^{D64}	R^{D64}	L_{C256}	R^{D4}	R^{D50}	L_{C448}	R^{D50}	R^{D118}	L_{C640}	R^{D145}	R^{D40}
L_{C65}	R^{D65}	R^{D65}	L_{C257}	R^{D4}	R^{D54}	L_{C449}	R^{D50}	R^{D119}	L_{C641}	R^{D145}	R^{D41}
L_{C66}	R^{D66}	R^{D66}	L_{C258}	R^{D4}	R^{D55}	L_{C450}	R^{D50}	R^{D120}	L_{C642}	R^{D145}	R^{D42}
L_{C67}	R^{D67}	R^{D67}	L_{C259}	R^{D4}	R^{D58}	L_{C451}	R^{D50}	R^{D133}	L_{C643}	R^{D145}	R^{D43}
L_{C68}	R^{D68}	R^{D68}	L_{C260}	R^{D4}	R^{D59}	L_{C452}	R^{D50}	R^{D134}	L_{C644}	R^{D145}	R^{D48}
L_{C69}	R^{D69}	R^{D69}	L_{C261}	R^{D4}	R^{D78}	L_{C453}	R^{D50}	R^{D135}	L_{C645}	R^{D145}	R^{D49}
L_{C70}	R^{D70}	R^{D70}	L_{C262}	R^{D4}	R^{D79}	L_{C454}	R^{D50}	R^{D136}	L_{C646}	R^{D145}	R^{D54}
L_{C71}	R^{D71}	R^{D71}	L_{C263}	R^{D4}	R^{D81}	L_{C455}	R^{D50}	R^{D143}	L_{C647}	R^{D145}	R^{D58}
L_{C72}	R^{D72}	R^{D72}	L_{C264}	R^{D4}	R^{D87}	L_{C456}	R^{D50}	R^{D144}	L_{C648}	R^{D145}	R^{D59}
L_{C73}	R^{D73}	R^{D73}	L_{C265}	R^{D4}	R^{D88}	L_{C457}	R^{D50}	R^{D145}	L_{C649}	R^{D145}	R^{D78}
L_{C74}	R^{D74}	R^{D74}	L_{C266}	R^{D4}	R^{D89}	L_{C458}	R^{D50}	R^{D146}	L_{C650}	R^{D145}	R^{D79}
L_{C75}	R^{D75}	R^{D75}	L_{C267}	R^{D4}	R^{D93}	L_{C459}	R^{D50}	R^{D147}	L_{C651}	R^{D145}	R^{D81}
L_{C76}	R^{D76}	R^{D76}	L_{C268}	R^{D4}	R^{D116}	L_{C460}	R^{D50}	R^{D149}	L_{C652}	R^{D145}	R^{D87}
L_{C77}	R^{D77}	R^{D77}	L_{C269}	R^{D4}	R^{D117}	L_{C461}	R^{D50}	R^{D151}	L_{C653}	R^{D145}	R^{D88}
L_{C78}	R^{D78}	R^{D78}	L_{C270}	R^{D4}	R^{D118}	L_{C462}	R^{D50}	R^{D154}	L_{C654}	R^{D145}	R^{D89}
L_{C79}	R^{D79}	R^{D79}	L_{C271}	R^{D4}	R^{D119}	L_{C463}	R^{D50}	R^{D155}	L_{C655}	R^{D145}	R^{D93}
L_{C80}	R^{D80}	R^{D80}	L_{C272}	R^{D4}	R^{D120}	L_{C464}	R^{D50}	R^{D161}	L_{C656}	R^{D145}	R^{D116}
L_{C81}	R^{D81}	R^{D81}	L_{C273}	R^{D4}	R^{D133}	L_{C465}	R^{D50}	R^{D175}	L_{C657}	R^{D145}	R^{D117}
L_{C82}	R^{D82}	R^{D82}	L_{C274}	R^{D4}	R^{D134}	L_{C466}	R^{D55}	R^{D3}	L_{C658}	R^{D145}	R^{D118}
L_{C83}	R^{D83}	R^{D83}	L_{C275}	R^{D4}	R^{D135}	L_{C467}	R^{D55}	R^{D5}	L_{C659}	R^{D145}	R^{D119}
L_{C84}	R^{D84}	R^{D84}	L_{C276}	R^{D4}	R^{D136}	L_{C468}	R^{D55}	R^{D18}	L_{C660}	R^{D145}	R^{D120}
L_{C85}	R^{D85}	R^{D85}	L_{C277}	R^{D4}	R^{D143}	L_{C469}	R^{D55}	R^{D20}	L_{C661}	R^{D145}	R^{D133}
L_{C86}	R^{D86}	R^{D86}	L_{C278}	R^{D4}	R^{D144}	L_{C470}	R^{D55}	R^{D22}	L_{C662}	R^{D145}	R^{D134}
L_{C87}	R^{D87}	R^{D87}	L_{C279}	R^{D4}	R^{D145}	L_{C471}	R^{D55}	R^{D37}	L_{C663}	R^{D145}	R^{D135}
L_{C88}	R^{D88}	R^{D88}	L_{C280}	R^{D4}	R^{D146}	L_{C472}	R^{D55}	R^{D40}	L_{C664}	R^{D145}	R^{D136}
L_{C89}	R^{D89}	R^{D89}	L_{C281}	R^{D4}	R^{D147}	L_{C473}	R^{D55}	R^{D41}	L_{C665}	R^{D145}	R^{D146}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C90}	R^{D90}	R^{D90}	L_{C282}	R^{D4}	R^{D149}	L_{C474}	R^{D55}	R^{D42}	L_{C666}	R^{D145}	R^{D147}
L_{C91}	R^{D91}	R^{D91}	L_{C283}	R^{D4}	R^{D151}	L_{C475}	R^{D55}	R^{D43}	L_{C667}	R^{D145}	R^{D149}
L_{C92}	R^{D92}	R^{D92}	L_{C284}	R^{D4}	R^{D154}	L_{C476}	R^{D55}	R^{D48}	L_{C668}	R^{D145}	R^{D151}
L_{C93}	R^{D93}	R^{D93}	L_{C285}	R^{D4}	R^{D155}	L_{C477}	R^{D55}	R^{D49}	L_{C669}	R^{D145}	R^{D154}
L_{C94}	R^{D94}	R^{D94}	L_{C286}	R^{D4}	R^{D161}	L_{C478}	R^{D55}	R^{D54}	L_{C670}	R^{D145}	R^{D155}
L_{C95}	R^{D95}	R^{D95}	L_{C287}	R^{D4}	R^{D175}	L_{C479}	R^{D55}	R^{D58}	L_{C671}	R^{D145}	R^{D161}
L_{C96}	R^{D96}	R^{D96}	L_{C288}	R^{D9}	R^{D3}	L_{C480}	R^{D55}	R^{D59}	L_{C672}	R^{D145}	R^{D175}
L_{C97}	R^{D97}	R^{D97}	L_{C289}	R^{D9}	R^{D5}	L_{C481}	R^{D55}	R^{D78}	L_{C673}	R^{D146}	R^{D3}
L_{C98}	R^{D98}	R^{D98}	L_{C290}	R^{D9}	R^{D10}	L_{C482}	R^{D55}	R^{D79}	L_{C674}	R^{D146}	R^{D5}
L_{C99}	R^{D99}	R^{D99}	L_{C291}	R^{D9}	R^{D17}	L_{C483}	R^{D55}	R^{D81}	L_{C675}	R^{D146}	R^{D17}
L_{C100}	R^{D100}	R^{D100}	L_{C292}	R^{D9}	R^{D18}	L_{C484}	R^{D55}	R^{D87}	L_{C676}	R^{D146}	R^{D18}
L_{C101}	R^{D101}	R^{D101}	L_{C293}	R^{D9}	R^{D20}	L_{C485}	R^{D55}	R^{D88}	L_{C677}	R^{D146}	R^{D20}
L_{C102}	R^{D102}	R^{D102}	L_{C294}	R^{D9}	R^{D22}	L_{C486}	R^{D55}	R^{D89}	L_{C678}	R^{D146}	R^{D22}
L_{C103}	R^{D103}	R^{D103}	L_{C295}	R^{D9}	R^{D37}	L_{C487}	R^{D55}	R^{D93}	L_{C679}	R^{D146}	R^{D37}
L_{C104}	R^{D104}	R^{D104}	L_{C296}	R^{D9}	R^{D40}	L_{C488}	R^{D55}	R^{D116}	L_{C680}	R^{D146}	R^{D40}
L_{C105}	R^{D105}	R^{D105}	L_{C297}	R^{D9}	R^{D41}	L_{C489}	R^{D55}	R^{D117}	L_{C681}	R^{D146}	R^{D41}
L_{C106}	R^{D106}	R^{D106}	L_{C298}	R^{D9}	R^{D42}	L_{C490}	R^{D55}	R^{D118}	L_{C682}	R^{D146}	R^{D42}
L_{C107}	R^{D107}	R^{D107}	L_{C299}	R^{D9}	R^{D43}	L_{C491}	R^{D55}	R^{D119}	L_{C683}	R^{D146}	R^{D43}
L_{C108}	R^{D108}	R^{D108}	L_{C300}	R^{D9}	R^{D48}	L_{C492}	R^{D55}	R^{D120}	L_{C684}	R^{D146}	R^{D48}
L_{C109}	R^{D109}	R^{D109}	L_{C301}	R^{D9}	R^{D49}	L_{C493}	R^{D55}	R^{D133}	L_{C685}	R^{D146}	R^{D49}
L_{C110}	R^{D110}	R^{D110}	L_{C302}	R^{D9}	R^{D50}	L_{C494}	R^{D55}	R^{D134}	L_{C686}	R^{D146}	R^{D54}
L_{C111}	R^{D111}	R^{D111}	L_{C303}	R^{D9}	R^{D54}	L_{C495}	R^{D55}	R^{D135}	L_{C687}	R^{D146}	R^{D58}
L_{C112}	R^{D112}	R^{D112}	L_{C304}	R^{D9}	R^{D55}	L_{C496}	R^{D55}	R^{D136}	L_{C688}	R^{D146}	R^{D59}
L_{C113}	R^{D113}	R^{D113}	L_{C305}	R^{D9}	R^{D58}	L_{C497}	R^{D55}	R^{D143}	L_{C689}	R^{D146}	R^{D78}
L_{C114}	R^{D114}	R^{D114}	L_{C306}	R^{D9}	R^{D59}	L_{C498}	R^{D55}	R^{D144}	L_{C690}	R^{D146}	R^{D79}
L_{C115}	R^{D115}	R^{D115}	L_{C307}	R^{D9}	R^{D78}	L_{C499}	R^{D55}	R^{D145}	L_{C691}	R^{D146}	R^{D81}
L_{C116}	R^{D116}	R^{D116}	L_{C308}	R^{D9}	R^{D79}	L_{C500}	R^{D55}	R^{D146}	L_{C692}	R^{D146}	R^{D87}
L_{C117}	R^{D117}	R^{D117}	L_{C309}	R^{D9}	R^{D81}	L_{C501}	R^{D55}	R^{D147}	L_{C693}	R^{D146}	R^{D88}
L_{C118}	R^{D118}	R^{D118}	L_{C310}	R^{D9}	R^{D87}	L_{C502}	R^{D55}	R^{D149}	L_{C694}	R^{D146}	R^{D89}
L_{C119}	R^{D119}	R^{D119}	L_{C311}	R^{D9}	R^{D88}	L_{C503}	R^{D55}	R^{D151}	L_{C695}	R^{D146}	R^{D93}
L_{C120}	R^{D120}	R^{D120}	L_{C312}	R^{D9}	R^{D89}	L_{C504}	R^{D55}	R^{D154}	L_{C696}	R^{D146}	R^{D117}
L_{C121}	R^{D121}	R^{D121}	L_{C313}	R^{D9}	R^{D93}	L_{C505}	R^{D55}	R^{D155}	L_{C697}	R^{D146}	R^{D118}
L_{C122}	R^{D122}	R^{D122}	L_{C314}	R^{D9}	R^{D116}	L_{C506}	R^{D55}	R^{D161}	L_{C698}	R^{D146}	R^{D119}
L_{C123}	R^{D123}	R^{D123}	L_{C315}	R^{D9}	R^{D117}	L_{C507}	R^{D55}	R^{D175}	L_{C699}	R^{D146}	R^{D120}
L_{C124}	R^{D124}	R^{D124}	L_{C316}	R^{D9}	R^{D118}	L_{C508}	R^{D116}	R^{D3}	L_{C700}	R^{D146}	R^{D133}
L_{C125}	R^{D125}	R^{D125}	L_{C317}	R^{D9}	R^{D119}	L_{C509}	R^{D116}	R^{D5}	L_{C701}	R^{D146}	R^{D134}
L_{C126}	R^{D126}	R^{D126}	L_{C318}	R^{D9}	R^{D120}	L_{C510}	R^{D116}	R^{D17}	L_{C702}	R^{D146}	R^{D135}
L_{C127}	R^{D127}	R^{D127}	L_{C319}	R^{D9}	R^{D133}	L_{C511}	R^{D116}	R^{D18}	L_{C703}	R^{D146}	R^{D136}
L_{C128}	R^{D128}	R^{D128}	L_{C320}	R^{D9}	R^{D134}	L_{C512}	R^{D116}	R^{D20}	L_{C704}	R^{D146}	R^{D146}
L_{C129}	R^{D129}	R^{D129}	L_{C321}	R^{D9}	R^{D135}	L_{C513}	R^{D116}	R^{D22}	L_{C705}	R^{D146}	R^{D147}
L_{C130}	R^{D130}	R^{D130}	L_{C322}	R^{D9}	R^{D136}	L_{C514}	R^{D116}	R^{D37}	L_{C706}	R^{D146}	R^{D149}
L_{C131}	R^{D131}	R^{D131}	L_{C323}	R^{D9}	R^{D143}	L_{C515}	R^{D116}	R^{D40}	L_{C707}	R^{D146}	R^{D151}
L_{C132}	R^{D132}	R^{D132}	L_{C324}	R^{D9}	R^{D144}	L_{C516}	R^{D116}	R^{D41}	L_{C708}	R^{D146}	R^{D154}
L_{C133}	R^{D133}	R^{D133}	L_{C325}	R^{D9}	R^{D145}	L_{C517}	R^{D116}	R^{D42}	L_{C709}	R^{D146}	R^{D155}
L_{C134}	R^{D134}	R^{D134}	L_{C326}	R^{D9}	R^{D146}	L_{C518}	R^{D116}	R^{D43}	L_{C710}	R^{D146}	R^{D161}
L_{C135}	R^{D135}	R^{D135}	L_{C327}	R^{D9}	R^{D147}	L_{C519}	R^{D116}	R^{D48}	L_{C711}	R^{D146}	R^{D175}
L_{C136}	R^{D136}	R^{D136}	L_{C328}	R^{D9}	R^{D149}	L_{C520}	R^{D116}	R^{D49}	L_{C712}	R^{D133}	R^{D3}
L_{C137}	R^{D137}	R^{D137}	L_{C329}	R^{D9}	R^{D151}	L_{C521}	R^{D116}	R^{D54}	L_{C713}	R^{D133}	R^{D5}
L_{C138}	R^{D138}	R^{D138}	L_{C330}	R^{D9}	R^{D154}	L_{C522}	R^{D116}	R^{D58}	L_{C714}	R^{D133}	R^{D3}
L_{C139}	R^{D139}	R^{D139}	L_{C331}	R^{D9}	R^{D155}	L_{C523}	R^{D116}	R^{D59}	L_{C715}	R^{D133}	R^{D18}
L_{C140}	R^{D140}	R^{D140}	L_{C332}	R^{D9}	R^{D161}	L_{C524}	R^{D116}	R^{D78}	L_{C716}	R^{D133}	R^{D20}
L_{C141}	R^{D141}	R^{D141}	L_{C333}	R^{D9}	R^{D175}	L_{C525}	R^{D116}	R^{D79}	L_{C717}	R^{D133}	R^{D22}
L_{C142}	R^{D142}	R^{D142}	L_{C334}	R^{D10}	R^{D3}	L_{C526}	R^{D116}	R^{D81}	L_{C718}	R^{D133}	R^{D37}
L_{C143}	R^{D143}	R^{D143}	L_{C335}	R^{D10}	R^{D5}	L_{C527}	R^{D116}	R^{D87}	L_{C719}	R^{D133}	R^{D40}
L_{C144}	R^{D144}	R^{D144}	L_{C336}	R^{D10}	R^{D17}	L_{C528}	R^{D116}	R^{D88}	L_{C720}	R^{D133}	R^{D41}
L_{C145}	R^{D145}	R^{D145}	L_{C337}	R^{D10}	R^{D18}	L_{C529}	R^{D116}	R^{D89}	L_{C721}	R^{D133}	R^{D42}
L_{C146}	R^{D146}	R^{D146}	L_{C338}	R^{D10}	R^{D20}	L_{C530}	R^{D116}	R^{D93}	L_{C722}	R^{D133}	R^{D43}
L_{C147}	R^{D147}	R^{D147}	L_{C339}	R^{D10}	R^{D22}	L_{C531}	R^{D116}	R^{D117}	L_{C723}	R^{D133}	R^{D48}
L_{C148}	R^{D148}	R^{D148}	L_{C340}	R^{D10}	R^{D37}	L_{C532}	R^{D116}	R^{D118}	L_{C724}	R^{D133}	R^{D49}
L_{C149}	R^{D149}	R^{D149}	L_{C341}	R^{D10}	R^{D40}	L_{C533}	R^{D116}	R^{D119}	L_{C725}	R^{D133}	R^{D54}
L_{C150}	R^{D150}	R^{D150}	L_{C342}	R^{D10}	R^{D41}	L_{C534}	R^{D116}	R^{D120}	L_{C726}	R^{D133}	R^{D58}
L_{C151}	R^{D151}	R^{D151}	L_{C343}	R^{D10}	R^{D42}	L_{C535}	R^{D116}	R^{D133}	L_{C727}	R^{D133}	R^{D59}
L_{C152}	R^{D152}	R^{D152}	L_{C344}	R^{D10}	R^{D43}	L_{C536}	R^{D116}	R^{D134}	L_{C728}	R^{D133}	R^{D78}
L_{C153}	R^{D153}	R^{D153}	L_{C345}	R^{D10}	R^{D48}	L_{C537}	R^{D116}	R^{D135}	L_{C729}	R^{D133}	R^{D79}
L_{C154}	R^{D154}	R^{D154}	L_{C346}	R^{D10}	R^{D49}	L_{C538}	R^{D116}	R^{D136}	L_{C730}	R^{D133}	R^{D81}
L_{C155}	R^{D155}	R^{D155}	L_{C347}	R^{D10}	R^{D50}	L_{C539}	R^{D116}	R^{D143}	L_{C731}	R^{D133}	R^{D87}
L_{C156}	R^{D156}	R^{D156}	L_{C348}	R^{D10}	R^{D54}	L_{C540}	R^{D116}	R^{D144}	L_{C732}	R^{D133}	R^{D88}
L_{C157}	R^{D157}	R^{D157}	L_{C349}	R^{D10}	R^{D55}	L_{C541}	R^{D116}	R^{D145}	L_{C733}	R^{D133}	R^{D89}
L_{C158}	R^{D158}	R^{D158}	L_{C350}	R^{D10}	R^{D58}	L_{C542}	R^{D116}	R^{D146}	L_{C734}	R^{D133}	R^{D93}
L_{C159}	R^{D159}	R^{D159}	L_{C351}	R^{D10}	R^{D59}	L_{C543}	R^{D116}	R^{D147}	L_{C735}	R^{D133}	R^{D117}
L_{C160}	R^{D160}	R^{D160}	L_{C352}	R^{D10}	R^{D78}	L_{C544}	R^{D116}	R^{D149}	L_{C736}	R^{D133}	R^{D118}
L_{C161}	R^{D161}	R^{D161}	L_{C353}	R^{D10}	R^{D79}	L_{C545}	R^{D116}	R^{D151}	L_{C737}	R^{D133}	R^{D119}
L_{C162}	R^{D162}	R^{D162}	L_{C354}	R^{D10}	R^{D81}	L_{C546}	R^{D116}	R^{D154}	L_{C738}	R^{D133}	R^{D120}
L_{C163}	R^{D163}	R^{D163}	L_{C355}	R^{D10}	R^{D87}	L_{C547}	R^{D116}	R^{D155}	L_{C739}	R^{D133}	R^{D133}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C164}	R^{D164}	R^{D164}	L_{C356}	R^{D10}	R^{D88}	L_{C548}	R^{D116}	R^{D161}	L_{C740}	R^{D133}	R^{D134}
L_{C165}	R^{D165}	R^{D165}	L_{C357}	R^{D10}	R^{D89}	L_{C549}	R^{D116}	R^{D175}	L_{C741}	R^{D133}	R^{D135}
L_{C166}	R^{D166}	R^{D166}	L_{C358}	R^{D10}	R^{D93}	L_{C550}	R^{D143}	R^{D3}	L_{C742}	R^{D133}	R^{D136}
L_{C167}	R^{D167}	R^{D167}	L_{C359}	R^{D10}	R^{D116}	L_{C551}	R^{D143}	R^{D5}	L_{C743}	R^{D133}	R^{D146}
L_{C168}	R^{D168}	R^{D168}	L_{C360}	R^{D10}	R^{D117}	L_{C552}	R^{D143}	R^{D17}	L_{C744}	R^{D133}	R^{D147}
L_{C169}	R^{D169}	R^{D169}	L_{C361}	R^{D10}	R^{D118}	L_{C553}	R^{D143}	R^{D18}	L_{C745}	R^{D133}	R^{D149}
L_{C170}	R^{D170}	R^{D170}	L_{C362}	R^{D10}	R^{D119}	L_{C554}	R^{D143}	R^{D20}	L_{C746}	R^{D133}	R^{D151}
L_{C171}	R^{D171}	R^{D171}	L_{C363}	R^{D10}	R^{D120}	L_{C555}	R^{D143}	R^{D22}	L_{C747}	R^{D133}	R^{D154}
L_{C172}	R^{D172}	R^{D172}	L_{C364}	R^{D10}	R^{D133}	L_{C556}	R^{D143}	R^{D37}	L_{C748}	R^{D133}	R^{D155}
L_{C173}	R^{D173}	R^{D173}	L_{C365}	R^{D10}	R^{D134}	L_{C557}	R^{D143}	R^{D40}	L_{C749}	R^{D133}	R^{D161}
L_{C174}	R^{D174}	R^{D174}	L_{C366}	R^{D10}	R^{D135}	L_{C558}	R^{D143}	R^{D41}	L_{C750}	R^{D133}	R^{D175}
L_{C175}	R^{D175}	R^{D175}	L_{C367}	R^{D10}	R^{D136}	L_{C559}	R^{D143}	R^{D42}	L_{C751}	R^{D175}	R^{D3}
L_{C176}	R^{D176}	R^{D176}	L_{C368}	R^{D10}	R^{D143}	L_{C560}	R^{D143}	R^{D43}	L_{C752}	R^{D175}	R^{D5}
L_{C177}	R^{D177}	R^{D177}	L_{C369}	R^{D10}	R^{D144}	L_{C561}	R^{D143}	R^{D48}	L_{C753}	R^{D175}	R^{D18}
L_{C178}	R^{D178}	R^{D178}	L_{C370}	R^{D10}	R^{D145}	L_{C562}	R^{D143}	R^{D49}	L_{C754}	R^{D175}	R^{D20}
L_{C179}	R^{D179}	R^{D179}	L_{C371}	R^{D10}	R^{D146}	L_{C563}	R^{D143}	R^{D54}	L_{C755}	R^{D175}	R^{D22}
L_{C180}	R^{D180}	R^{D180}	L_{C372}	R^{D10}	R^{D147}	L_{C564}	R^{D143}	R^{D58}	L_{C756}	R^{D175}	R^{D37}
L_{C181}	R^{D181}	R^{D181}	L_{C373}	R^{D10}	R^{D149}	L_{C565}	R^{D143}	R^{D59}	L_{C757}	R^{D175}	R^{D40}
L_{C182}	R^{D182}	R^{D182}	L_{C374}	R^{D10}	R^{D151}	L_{C566}	R^{D143}	R^{D78}	L_{C758}	R^{D175}	R^{D41}
L_{C183}	R^{D183}	R^{D183}	L_{C375}	R^{D10}	R^{D154}	L_{C567}	R^{D143}	R^{D79}	L_{C759}	R^{D175}	R^{D42}
L_{C184}	R^{D184}	R^{D184}	L_{C376}	R^{D10}	R^{D155}	L_{C568}	R^{D143}	R^{D81}	L_{C760}	R^{D175}	R^{D43}
L_{C185}	R^{D185}	R^{D185}	L_{C377}	R^{D10}	R^{D161}	L_{C569}	R^{D143}	R^{D87}	L_{C761}	R^{D175}	R^{D48}
L_{C186}	R^{D186}	R^{D186}	L_{C378}	R^{D10}	R^{D175}	L_{C570}	R^{D143}	R^{D88}	L_{C762}	R^{D175}	R^{D49}
L_{C187}	R^{D187}	R^{D187}	L_{C379}	R^{D17}	R^{D3}	L_{C571}	R^{D143}	R^{D89}	L_{C763}	R^{D175}	R^{D54}
L_{C188}	R^{D188}	R^{D188}	L_{C380}	R^{D17}	R^{D5}	L_{C572}	R^{D143}	R^{D93}	L_{C764}	R^{D175}	R^{D58}
L_{C189}	R^{D189}	R^{D189}	L_{C381}	R^{D17}	R^{D18}	L_{C573}	R^{D143}	R^{D116}	L_{C765}	R^{D175}	R^{D59}
L_{C190}	R^{D190}	R^{D190}	L_{C382}	R^{D17}	R^{D20}	L_{C574}	R^{D143}	R^{D117}	L_{C766}	R^{D175}	R^{D78}
L_{C191}	R^{D191}	R^{D191}	L_{C383}	R^{D17}	R^{D22}	L_{C575}	R^{D143}	R^{D118}	L_{C767}	R^{D175}	R^{D79}
L_{C192}	R^{D192}	R^{D192}	L_{C384}	R^{D17}	R^{D37}	L_{C576}	R^{D143}	R^{D119}	L_{C768}	R^{D175}	R^{D81}
L_{C769}	R^{D193}	R^{D193}	L_{C877}	R^{D1}	R^{D193}	L_{C985}	R^{D4}	R^{D193}	L_{C1093}	R^{D9}	R^{D193}
L_{C770}	R^{D194}	R^{D194}	L_{C878}	R^{D1}	R^{D194}	L_{C986}	R^{D4}	R^{D194}	L_{C1094}	R^{D9}	R^{D194}
L_{C771}	R^{D195}	R^{D195}	L_{C879}	R^{D1}	R^{D195}	L_{C987}	R^{D4}	R^{D195}	L_{C1095}	R^{D9}	R^{D195}
L_{C772}	R^{D196}	R^{D196}	L_{C880}	R^{D1}	R^{D196}	L_{C988}	R^{D4}	R^{D196}	L_{C1096}	R^{D9}	R^{D196}
L_{C773}	R^{D197}	R^{D197}	L_{C881}	R^{D1}	R^{D197}	L_{C989}	R^{D4}	R^{D197}	L_{C1097}	R^{D9}	R^{D197}
L_{C774}	R^{D198}	R^{D198}	L_{C882}	R^{D1}	R^{D198}	L_{C990}	R^{D4}	R^{D198}	L_{C1098}	R^{D9}	R^{D198}
L_{C775}	R^{D199}	R^{D199}	L_{C883}	R^{D1}	R^{D199}	L_{C991}	R^{D4}	R^{D199}	L_{C1099}	R^{D9}	R^{D199}
L_{C776}	R^{D200}	R^{D200}	L_{C884}	R^{D1}	R^{D200}	L_{C992}	R^{D4}	R^{D200}	L_{C1100}	R^{D9}	R^{D200}
L_{C777}	R^{D201}	R^{D201}	L_{C885}	R^{D1}	R^{D201}	L_{C993}	R^{D4}	R^{D201}	L_{C1101}	R^{D9}	R^{D201}
L_{C778}	R^{D202}	R^{D202}	L_{C886}	R^{D1}	R^{D202}	L_{C994}	R^{D4}	R^{D202}	L_{C1102}	R^{D9}	R^{D202}
L_{C779}	R^{D203}	R^{D203}	L_{C887}	R^{D1}	R^{D203}	L_{C995}	R^{D4}	R^{D203}	L_{C1103}	R^{D9}	R^{D203}
L_{C780}	R^{D204}	R^{D204}	L_{C888}	R^{D1}	R^{D204}	L_{C996}	R^{D4}	R^{D204}	L_{C1104}	R^{D9}	R^{D204}
L_{C781}	R^{D205}	R^{D205}	L_{C889}	R^{D1}	R^{D205}	L_{C997}	R^{D4}	R^{D205}	L_{C1105}	R^{D9}	R^{D205}
L_{C782}	R^{D206}	R^{D206}	L_{C890}	R^{D1}	R^{D206}	L_{C998}	R^{D4}	R^{D206}	L_{C1106}	R^{D9}	R^{D206}
L_{C783}	R^{D207}	R^{D207}	L_{C891}	R^{D1}	R^{D207}	L_{C999}	R^{D4}	R^{D207}	L_{C1107}	R^{D9}	R^{D207}
L_{C784}	R^{D208}	R^{D208}	L_{C892}	R^{D1}	R^{D208}	L_{C1000}	R^{D4}	R^{D208}	L_{C1108}	R^{D9}	R^{D208}
L_{C785}	R^{D209}	R^{D209}	L_{C893}	R^{D1}	R^{D209}	L_{C1001}	R^{D4}	R^{D209}	L_{C1109}	R^{D9}	R^{D209}
L_{C786}	R^{D210}	R^{D210}	L_{C894}	R^{D1}	R^{D210}	L_{C1002}	R^{D4}	R^{D210}	L_{C1110}	R^{D9}	R^{D210}
L_{C787}	R^{D211}	R^{D211}	L_{C895}	R^{D1}	R^{D211}	L_{C1003}	R^{D4}	R^{D211}	L_{C1111}	R^{D9}	R^{D211}
L_{C788}	R^{D212}	R^{D212}	L_{C896}	R^{D1}	R^{D212}	L_{C1004}	R^{D4}	R^{D212}	L_{C1112}	R^{D9}	R^{D212}
L_{C789}	R^{D213}	R^{D213}	L_{C897}	R^{D1}	R^{D213}	L_{C1005}	R^{D4}	R^{D213}	L_{C1113}	R^{D9}	R^{D213}
L_{C790}	R^{D214}	R^{D214}	L_{C898}	R^{D1}	R^{D214}	L_{C1006}	R^{D4}	R^{D214}	L_{C1114}	R^{D9}	R^{D214}
L_{C791}	R^{D215}	R^{D215}	L_{C899}	R^{D1}	R^{D215}	L_{C1007}	R^{D4}	R^{D215}	L_{C1115}	R^{D9}	R^{D215}
L_{C792}	R^{D216}	R^{D216}	L_{C900}	R^{D1}	R^{D216}	L_{C1008}	R^{D4}	R^{D216}	L_{C1116}	R^{D9}	R^{D216}
L_{C793}	R^{D217}	R^{D217}	L_{C901}	R^{D1}	R^{D217}	L_{C1009}	R^{D4}	R^{D217}	L_{C1117}	R^{D9}	R^{D217}
L_{C794}	R^{D218}	R^{D218}	L_{C902}	R^{D1}	R^{D218}	L_{C1010}	R^{D4}	R^{D218}	L_{C1118}	R^{D9}	R^{D218}
L_{C795}	R^{D219}	R^{D219}	L_{C903}	R^{D1}	R^{D219}	L_{C1011}	R^{D4}	R^{D219}	L_{C1119}	R^{D9}	R^{D219}
L_{C796}	R^{D220}	R^{D220}	L_{C904}	R^{D1}	R^{D220}	L_{C1012}	R^{D4}	R^{D220}	L_{C1120}	R^{D9}	R^{D220}
L_{C797}	R^{D221}	R^{D221}	L_{C905}	R^{D1}	R^{D221}	L_{C1013}	R^{D4}	R^{D221}	L_{C1121}	R^{D9}	R^{D221}
L_{C798}	R^{D222}	R^{D222}	L_{C906}	R^{D1}	R^{D222}	L_{C1014}	R^{D4}	R^{D222}	L_{C1122}	R^{D9}	R^{D222}
L_{C799}	R^{D223}	R^{D223}	L_{C907}	R^{D1}	R^{D223}	L_{C1015}	R^{D4}	R^{D223}	L_{C1123}	R^{D9}	R^{D223}
L_{C800}	R^{D224}	R^{D224}	L_{C908}	R^{D1}	R^{D224}	L_{C1016}	R^{D4}	R^{D224}	L_{C1124}	R^{D9}	R^{D224}
L_{C801}	R^{D225}	R^{D225}	L_{C909}	R^{D1}	R^{D225}	L_{C1017}	R^{D4}	R^{D225}	L_{C1125}	R^{D9}	R^{D225}
L_{C802}	R^{D226}	R^{D226}	L_{C910}	R^{D1}	R^{D226}	L_{C1018}	R^{D4}	R^{D226}	L_{C1126}	R^{D9}	R^{D226}
L_{C803}	R^{D227}	R^{D227}	L_{C911}	R^{D1}	R^{D227}	L_{C1019}	R^{D4}	R^{D227}	L_{C1127}	R^{D9}	R^{D227}
L_{C804}	R^{D228}	R^{D228}	L_{C912}	R^{D1}	R^{D228}	L_{C1020}	R^{D4}	R^{D228}	L_{C1128}	R^{D9}	R^{D228}
L_{C805}	R^{D229}	R^{D229}	L_{C913}	R^{D1}	R^{D229}	L_{C1021}	R^{D4}	R^{D229}	L_{C1129}	R^{D9}	R^{D229}
L_{C806}	R^{D230}	R^{D230}	L_{C914}	R^{D1}	R^{D230}	L_{C1022}	R^{D4}	R^{D230}	L_{C1130}	R^{D9}	R^{D230}
L_{C807}	R^{D231}	R^{D231}	L_{C915}	R^{D1}	R^{D231}	L_{C1023}	R^{D4}	R^{D231}	L_{C1131}	R^{D9}	R^{D231}
L_{C808}	R^{D232}	R^{D232}	L_{C916}	R^{D1}	R^{D232}	L_{C1024}	R^{D4}	R^{D232}	L_{C1132}	R^{D9}	R^{D232}
L_{C809}	R^{D233}	R^{D233}	L_{C917}	R^{D1}	R^{D233}	L_{C1025}	R^{D4}	R^{D233}	L_{C1133}	R^{D9}	R^{D233}
L_{C810}	R^{D234}	R^{D234}	L_{C918}	R^{D1}	R^{D234}	L_{C1026}	R^{D4}	R^{D234}	L_{C1134}	R^{D9}	R^{D234}
L_{C811}	R^{D235}	R^{D235}	L_{C919}	R^{D1}	R^{D235}	L_{C1027}	R^{D4}	R^{D235}	L_{C1135}	R^{D9}	R^{D235}
L_{C812}	R^{D236}	R^{D236}	L_{C920}	R^{D1}	R^{D236}	L_{C1028}	R^{D4}	R^{D236}	L_{C1136}	R^{D9}	R^{D236}
L_{C813}	R^{D237}	R^{D237}	L_{C921}	R^{D1}	R^{D237}	L_{C1029}	R^{D4}	R^{D237}	L_{C1137}	R^{D9}	R^{D237}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C814}	R^{D238}	R^{D238}	L_{C922}	R^{D1}	R^{D238}	L_{C1030}	R^{D4}	R^{D238}	L_{C1138}	R^{D9}	R^{D238}
L_{C815}	R^{D239}	R^{D239}	L_{C923}	R^{D1}	R^{D239}	L_{C1031}	R^{D4}	R^{D239}	L_{C1139}	R^{D9}	R^{D239}
L_{C816}	R^{D240}	R^{D240}	L_{C924}	R^{D1}	R^{D240}	L_{C1032}	R^{D4}	R^{D240}	L_{C1140}	R^{D9}	R^{D240}
L_{C817}	R^{D241}	R^{D241}	L_{C925}	R^{D1}	R^{D241}	L_{C1033}	R^{D4}	R^{D241}	L_{C1141}	R^{D9}	R^{D241}
L_{C818}	R^{D242}	R^{D242}	L_{C926}	R^{D1}	R^{D242}	L_{C1034}	R^{D4}	R^{D242}	L_{C1142}	R^{D9}	R^{D242}
L_{C819}	R^{D243}	R^{D243}	L_{C927}	R^{D1}	R^{D243}	L_{C1035}	R^{D4}	R^{D243}	L_{C1143}	R^{D9}	R^{D243}
L_{C820}	R^{D244}	R^{D244}	L_{C928}	R^{D1}	R^{D244}	L_{C1036}	R^{D4}	R^{D244}	L_{C1144}	R^{D9}	R^{D244}
L_{C821}	R^{D245}	R^{D245}	L_{C929}	R^{D1}	R^{D245}	L_{C1037}	R^{D4}	R^{D245}	L_{C1145}	R^{D9}	R^{D245}
L_{C822}	R^{D246}	R^{D246}	L_{C930}	R^{D1}	R^{D246}	L_{C1038}	R^{D4}	R^{D246}	L_{C1146}	R^{D9}	R^{D246}
L_{C823}	R^{D17}	R^{D193}	L_{C931}	R^{D50}	R^{D193}	L_{C1039}	R^{D145}	R^{D193}	L_{C1147}	R^{D168}	R^{D193}
L_{C824}	R^{D17}	R^{D194}	L_{C932}	R^{D50}	R^{D194}	L_{C1040}	R^{D145}	R^{D194}	L_{C1148}	R^{D168}	R^{D194}
L_{C825}	R^{D17}	R^{D195}	L_{C933}	R^{D50}	R^{D195}	L_{C1041}	R^{D145}	R^{D195}	L_{C1149}	R^{D168}	R^{D195}
L_{C826}	R^{D17}	R^{D196}	L_{C934}	R^{D50}	R^{D196}	L_{C1042}	R^{D145}	R^{D196}	L_{C1150}	R^{D168}	R^{D196}
L_{C827}	R^{D17}	R^{D197}	L_{C935}	R^{D50}	R^{D197}	L_{C1043}	R^{D145}	R^{D197}	L_{C1151}	R^{D168}	R^{D197}
L_{C828}	R^{D17}	R^{D198}	L_{C936}	R^{D50}	R^{D198}	L_{C1044}	R^{D145}	R^{D198}	L_{C1152}	R^{D168}	R^{D198}
L_{C829}	R^{D17}	R^{D199}	L_{C937}	R^{D50}	R^{D199}	L_{C1045}	R^{D145}	R^{D199}	L_{C1153}	R^{D168}	R^{D199}
L_{C830}	R^{D17}	R^{D200}	L_{C938}	R^{D50}	R^{D200}	L_{C1046}	R^{D145}	R^{D200}	L_{C1154}	R^{D168}	R^{D200}
L_{C831}	R^{D17}	R^{D201}	L_{C939}	R^{D50}	R^{D201}	L_{C1047}	R^{D145}	R^{D201}	L_{C1155}	R^{D168}	R^{D201}
L_{C832}	R^{D17}	R^{D202}	L_{C940}	R^{D50}	R^{D202}	L_{C1048}	R^{D145}	R^{D202}	L_{C1156}	R^{D168}	R^{D202}
L_{C833}	R^{D17}	R^{D203}	L_{C941}	R^{D50}	R^{D203}	L_{C1049}	R^{D145}	R^{D203}	L_{C1157}	R^{D168}	R^{D203}
L_{C834}	R^{D17}	R^{D204}	L_{C942}	R^{D50}	R^{D204}	L_{C1050}	R^{D145}	R^{D204}	L_{C1158}	R^{D168}	R^{D204}
L_{C835}	R^{D17}	R^{D205}	L_{C943}	R^{D50}	R^{D205}	L_{C1051}	R^{D145}	R^{D205}	L_{C1159}	R^{D168}	R^{D205}
L_{C836}	R^{D17}	R^{D206}	L_{C944}	R^{D50}	R^{D206}	L_{C1052}	R^{D145}	R^{D206}	L_{C1160}	R^{D168}	R^{D206}
L_{C837}	R^{D17}	R^{D207}	L_{C945}	R^{D50}	R^{D207}	L_{C1053}	R^{D145}	R^{D207}	L_{C1161}	R^{D168}	R^{D207}
L_{C838}	R^{D17}	R^{D208}	L_{C946}	R^{D50}	R^{D208}	L_{C1054}	R^{D145}	R^{D208}	L_{C1162}	R^{D168}	R^{D208}
L_{C839}	R^{D17}	R^{D209}	L_{C947}	R^{D50}	R^{D209}	L_{C1055}	R^{D145}	R^{D209}	L_{C1163}	R^{D168}	R^{D209}
L_{C840}	R^{D17}	R^{D210}	L_{C948}	R^{D50}	R^{D210}	L_{C1056}	R^{D145}	R^{D210}	L_{C1164}	R^{D168}	R^{D210}
L_{C841}	R^{D17}	R^{D211}	L_{C949}	R^{D50}	R^{D211}	L_{C1057}	R^{D145}	R^{D211}	L_{C1165}	R^{D168}	R^{D211}
L_{C842}	R^{D17}	R^{D212}	L_{C950}	R^{D50}	R^{D212}	L_{C1058}	R^{D145}	R^{D212}	L_{C1166}	R^{D168}	R^{D212}
L_{C843}	R^{D17}	R^{D213}	L_{C951}	R^{D50}	R^{D213}	L_{C1059}	R^{D145}	R^{D213}	L_{C1167}	R^{D168}	R^{D213}
L_{C844}	R^{D17}	R^{D214}	L_{C952}	R^{D50}	R^{D214}	L_{C1060}	R^{D145}	R^{D214}	L_{C1168}	R^{D168}	R^{D214}
L_{C845}	R^{D17}	R^{D215}	L_{C953}	R^{D50}	R^{D215}	L_{C1061}	R^{D145}	R^{D215}	L_{C1169}	R^{D168}	R^{D215}
L_{C846}	R^{D17}	R^{D216}	L_{C954}	R^{D50}	R^{D216}	L_{C1062}	R^{D145}	R^{D216}	L_{C1170}	R^{D168}	R^{D216}
L_{C847}	R^{D17}	R^{D217}	L_{C955}	R^{D50}	R^{D217}	L_{C1063}	R^{D145}	R^{D217}	L_{C1171}	R^{D168}	R^{D217}
L_{C848}	R^{D17}	R^{D218}	L_{C956}	R^{D50}	R^{D218}	L_{C1064}	R^{D145}	R^{D218}	L_{C1172}	R^{D168}	R^{D218}
L_{C849}	R^{D17}	R^{D219}	L_{C957}	R^{D50}	R^{D219}	L_{C1065}	R^{D145}	R^{D219}	L_{C1173}	R^{D168}	R^{D219}
L_{C850}	R^{D17}	R^{D220}	L_{C958}	R^{D50}	R^{D220}	L_{C1066}	R^{D145}	R^{D220}	L_{C1174}	R^{D168}	R^{D220}
L_{C851}	R^{D17}	R^{D221}	L_{C959}	R^{D50}	R^{D221}	L_{C1067}	R^{D145}	R^{D221}	L_{C1175}	R^{D168}	R^{D221}
L_{C852}	R^{D17}	R^{D222}	L_{C960}	R^{D50}	R^{D222}	L_{C1068}	R^{D145}	R^{D222}	L_{C1176}	R^{D168}	R^{D222}
L_{C853}	R^{D17}	R^{D223}	L_{C961}	R^{D50}	R^{D223}	L_{C1069}	R^{D145}	R^{D223}	L_{C1177}	R^{D168}	R^{D223}
L_{C854}	R^{D17}	R^{D224}	L_{C962}	R^{D50}	R^{D224}	L_{C1070}	R^{D145}	R^{D224}	L_{C1178}	R^{D168}	R^{D224}
L_{C855}	R^{D17}	R^{D225}	L_{C963}	R^{D50}	R^{D225}	L_{C1071}	R^{D145}	R^{D225}	L_{C1179}	R^{D168}	R^{D225}
L_{C856}	R^{D17}	R^{D226}	L_{C964}	R^{D50}	R^{D226}	L_{C1072}	R^{D145}	R^{D226}	L_{C1180}	R^{D168}	R^{D226}
L_{C857}	R^{D17}	R^{D227}	L_{C965}	R^{D50}	R^{D227}	L_{C1073}	R^{D145}	R^{D227}	L_{C1181}	R^{D168}	R^{D227}
L_{C858}	R^{D17}	R^{D228}	L_{C966}	R^{D50}	R^{D228}	L_{C1074}	R^{D145}	R^{D228}	L_{C1182}	R^{D168}	R^{D228}
L_{C859}	R^{D17}	R^{D229}	L_{C967}	R^{D50}	R^{D229}	L_{C1075}	R^{D145}	R^{D229}	L_{C1183}	R^{D168}	R^{D229}
L_{C860}	R^{D17}	R^{D230}	L_{C968}	R^{D50}	R^{D230}	L_{C1076}	R^{D145}	R^{D230}	L_{C1184}	R^{D168}	R^{D230}
L_{C861}	R^{D17}	R^{D231}	L_{C969}	R^{D50}	R^{D231}	L_{C1077}	R^{D145}	R^{D231}	L_{C1185}	R^{D168}	R^{D231}
L_{C862}	R^{D17}	R^{D232}	L_{C970}	R^{D50}	R^{D232}	L_{C1078}	R^{D145}	R^{D232}	L_{C1186}	R^{D168}	R^{D232}
L_{C863}	R^{D17}	R^{D233}	L_{C971}	R^{D50}	R^{D233}	L_{C1079}	R^{D145}	R^{D233}	L_{C1187}	R^{D168}	R^{D233}
L_{C864}	R^{D17}	R^{D234}	L_{C972}	R^{D50}	R^{D234}	L_{C1080}	R^{D145}	R^{D234}	L_{C1188}	R^{D168}	R^{D234}
L_{C865}	R^{D17}	R^{D235}	L_{C973}	R^{D50}	R^{D235}	L_{C1081}	R^{D145}	R^{D235}	L_{C1189}	R^{D168}	R^{D235}
L_{C866}	R^{D17}	R^{D236}	L_{C974}	R^{D50}	R^{D236}	L_{C1082}	R^{D145}	R^{D236}	L_{C1190}	R^{D168}	R^{D236}
L_{C867}	R^{D17}	R^{D237}	L_{C975}	R^{D50}	R^{D237}	L_{C1083}	R^{D145}	R^{D237}	L_{C1191}	R^{D168}	R^{D237}
L_{C868}	R^{D17}	R^{D238}	L_{C976}	R^{D50}	R^{D238}	L_{C1084}	R^{D145}	R^{D238}	L_{C1192}	R^{D168}	R^{D238}
L_{C869}	R^{D17}	R^{D239}	L_{C977}	R^{D50}	R^{D239}	L_{C1085}	R^{D145}	R^{D239}	L_{C1193}	R^{D168}	R^{D239}
L_{C870}	R^{D17}	R^{D240}	L_{C978}	R^{D50}	R^{D240}	L_{C1086}	R^{D145}	R^{D240}	L_{C1194}	R^{D168}	R^{D240}
L_{C871}	R^{D17}	R^{D241}	L_{C979}	R^{D50}	R^{D241}	L_{C1087}	R^{D145}	R^{D241}	L_{C1195}	R^{D168}	R^{D241}
L_{C872}	R^{D17}	R^{D242}	L_{C980}	R^{D50}	R^{D242}	L_{C1088}	R^{D145}	R^{D242}	L_{C1196}	R^{D168}	R^{D242}
L_{C873}	R^{D17}	R^{D243}	L_{C981}	R^{D50}	R^{D243}	L_{C1089}	R^{D145}	R^{D243}	L_{C1197}	R^{D168}	R^{D243}
L_{C874}	R^{D17}	R^{D244}	L_{C982}	R^{D50}	R^{D244}	L_{C1090}	R^{D145}	R^{D244}	L_{C1198}	R^{D168}	R^{D244}
L_{C875}	R^{D17}	R^{D245}	L_{C983}	R^{D50}	R^{D245}	L_{C1091}	R^{D145}	R^{D245}	L_{C1199}	R^{D168}	R^{D245}
L_{C876}	R^{D17}	R^{D246}	L_{C984}	R^{D50}	R^{D246}	L_{C1092}	R^{D145}	R^{D246}	L_{C1200}	R^{D168}	R^{D246}
L_{C1201}	R^{D10}	R^{D193}	L_{C1255}	R^{D55}	R^{D193}	L_{C1309}	R^{D37}	R^{D193}	L_{C1363}	R^{D143}	R^{D193}
L_{C1202}	R^{D10}	R^{D194}	L_{C1256}	R^{D55}	R^{D194}	L_{C1310}	R^{D37}	R^{D194}	L_{C1364}	R^{D143}	R^{D194}
L_{C1203}	R^{D10}	R^{D195}	L_{C1257}	R^{D55}	R^{D195}	L_{C1311}	R^{D37}	R^{D195}	L_{C1365}	R^{D143}	R^{D195}
L_{C1204}	R^{D10}	R^{D196}	L_{C1258}	R^{D55}	R^{D196}	L_{C1312}	R^{D37}	R^{D196}	L_{C1366}	R^{D143}	R^{D196}
L_{C1205}	R^{D10}	R^{D197}	L_{C1259}	R^{D55}	R^{D197}	L_{C1313}	R^{D37}	R^{D197}	L_{C1367}	R^{D143}	R^{D197}
L_{C1206}	R^{D10}	R^{D198}	L_{C1260}	R^{D55}	R^{D198}	L_{C1314}	R^{D37}	R^{D198}	L_{C1368}	R^{D143}	R^{D198}
L_{C1207}	R^{D10}	R^{D199}	L_{C1261}	R^{D55}	R^{D199}	L_{C1315}	R^{D37}	R^{D199}	L_{C1369}	R^{D143}	R^{D199}
L_{C1208}	R^{D10}	R^{D200}	L_{C1262}	R^{D55}	R^{D200}	L_{C1316}	R^{D37}	R^{D200}	L_{C1370}	R^{D143}	R^{D200}
L_{C1209}	R^{D10}	R^{D201}	L_{C1263}	R^{D55}	R^{D201}	L_{C1317}	R^{D37}	R^{D201}	L_{C1371}	R^{D143}	R^{D201}
L_{C1210}	R^{D10}	R^{D202}	L_{C1264}	R^{D55}	R^{D202}	L_{C1318}	R^{D37}	R^{D202}	L_{C1372}	R^{D143}	R^{D202}
L_{C1211}	R^{D10}	R^{D203}	L_{C1265}	R^{D55}	R^{D203}	L_{C1319}	R^{D37}	R^{D203}	L_{C1373}	R^{D143}	R^{D203}

-continued

L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}	L_{Cj}	R^{201}	R^{202}
L_{C1212}	R^{D10}	R^{D204}	L_{C1266}	R^{D55}	R^{D204}	L_{C1320}	R^{D37}	R^{D204}	L_{C1374}	R^{D143}	R^{D204}
L_{C1213}	R^{D10}	R^{D205}	L_{C1267}	R^{D55}	R^{D205}	L_{C1321}	R^{D37}	R^{D205}	L_{C1375}	R^{D143}	R^{D205}
L_{C1214}	R^{D10}	R^{D206}	L_{C1268}	R^{D55}	R^{D206}	L_{C1322}	R^{D37}	R^{D206}	L_{C1376}	R^{D143}	R^{D206}
L_{C1215}	R^{D10}	R^{D207}	L_{C1269}	R^{D55}	R^{D207}	L_{C1323}	R^{D37}	R^{D207}	L_{C1377}	R^{D143}	R^{D207}
L_{C1216}	R^{D10}	R^{D208}	L_{C1270}	R^{D55}	R^{D208}	L_{C1324}	R^{D37}	R^{D208}	L_{C1378}	R^{D143}	R^{D208}
L_{C1217}	R^{D10}	R^{D209}	L_{C1271}	R^{D55}	R^{D209}	L_{C1325}	R^{D37}	R^{D209}	L_{C1379}	R^{D143}	R^{D209}
L_{C1218}	R^{D10}	R^{D210}	L_{C1272}	R^{D55}	R^{D210}	L_{C1326}	R^{D37}	R^{D210}	L_{C1380}	R^{D143}	R^{D210}
L_{C1219}	R^{D10}	R^{D211}	L_{C1273}	R^{D55}	R^{D211}	L_{C1327}	R^{D37}	R^{D211}	L_{C1381}	R^{D143}	R^{D211}
L_{C1220}	R^{D10}	R^{D212}	L_{C1274}	R^{D55}	R^{D212}	L_{C1328}	R^{D37}	R^{D212}	L_{C1382}	R^{D143}	R^{D212}
L_{C1221}	R^{D10}	R^{D213}	L_{C1275}	R^{D55}	R^{D213}	L_{C1329}	R^{D37}	R^{D213}	L_{C1383}	R^{D143}	R^{D213}
L_{C1222}	R^{D10}	R^{D214}	L_{C1276}	R^{D55}	R^{D214}	L_{C1330}	R^{D37}	R^{D214}	L_{C1384}	R^{D143}	R^{D214}
L_{C1223}	R^{D10}	R^{D215}	L_{C1277}	R^{D55}	R^{D215}	L_{C1331}	R^{D37}	R^{D215}	L_{C1385}	R^{D143}	R^{D215}
L_{C1224}	R^{D10}	R^{D216}	L_{C1278}	R^{D55}	R^{D216}	L_{C1332}	R^{D37}	R^{D216}	L_{C1386}	R^{D143}	R^{D216}
L_{C1225}	R^{D10}	R^{D217}	L_{C1279}	R^{D55}	R^{D217}	L_{C1333}	R^{D37}	R^{D217}	L_{C1387}	R^{D143}	R^{D217}
L_{C1226}	R^{D10}	R^{D218}	L_{C1280}	R^{D55}	R^{D218}	L_{C1334}	R^{D37}	R^{D218}	L_{C1388}	R^{D143}	R^{D218}
L_{C1227}	R^{D10}	R^{D219}	L_{C1281}	R^{D55}	R^{D219}	L_{C1335}	R^{D37}	R^{D219}	L_{C1389}	R^{D143}	R^{D219}
L_{C1228}	R^{D10}	R^{D220}	L_{C1282}	R^{D55}	R^{D220}	L_{C1336}	R^{D37}	R^{D220}	L_{C1390}	R^{D143}	R^{D220}
L_{C1229}	R^{D10}	R^{D221}	L_{C1283}	R^{D55}	R^{D221}	L_{C1337}	R^{D37}	R^{D221}	L_{C1391}	R^{D143}	R^{D221}
L_{C1230}	R^{D10}	R^{D222}	L_{C1284}	R^{D55}	R^{D222}	L_{C1338}	R^{D37}	R^{D222}	L_{C1392}	R^{D143}	R^{D222}
L_{C1231}	R^{D10}	R^{D223}	L_{C1285}	R^{D55}	R^{D223}	L_{C1339}	R^{D37}	R^{D223}	L_{C1393}	R^{D143}	R^{D223}
L_{C1232}	R^{D10}	R^{D224}	L_{C1286}	R^{D55}	R^{D224}	L_{C1340}	R^{D37}	R^{D224}	L_{C1394}	R^{D143}	R^{D224}
L_{C1233}	R^{D10}	R^{D225}	L_{C1287}	R^{D55}	R^{D225}	L_{C1341}	R^{D37}	R^{D225}	L_{C1395}	R^{D143}	R^{D225}
L_{C1234}	R^{D10}	R^{D226}	L_{C1288}	R^{D55}	R^{D226}	L_{C1342}	R^{D37}	R^{D226}	L_{C1396}	R^{D143}	R^{D226}
L_{C1235}	R^{D10}	R^{D227}	L_{C1289}	R^{D55}	R^{D227}	L_{C1343}	R^{D37}	R^{D227}	L_{C1397}	R^{D143}	R^{D227}
L_{C1236}	R^{D10}	R^{D228}	L_{C1290}	R^{D55}	R^{D228}	L_{C1344}	R^{D37}	R^{D228}	L_{C1398}	R^{D143}	R^{D228}
L_{C1237}	R^{D10}	R^{D229}	L_{C1291}	R^{D55}	R^{D229}	L_{C1345}	R^{D37}	R^{D229}	L_{C1399}	R^{D143}	R^{D229}
L_{C1238}	R^{D10}	R^{D230}	L_{C1292}	R^{D55}	R^{D230}	L_{C1346}	R^{D37}	R^{D230}	L_{C1400}	R^{D143}	R^{D230}
L_{C1239}	R^{D10}	R^{D231}	L_{C1293}	R^{D55}	R^{D231}	L_{C1347}	R^{D37}	R^{D231}	L_{C1401}	R^{D143}	R^{D231}
L_{C1240}	R^{D10}	R^{D232}	L_{C1294}	R^{D55}	R^{D232}	L_{C1348}	R^{D37}	R^{D232}	L_{C1402}	R^{D143}	R^{D232}
L_{C1241}	R^{D10}	R^{D233}	L_{C1295}	R^{D55}	R^{D233}	L_{C1349}	R^{D37}	R^{D233}	L_{C1403}	R^{D143}	R^{D233}
L_{C1242}	R^{D10}	R^{D234}	L_{C1296}	R^{D55}	R^{D234}	L_{C1350}	R^{D37}	R^{D234}	L_{C1404}	R^{D143}	R^{D234}
L_{C1243}	R^{D10}	R^{D235}	L_{C1297}	R^{D55}	R^{D235}	L_{C1351}	R^{D37}	R^{D235}	L_{C1405}	R^{D143}	R^{D235}
L_{C1244}	R^{D10}	R^{D236}	L_{C1298}	R^{D55}	R^{D236}	L_{C1352}	R^{D37}	R^{D236}	L_{C1406}	R^{D143}	R^{D236}
L_{C1245}	R^{D10}	R^{D237}	L_{C1299}	R^{D55}	R^{D237}	L_{C1353}	R^{D37}	R^{D237}	L_{C1407}	R^{D143}	R^{D237}
L_{C1246}	R^{D10}	R^{D238}	L_{C1300}	R^{D55}	R^{D238}	L_{C1354}	R^{D37}	R^{D238}	L_{C1408}	R^{D143}	R^{D238}
L_{C1247}	R^{D10}	R^{D239}	L_{C1301}	R^{D55}	R^{D239}	L_{C1355}	R^{D37}	R^{D239}	L_{C1409}	R^{D143}	R^{D239}
L_{C1248}	R^{D10}	R^{D240}	L_{C1302}	R^{D55}	R^{D240}	L_{C1356}	R^{D37}	R^{D240}	L_{C1410}	R^{D143}	R^{D240}
L_{C1249}	R^{D10}	R^{D241}	L_{C1303}	R^{D55}	R^{D241}	L_{C1357}	R^{D37}	R^{D241}	L_{C1411}	R^{D143}	R^{D241}
L_{C1250}	R^{D10}	R^{D242}	L_{C1304}	R^{D55}	R^{D242}	L_{C1358}	R^{D37}	R^{D242}	L_{C1412}	R^{D143}	R^{D242}
L_{C1251}	R^{D10}	R^{D243}	L_{C1305}	R^{D55}	R^{D243}	L_{C1359}	R^{D37}	R^{D243}	L_{C1413}	R^{D143}	R^{D243}
L_{C1252}	R^{D10}	R^{D244}	L_{C1306}	R^{D55}	R^{D244}	L_{C1360}	R^{D37}	R^{D244}	L_{C1414}	R^{D143}	R^{D244}
L_{C1253}	R^{D10}	R^{D245}	L_{C1307}	R^{D55}	R^{D245}	L_{C1361}	R^{D37}	R^{D245}	L_{C1415}	R^{D143}	R^{D245}
L_{C1254}	R^{D10}	R^{D246}	L_{C1308}	R^{D55}	R^{D246}	L_{C1362}	R^{D37}	R^{D246}	L_{C1416}	R^{D143}	R^{D246}

wherein R^{D1} to R^{D246} have the following structures:

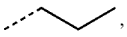
R^{D1}

R^{D2}

R^{D3}

R^{D4}

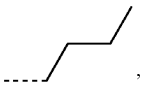
R^{D5}



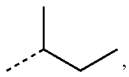
R^{D6}

-continued

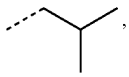
R^{D7}



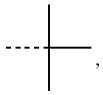
R^{D8}



R^{D9}



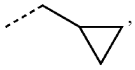
R^{D10}



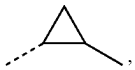
R^{D11}

-continued

R^{D12}

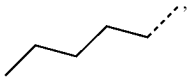


R^{D13}

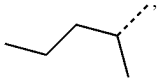


R^{D14}

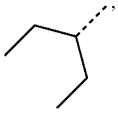
R^{D15}



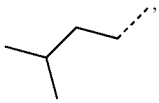
R^{D26}



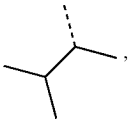
R^{D17}



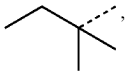
R^{D18}



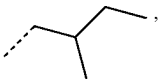
R^{D19}



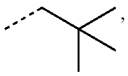
R^{D20}



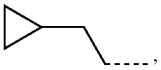
R^{D21}



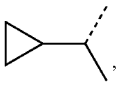
R^{D22}



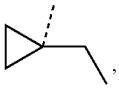
R^{D23}



R^{D24}



R^{D25}



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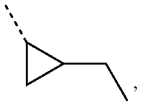
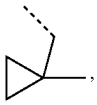
R^{D26}

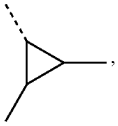


R^{D27}

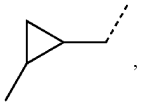
R^{D28}



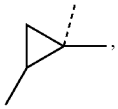
R^{D29}



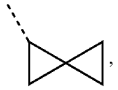
R^{D30}



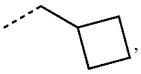
R^{D31}



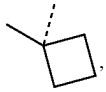
R^{D32}



R^{D33}



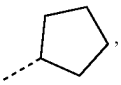
R^{D34}



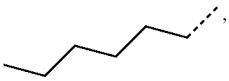
R^{D35}

R^{D36}

R^{D37}



R^{D38}



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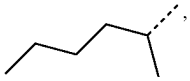
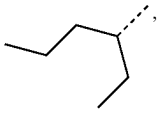
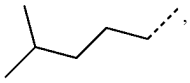
R^{D39}



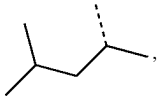
R^{D40}



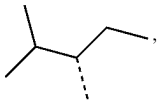
R^{D41}



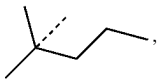
R^{D42}



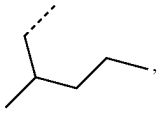
R^{D43}



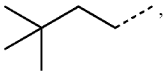
R^{D44}



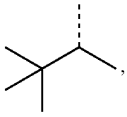
R^{D45}



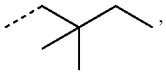
R^{D46}



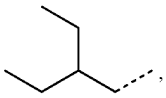
R^{D47}



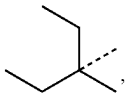
R^{D48}



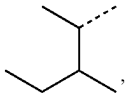
R^{D49}



R^{D50}



R^{D51}



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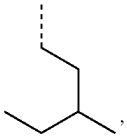
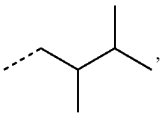
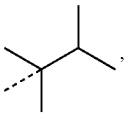
R^{D52}



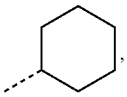
R^{D53}



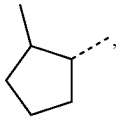
R^{D54}



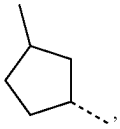
R^{D55}



R^{D56}

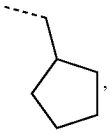


R^{D57}

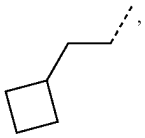


R^{D58}

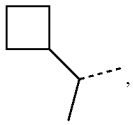
R^{D59}



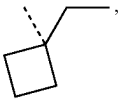
R^{D60}



R^{D61}



R^{D62}



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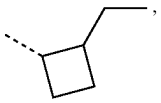
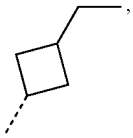
R^{D63}

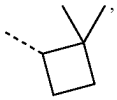


R^{D64}

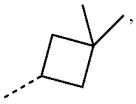


R^{D65}

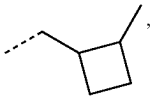
R^{D66}



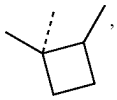
R^{D67}



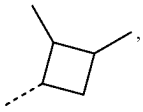
R^{D68}



R^{D69}

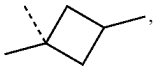


R^{D70}

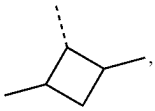


R^{D71}

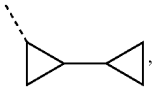
R^{D72}



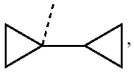
R^{D73}



R^{D74}



R^{D75}



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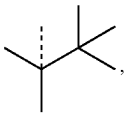
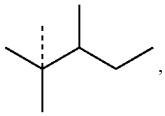
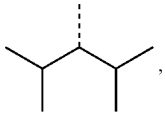
R^{D76}



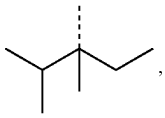
R^{D77}



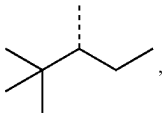
R^{D78}



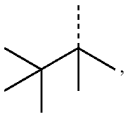
R^{D79}



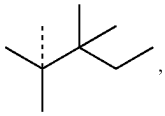
R^{D80}



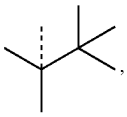
R^{D81}



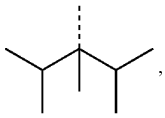
R^{D82}



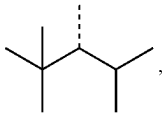
R^{D83}



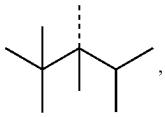
R^{D84}



R^{D85}



R^{D86}



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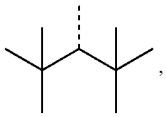
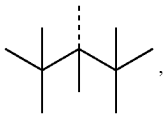
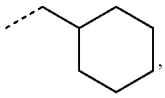
R^{D87}



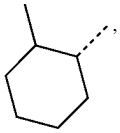
R^{D88}



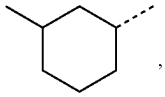
R^{D89}



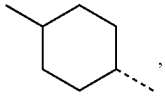
R^{D90}



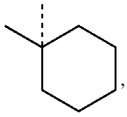
R^{D91}



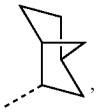
R^{D92}



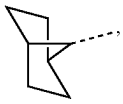
R^{D93}



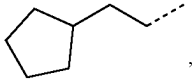
R^{D94}



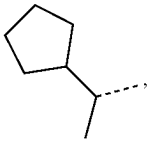
R^{D95}



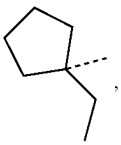
R^{D96}



R^{D97}



R^{D98}



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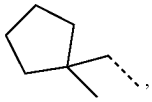
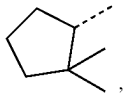
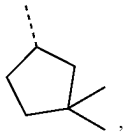
R^{D99}



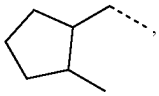
R^{D100}



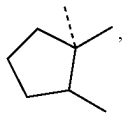
R^{D101}



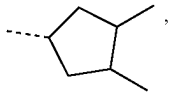
R^{D102}



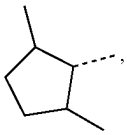
R^{D103}



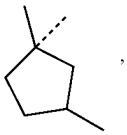
R^{D104}



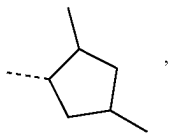
R^{D105}



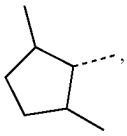
R^{D106}



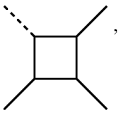
R^{D107}



R^{D108}



R^{D109}



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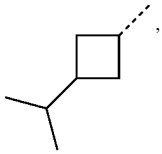
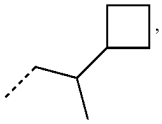
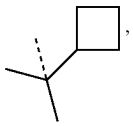
R^{D110}



R^{D111}

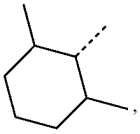


R^{D112}

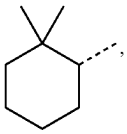


R^{D113}

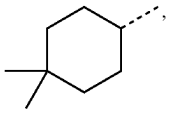
R^{D114}



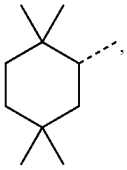
R^{D115}



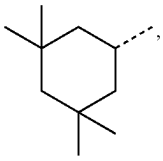
R^{D116}



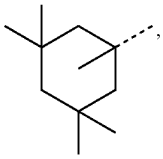
R^{D117}



R^{D118}



R^{D119}



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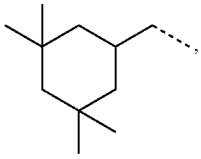
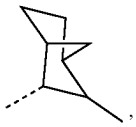
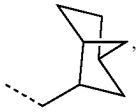
R^{D120}



R^{D121}

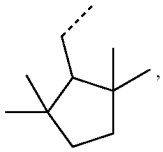


R^{D122}

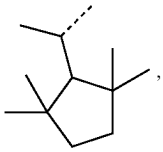


R^{D123}

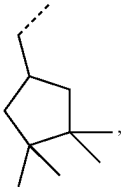
R^{D124}



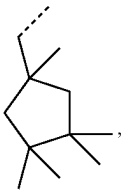
R^{D125}



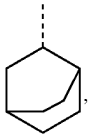
R^{D126}



R^{D127}



R^{D128}



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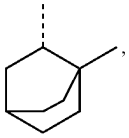
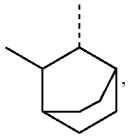
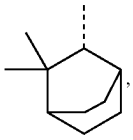
R^{D129}



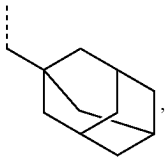
R^{D130}



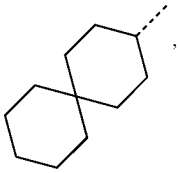
R^{D131}



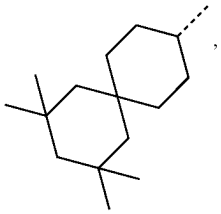
R^{D132}



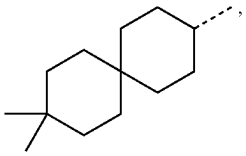
R^{D133}



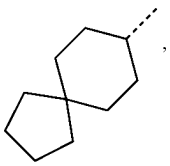
R^{D134}



R^{D135}



R^{D136}



R^{D137}

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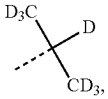
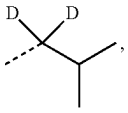
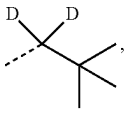
R^{D138}



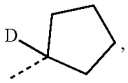
R^{D139}



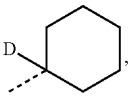
R^{D140}



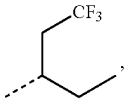
R^{D141}



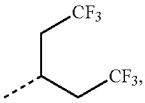
R^{D142}



R^{D143}

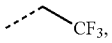


R^{D144}

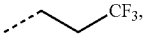


R^{D145}

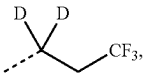
R^{D146}



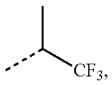
R^{D147}



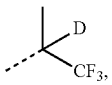
R^{D148}



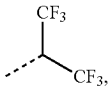
R^{D149}



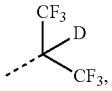
R^{D150}



R^{D151}



R^{D152}



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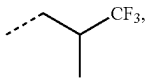
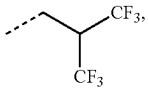
R^{D153}

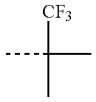
R^{D154}



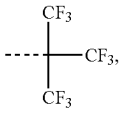
R^{D155}



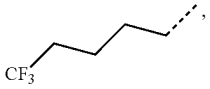
R^{D156}



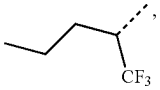
R^{D157}



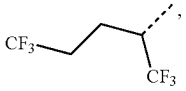
R^{D158}



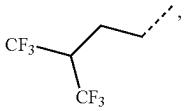
R^{D159}



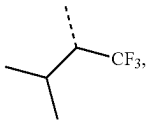
R^{D160}



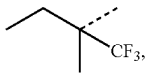
R^{D161}



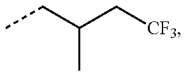
R^{D162}



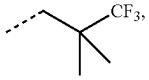
R^{D163}



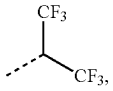
R^{D164}



R^{D165}



R^{D151}



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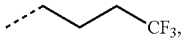
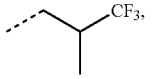
R^{D152}

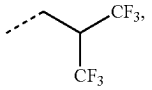
R^{D153}



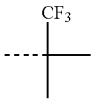
R^{D154}



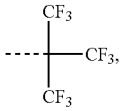
R^{D155}



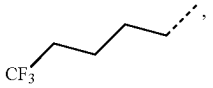
R^{D156}



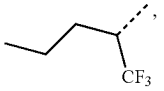
R^{D157}



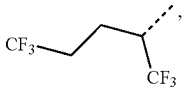
R^{D158}



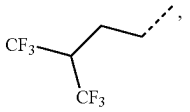
R^{D159}



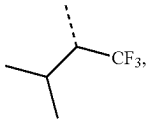
R^{D160}



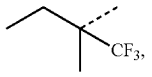
R^{D161}



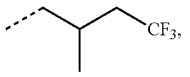
R^{D162}



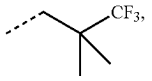
R^{D163}



R^{D164}



R^{D165}



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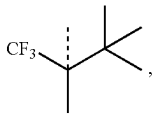
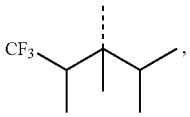
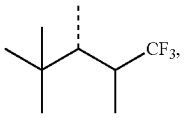
R^{D180}



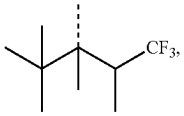
R^{D181}



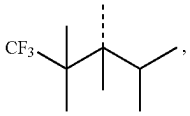
R^{D182}



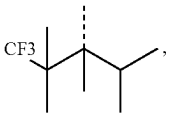
R^{D183}



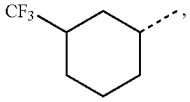
R^{D184}



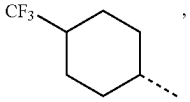
R^{D185}



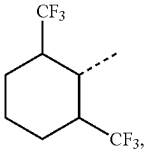
R^{D186}



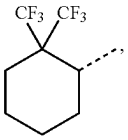
R^{D187}



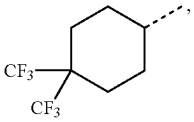
R^{D188}



R^{D189}



R^{D190}



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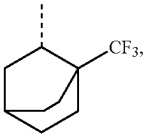
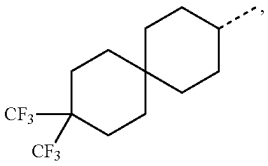
R^{D191}



R^{D192}

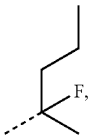


R^{D193}

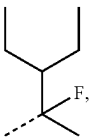
R^{D194}

R^{D195}

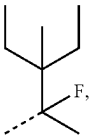
R^{D196}



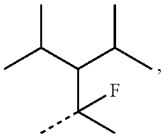
R^{D197}



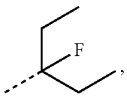
R^{D198}



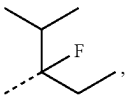
R^{D199}



R^{D200}



R^{D201}



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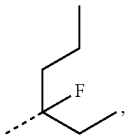
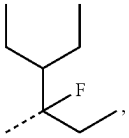
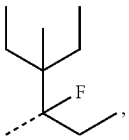
R^{D202}



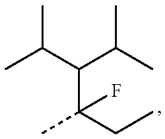
R^{D203}



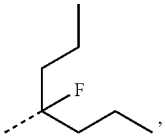
R^{D204}



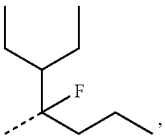
R^{D205}



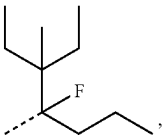
R^{D206}



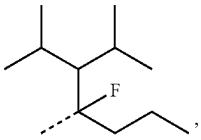
R^{D207}



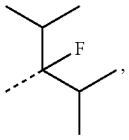
R^{D208}



R^{D209}



R^{D210}



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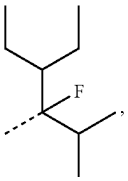
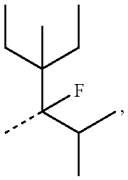
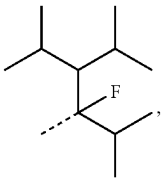
R^{D211}



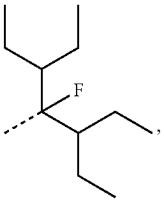
R^{D212}



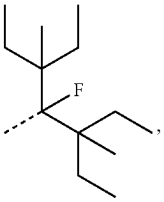
R^{D213}



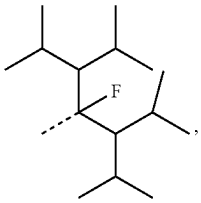
R^{D214}



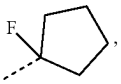
R^{D215}



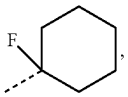
R^{D216}



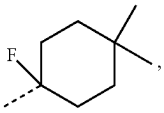
R^{D217}



R^{D218}



R^{D219}



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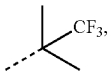
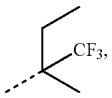
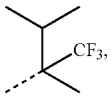
R^{D220}



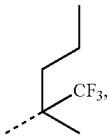
R^{D221}



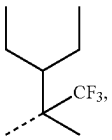
R^{D222}



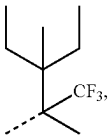
R^{D223}



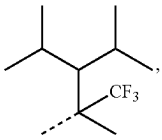
R^{D224}



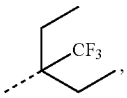
R^{D225}



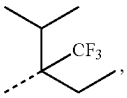
R^{D226}



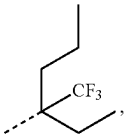
R^{D227}



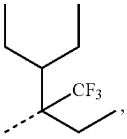
R^{D228}



R^{D229}



R^{D230}



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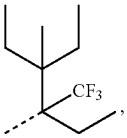
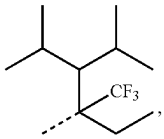
R^{D231}



R^{D232}



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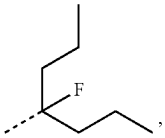

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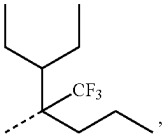

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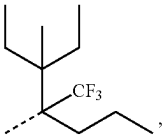
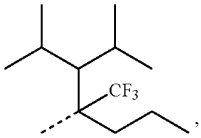


R^{D236}



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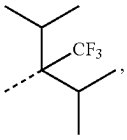
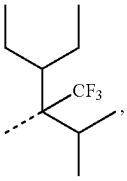
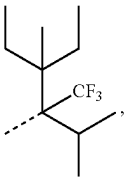


R^{D238}



R^{D239}



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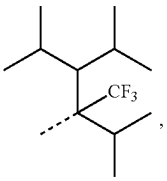
R^{D240}



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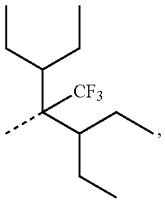
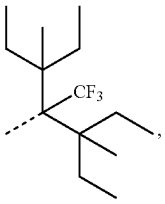


R^{D242}



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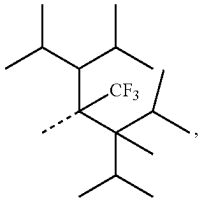
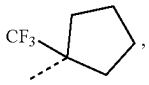
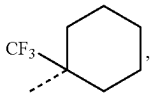
R^{D243}



R^{D244}

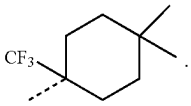


R^{D245}

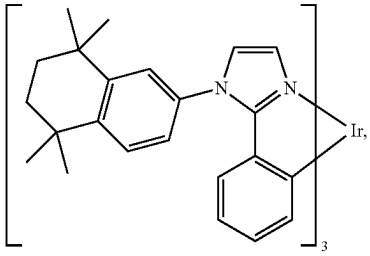


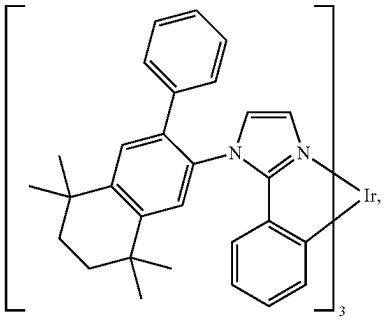
and

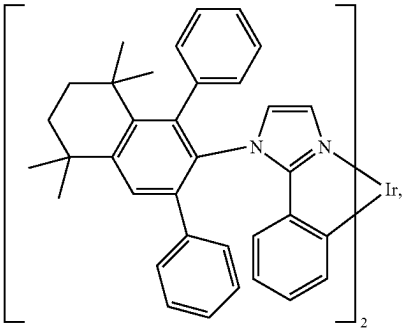
R^{D246}

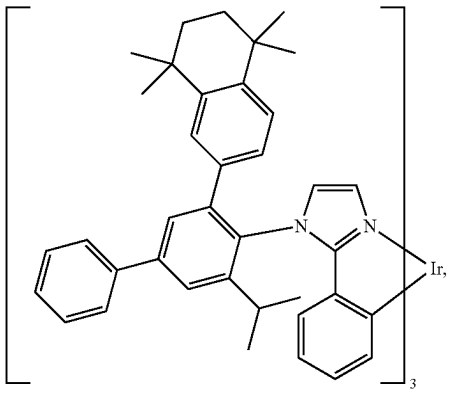


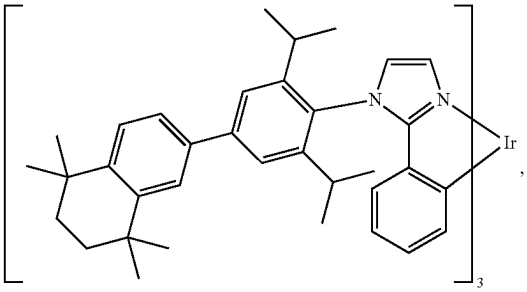
14. The compound of claim **1**, wherein the compound is selected from the group consisting of:











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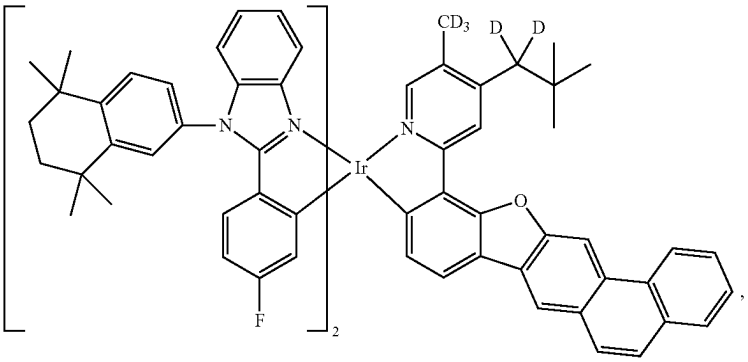

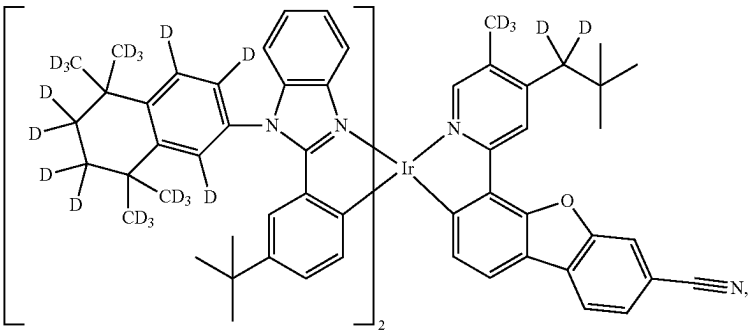

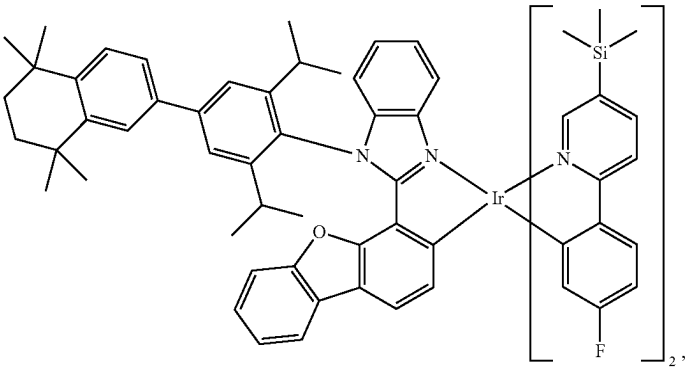

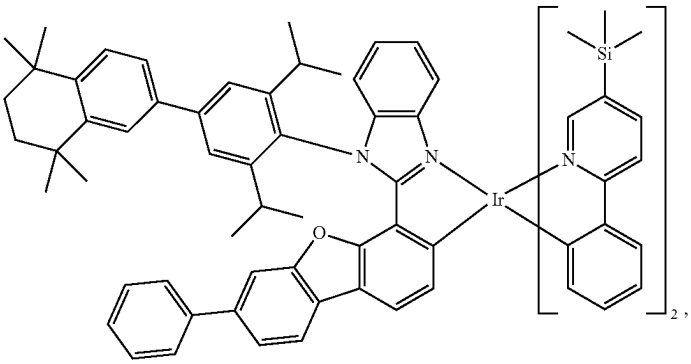

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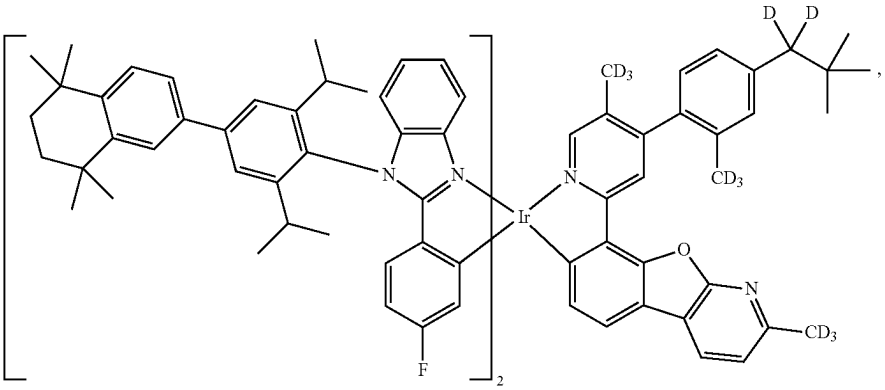

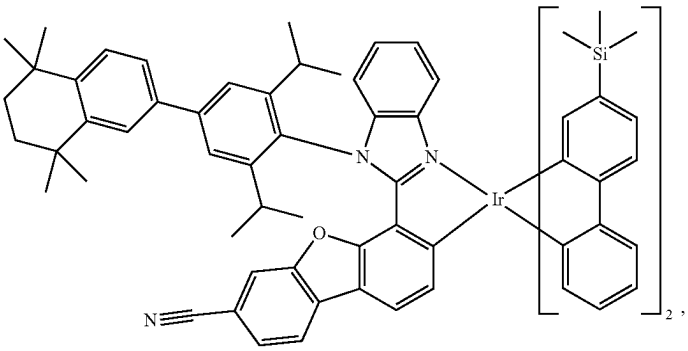

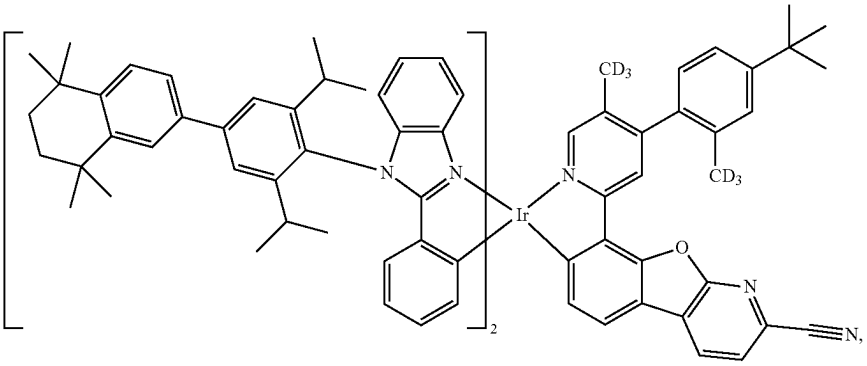

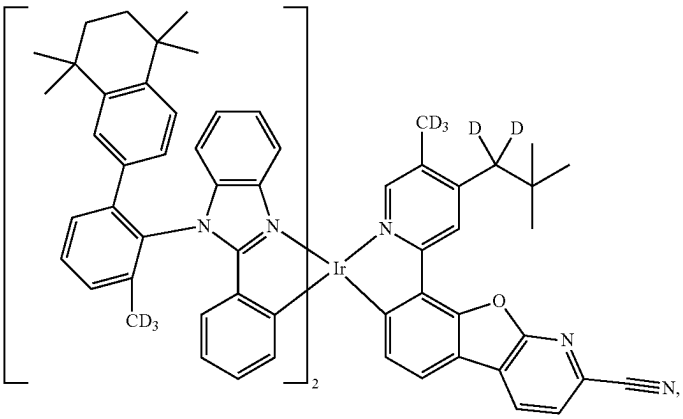

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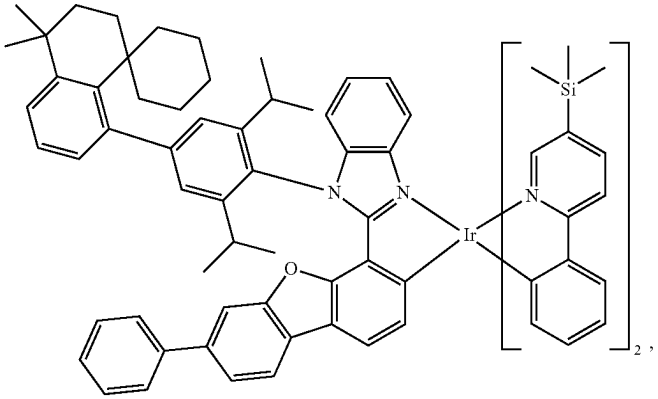

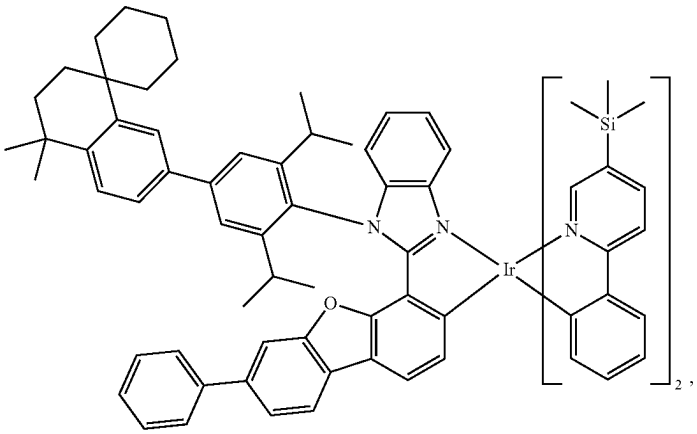

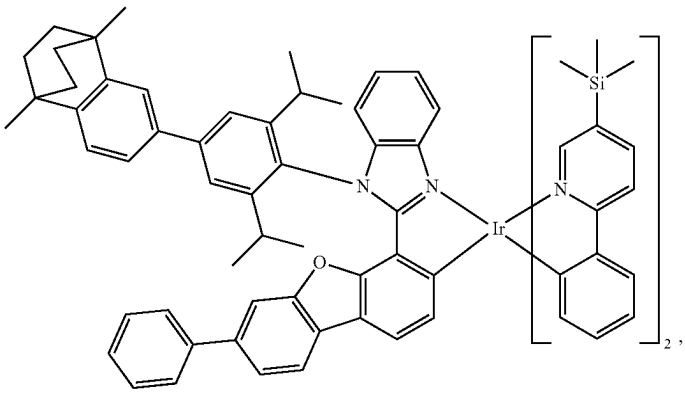

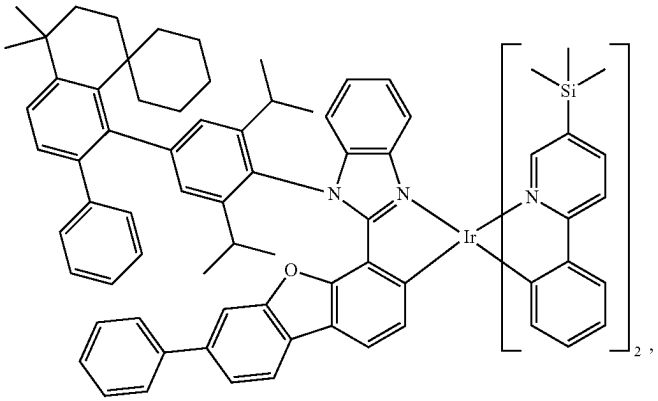

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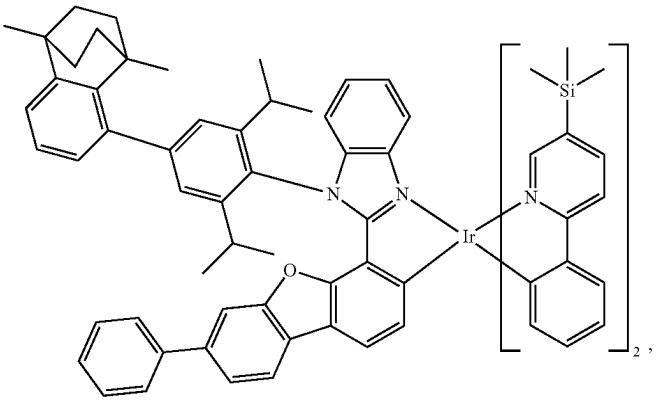

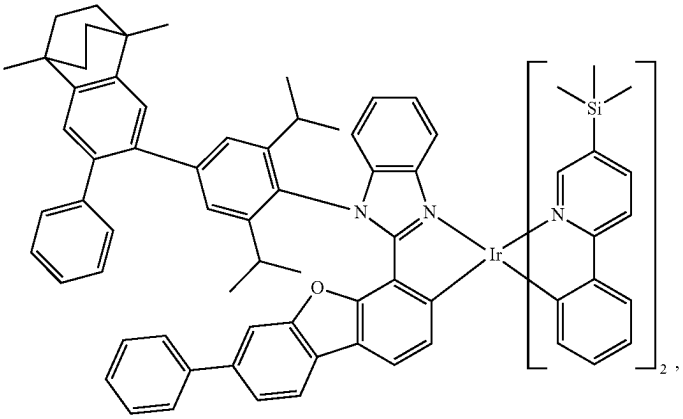

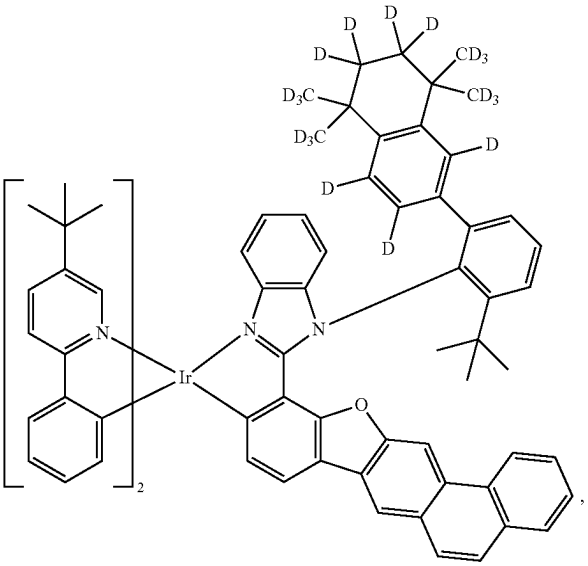

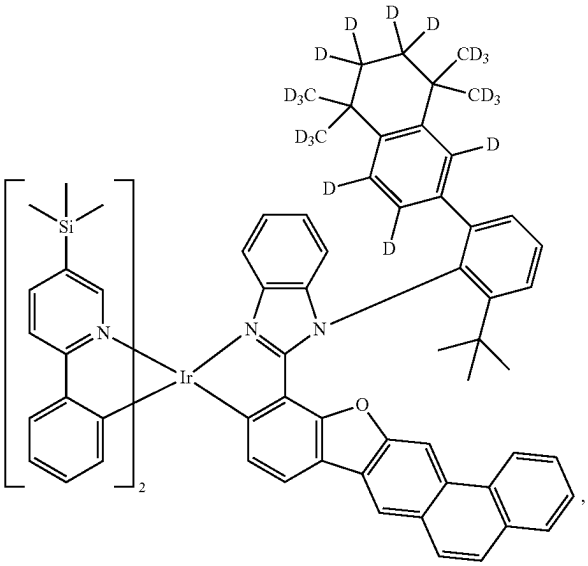

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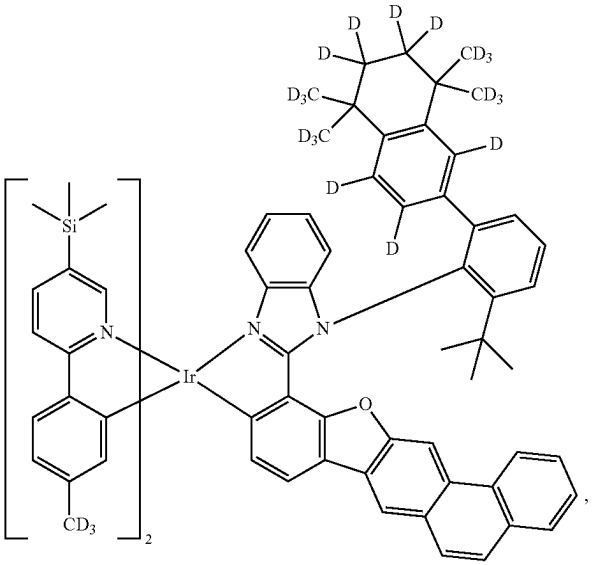

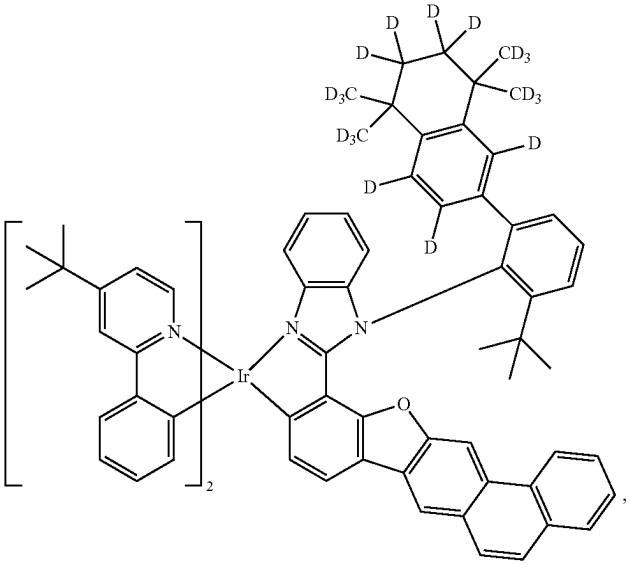

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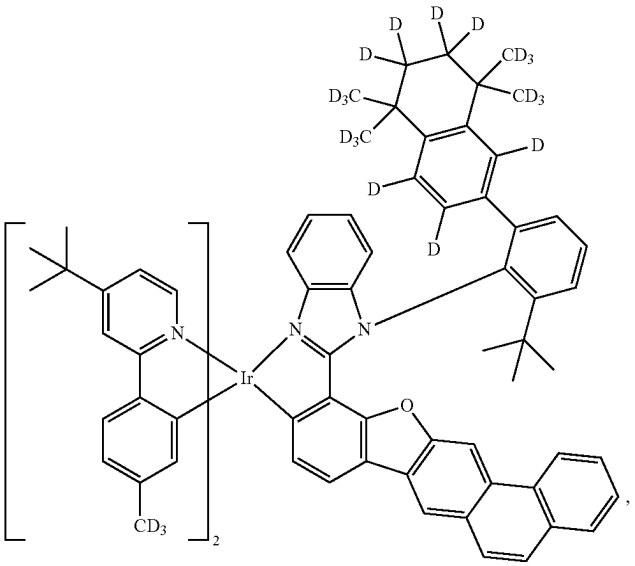

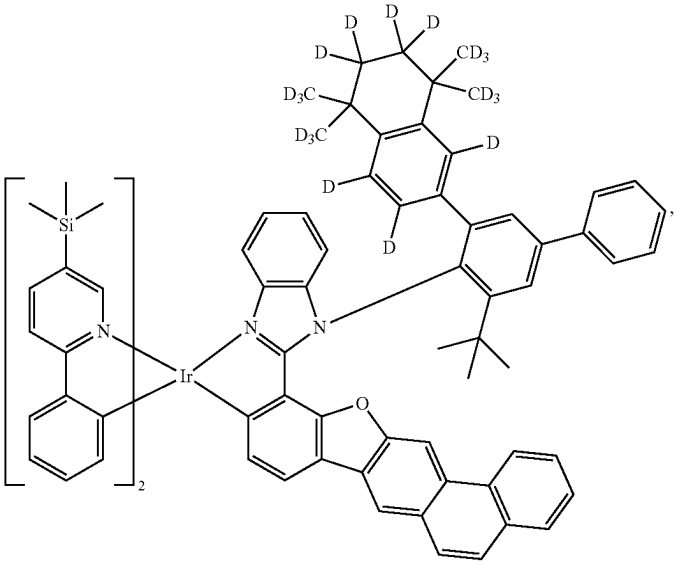

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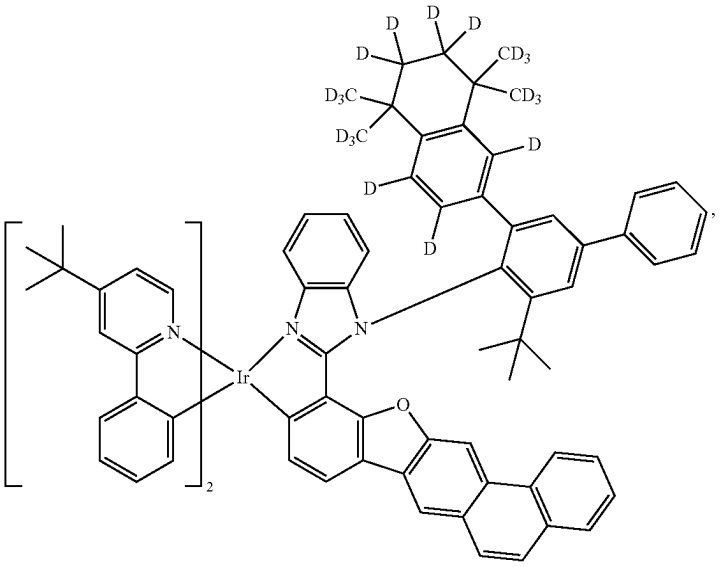

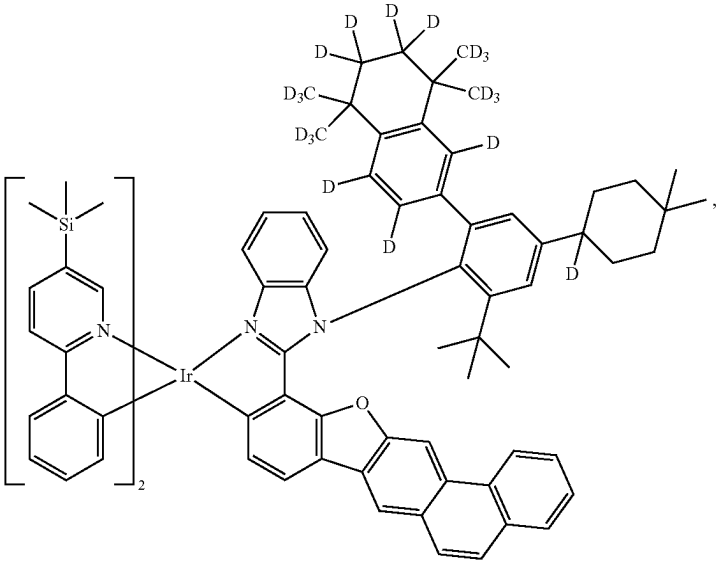

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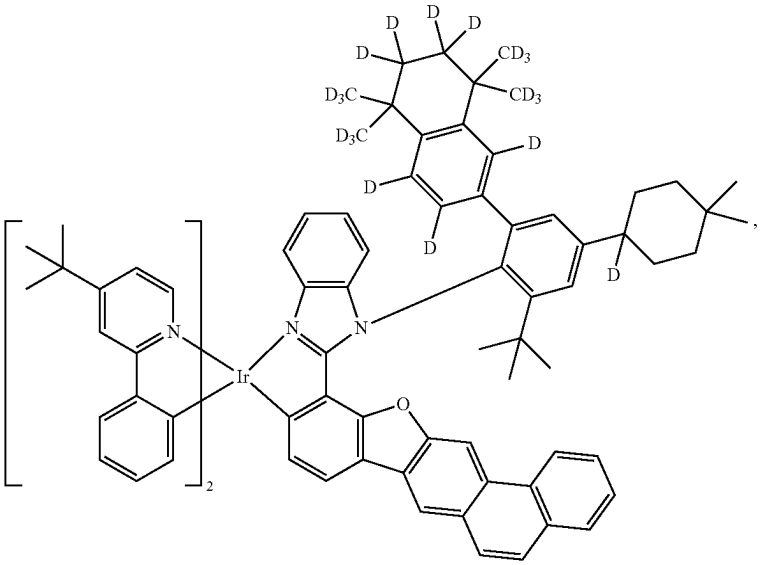

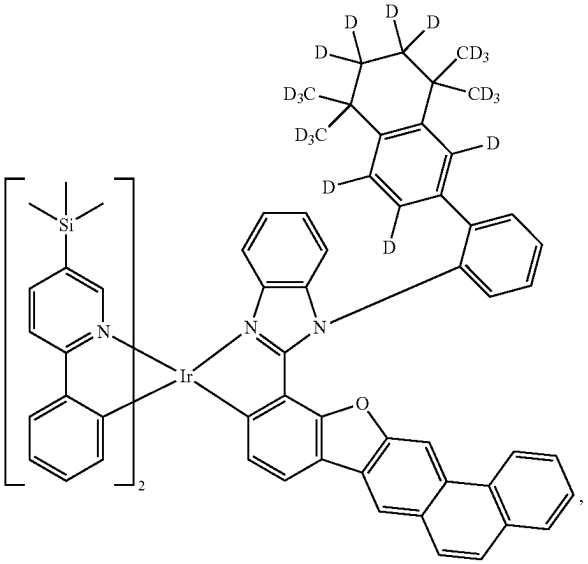

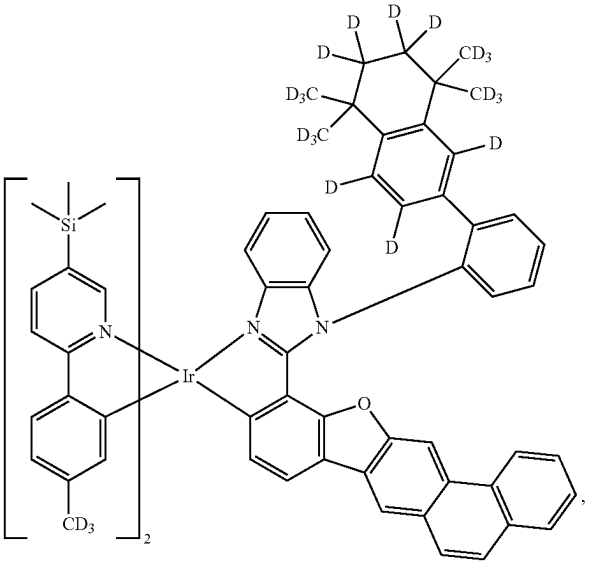

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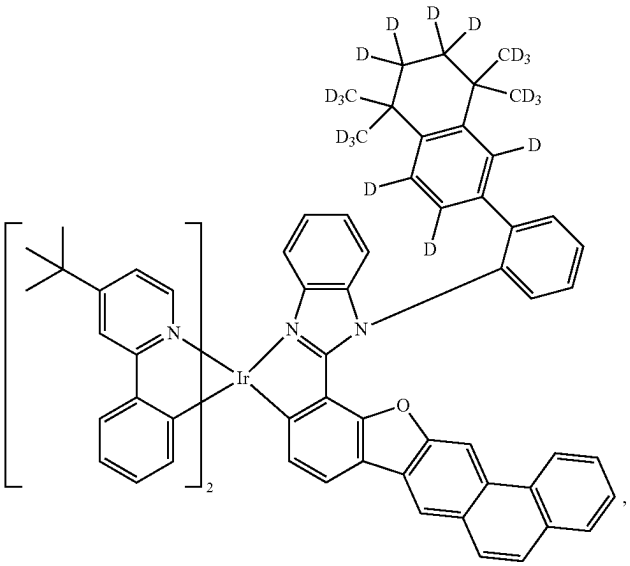

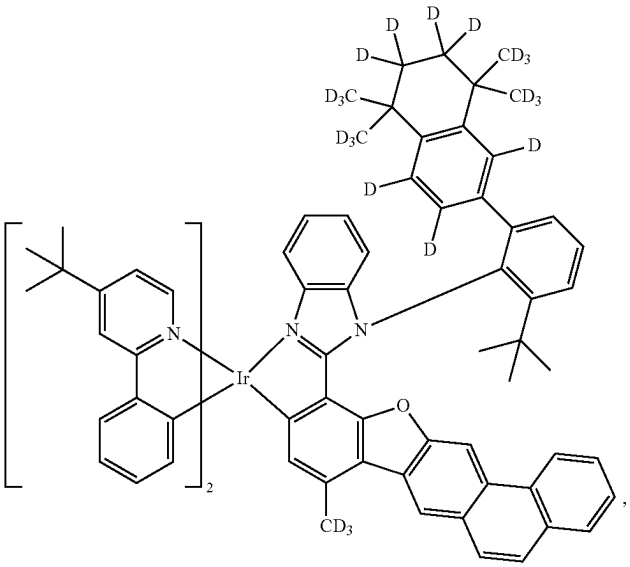

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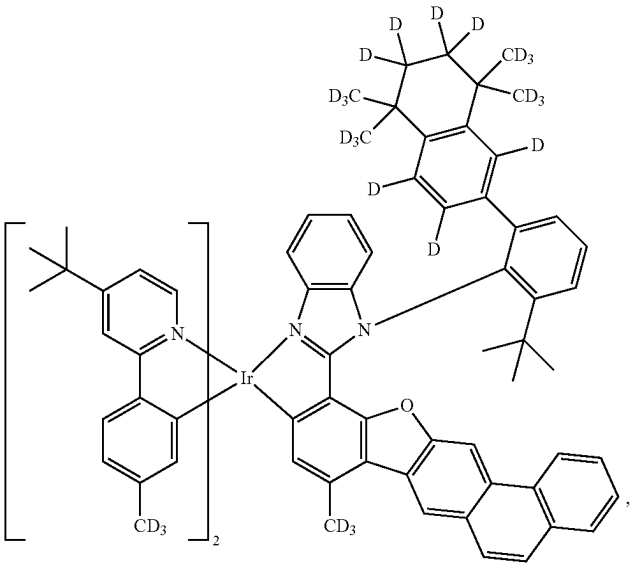

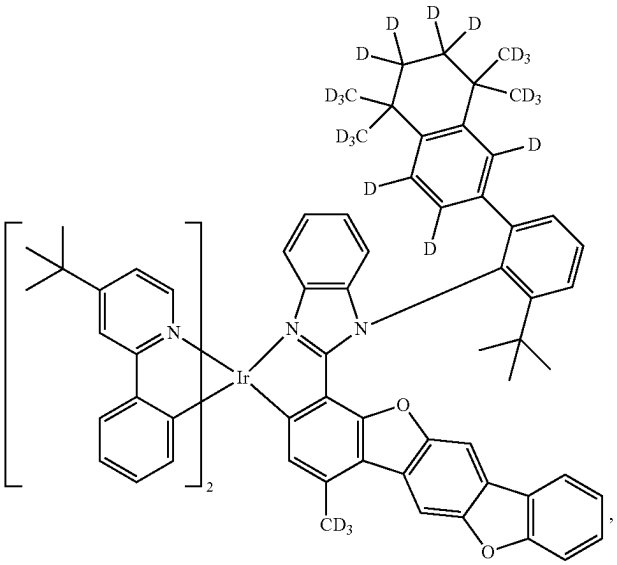

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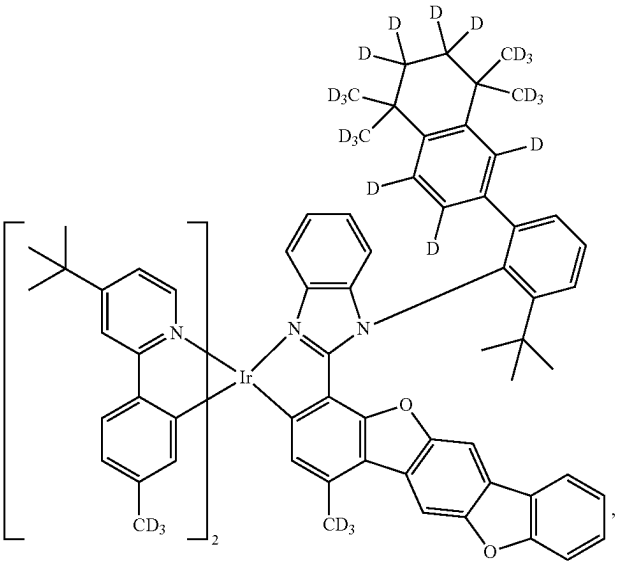

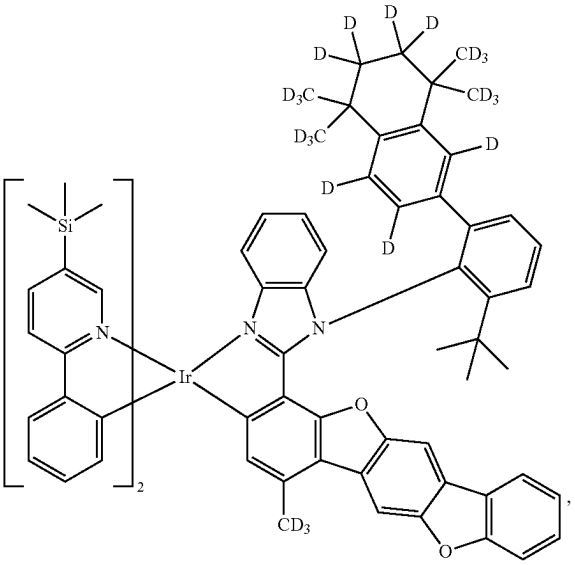

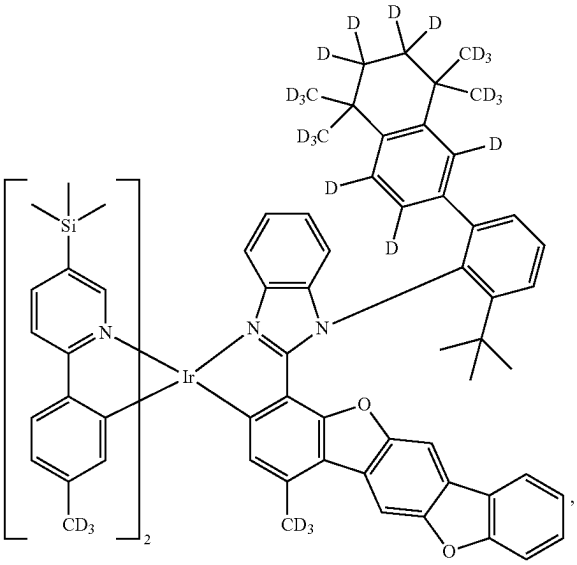

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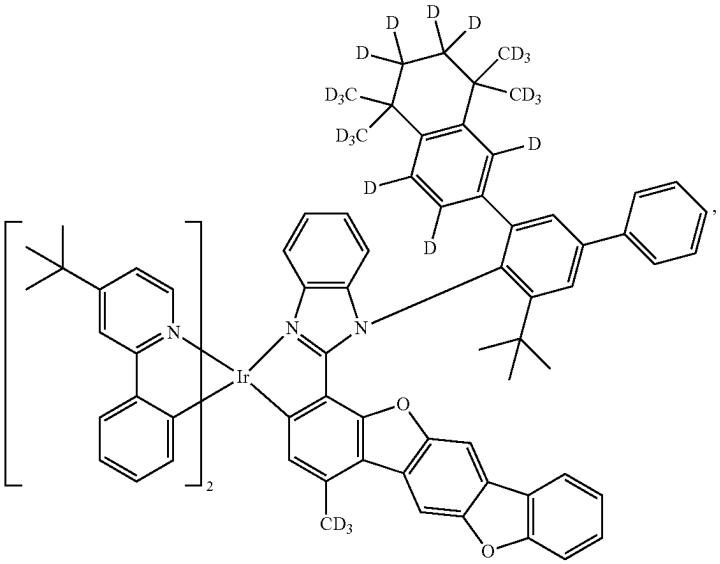

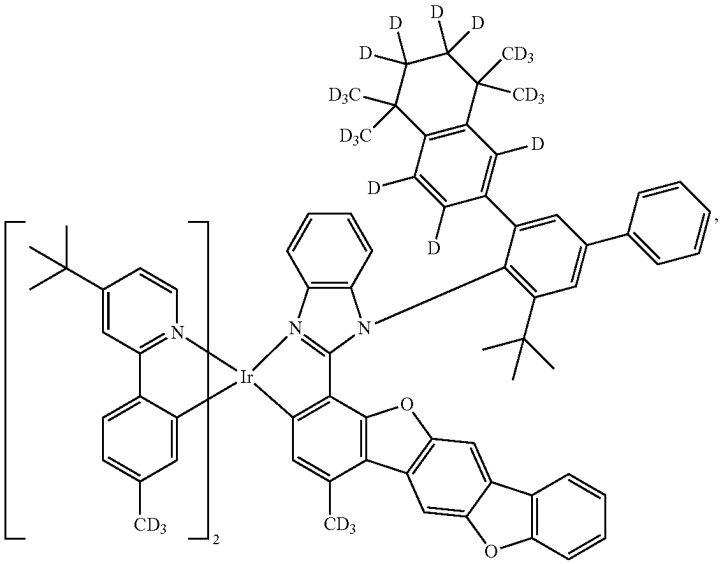

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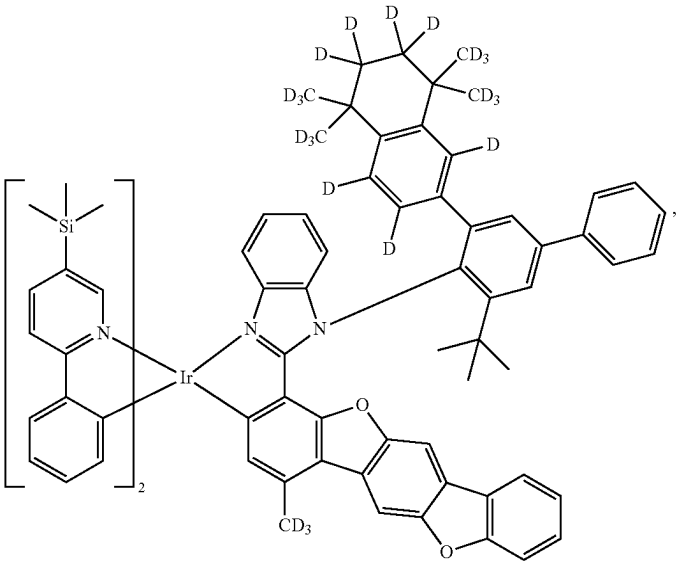

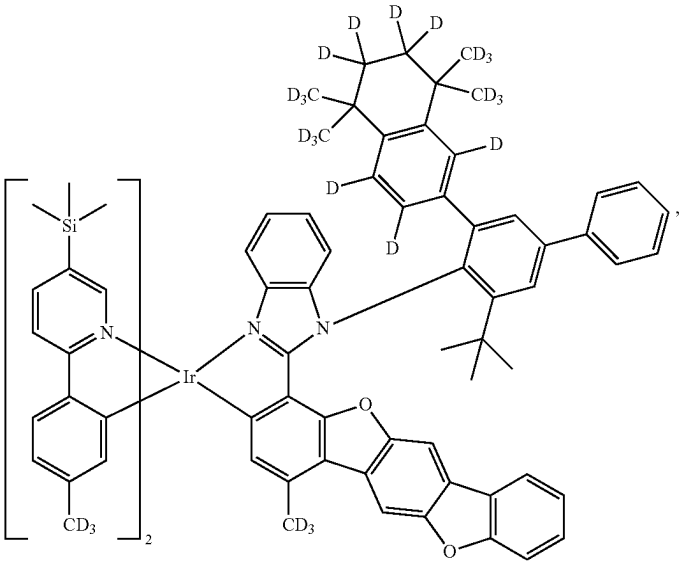

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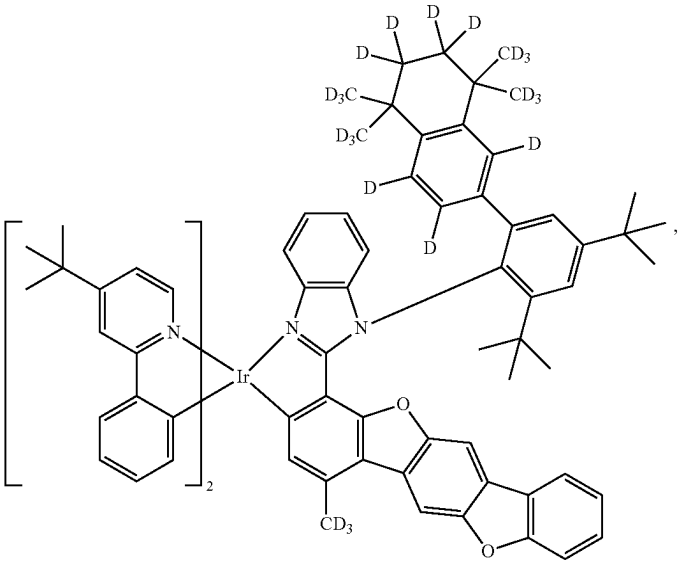

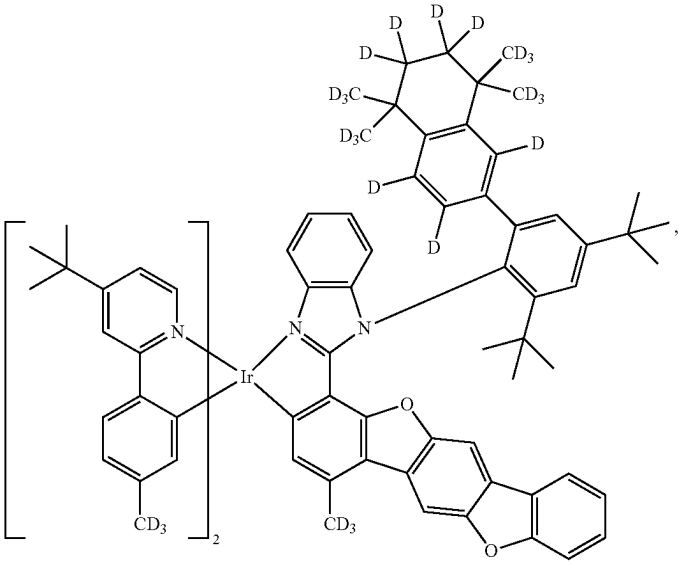

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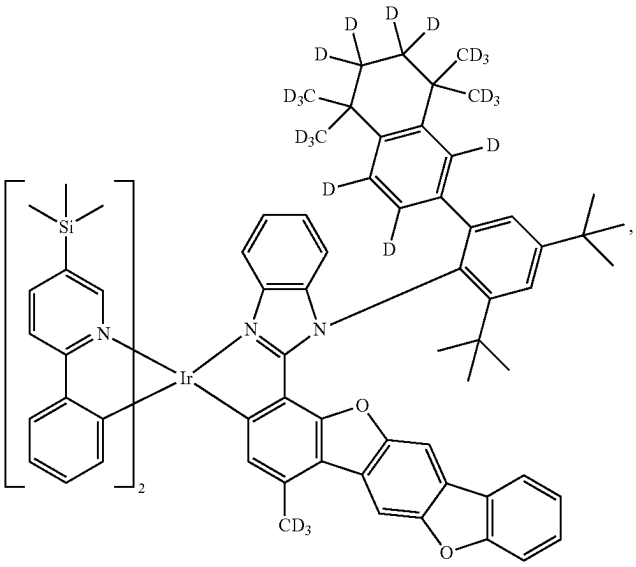

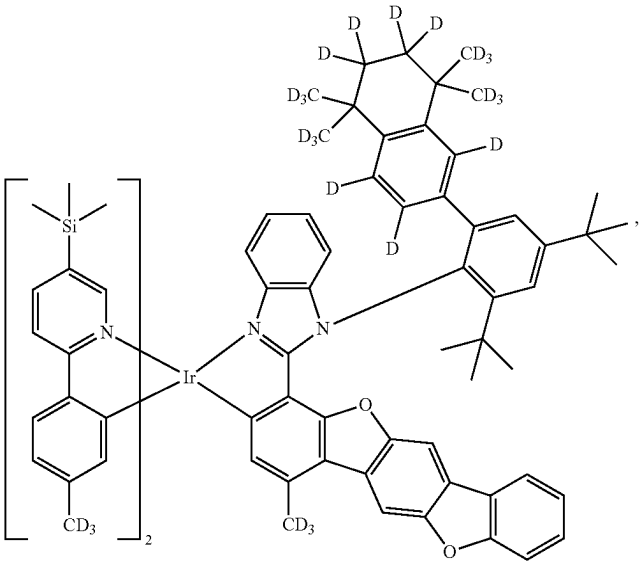

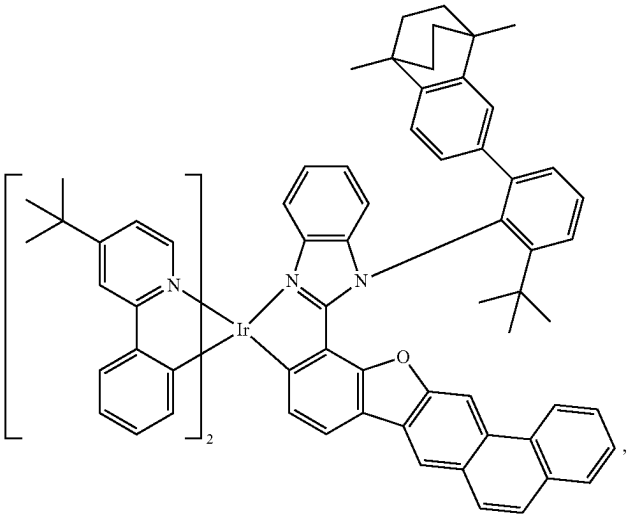

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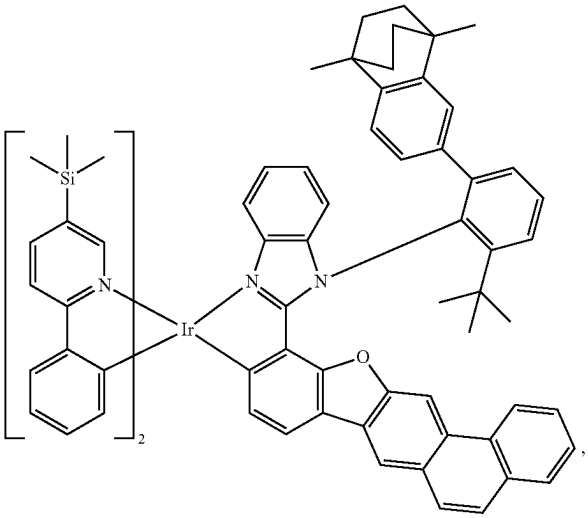

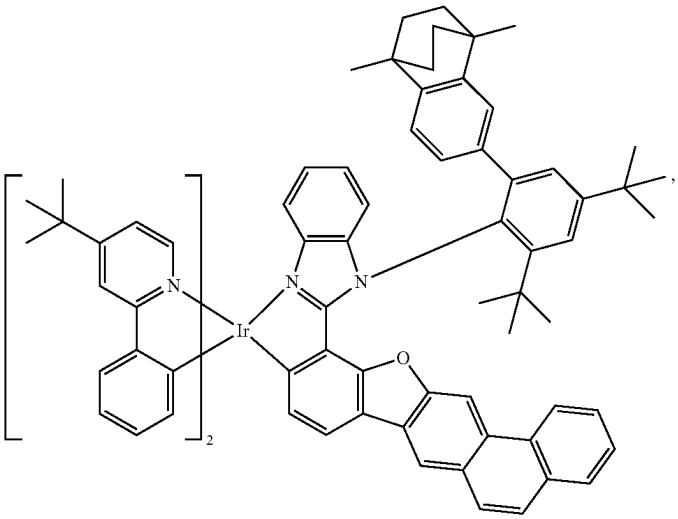

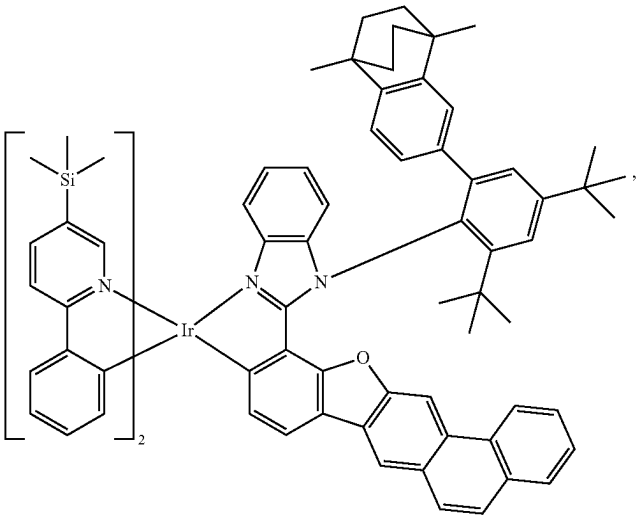

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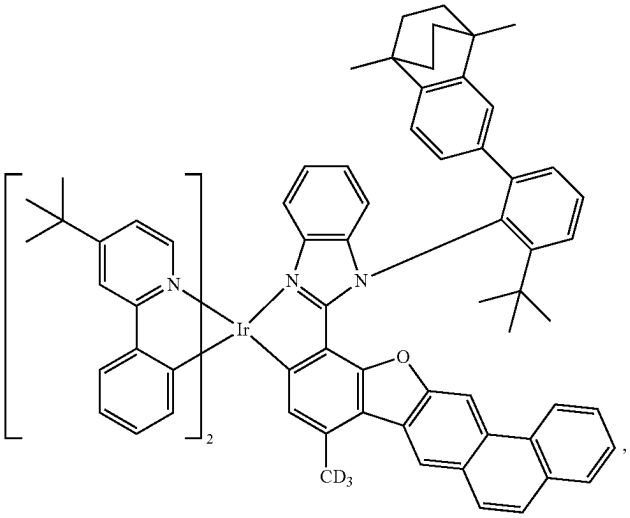

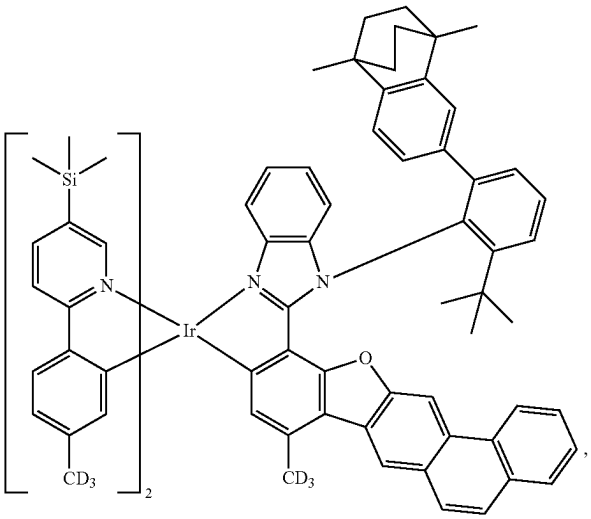

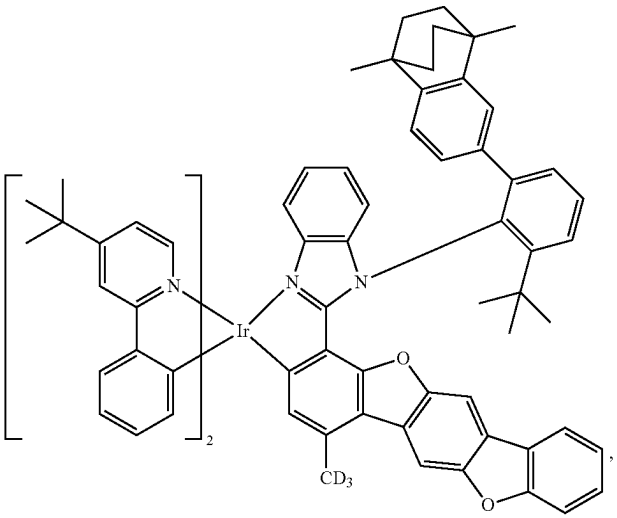

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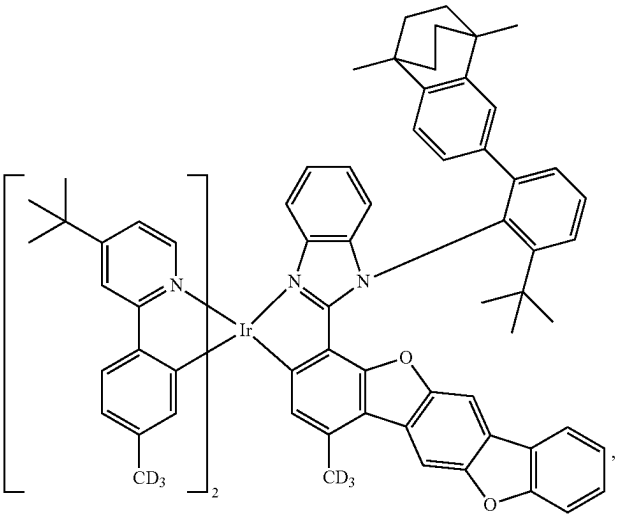

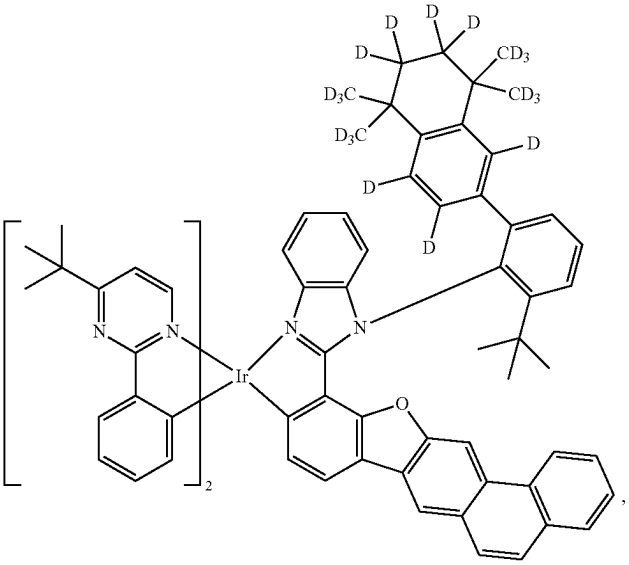

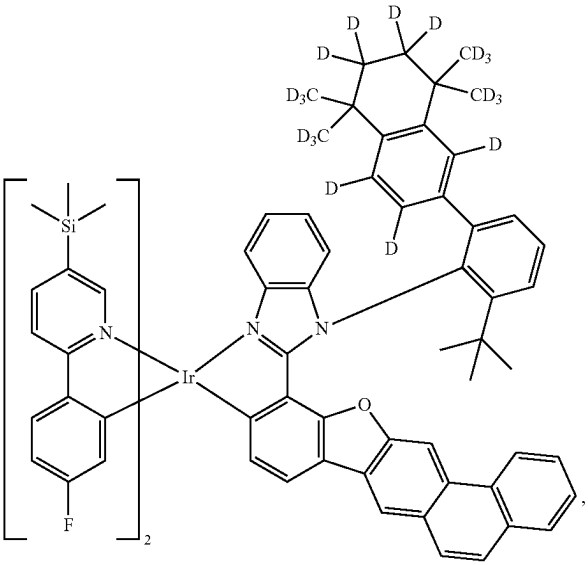

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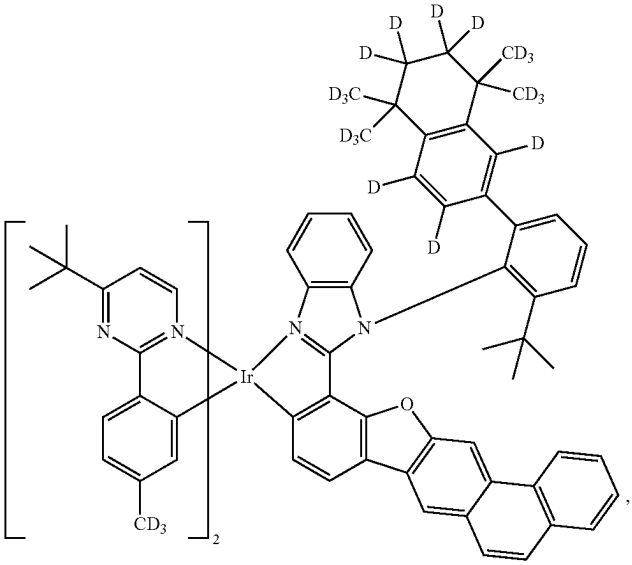

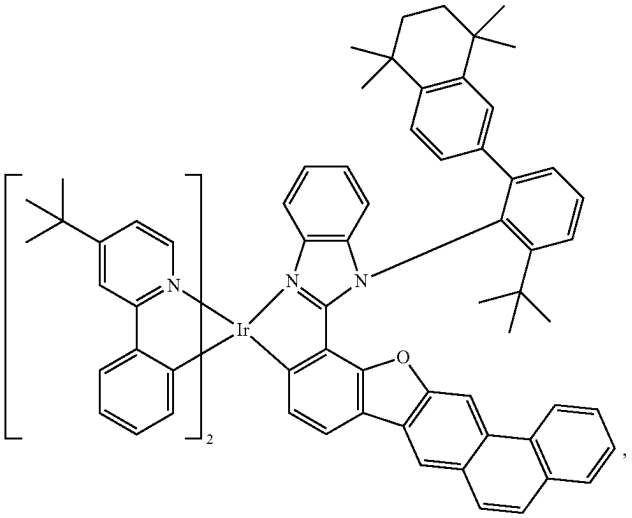

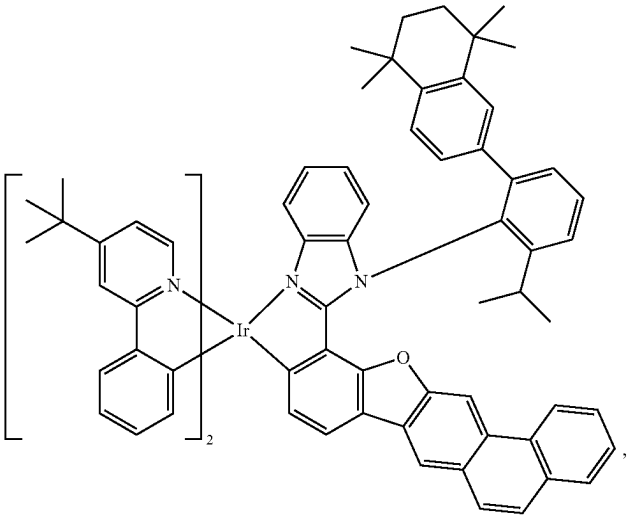

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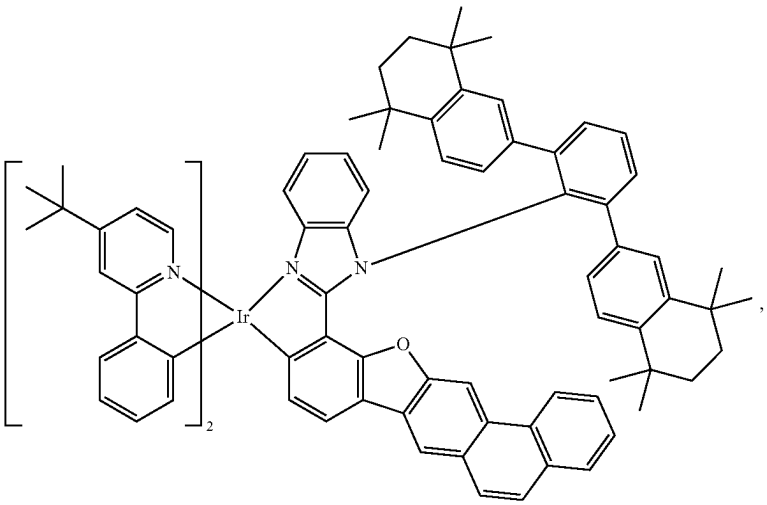

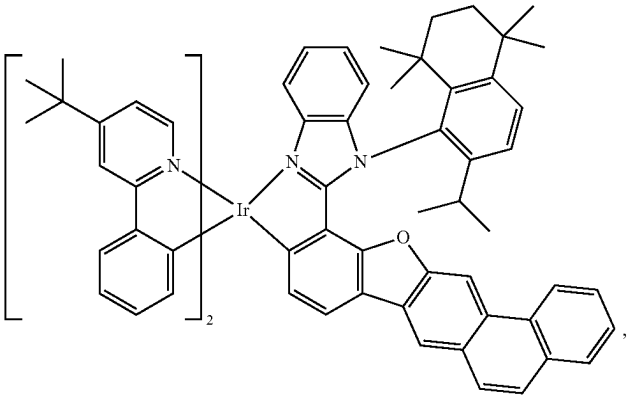

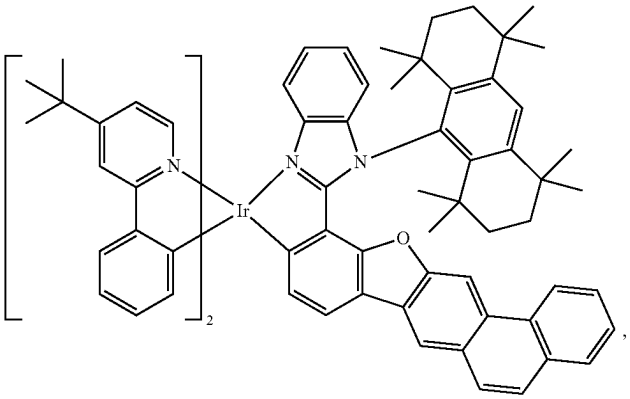

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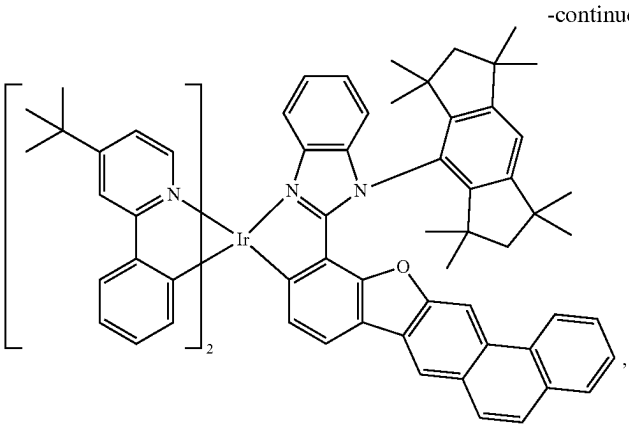
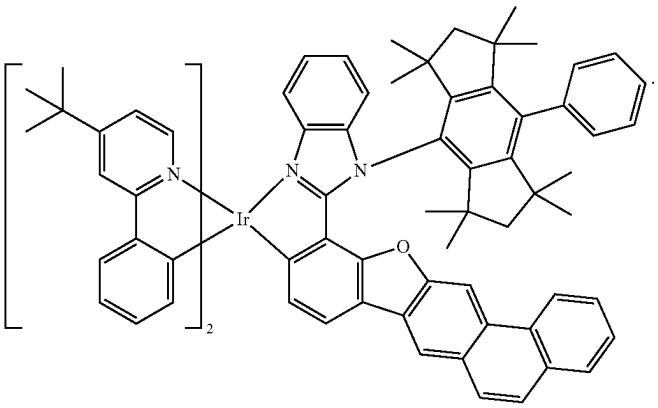


, and



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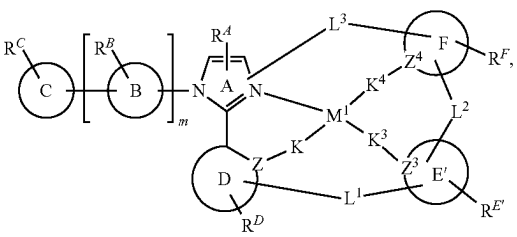
15. The compound of claim **10**, wherein the compound has the Formula III:



wherein:

M^1 is Pd or Pt;

moieties E and F are each independently monocyclic or polycyclic ring structure comprising 5-membered and/or 6-membered carbocyclic or heterocyclic rings;

Z^3 and Z^4 are each independently C or N;

K, K^3, and K^4 are each independently selected from the group consisting of a direct bond, O, and S, wherein at least two of them are direct bonds;

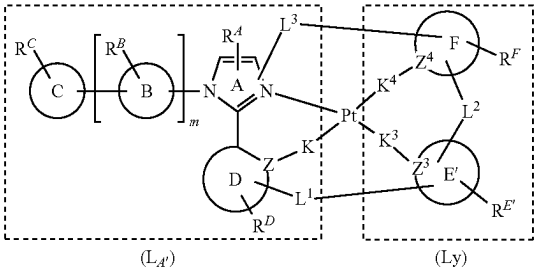
L^1, L^2, and L^3 are each independently absent or selected from the group consisting of a direct bond, BR, BRR', NR, PR, P(O)R, O, S, Se, C═O, C═S, C═Se, C═NR, C═CRR', S═O, SO_2, CR, CRR', SiRR', GeRR', alkylene, cycloalkyl, aryl, cycloalkylene, arylene, heteroarylene, and combinations thereof, wherein at least one of L^1 and L^2 is present;

$R^{E'}$ and R^F each independently represents zero, mono, or up to a maximum allowed number of substitutions to its associated ring;

each of R, R', $R^{E'}$, and R^F is independently a hydrogen or a substituent selected from the group consisting of deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acid, ester, nitrile, isonitrile, sulfanyl, selenyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

two adjacent R^A, R^B, R^C, $R^{E'}$, and R^F can be joined or fused together to form a ring.

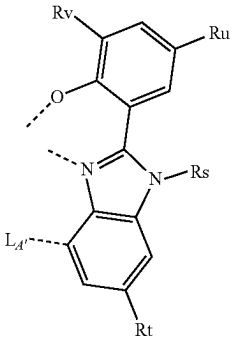
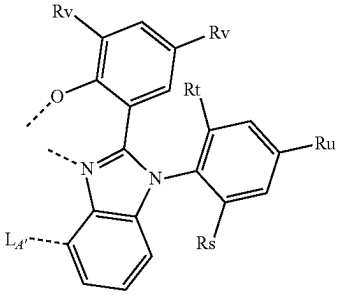
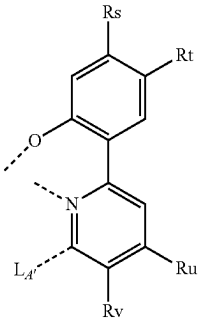
16. The compound of claim **15**, wherein the compound is selected from the group consisting of the compounds having the formula of $Pt(L_{A'})(Ly)$:



$(L_{A'})$ (Ly)

$L_{A'}$ is selected from $L_{A'}$ i'-(Lw)(Ti)(Rm)(Rn)(Ro), wherein i' is an integer from 1 to 27, Lw is L1 or L2, Ti is selected from the group consisting of T1 to T76, and each Rm, Rn, and Ro is independently selected from the group consisting of R1 to R468; wherein each of $L_{A'}$ 1-(L1)(T1)(R1)(R1)(R1) to $L_{A'}$26-(L2)(T63)(R468)(R468)(R468) is defined in LIST 13 defined herein;

wherein L_y is selected from L_yj'-(Rs)(Rt)(Ru)(Rv), wherein j' is an integer from 1 to 23, and each Rs, Rt, Ru, and Rv is independently selected from the group consisting of R1 to R468; wherein each of L_y1-(R1)(R1)(R1)(R1) to L_y23-(R468)(R468)(R468)(R468) is defined as follows:

Compound	Structure of compound
L_y1-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y1-(R1)(R1)(R1)(R1) to L_y1-(R468)(R468)(R468)(R468) have the structure	
L_y2-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y2-(R1)(R1)(R1)(R1) to L_y2-(R468)(R468)(R468)(R468) have the structure	
L_y3-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y3-(R1)(R1)(R1)(R1) to L_y3-(R468)(R468)(R468)(R468) have the structure	

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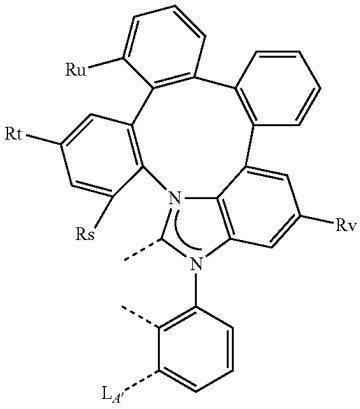
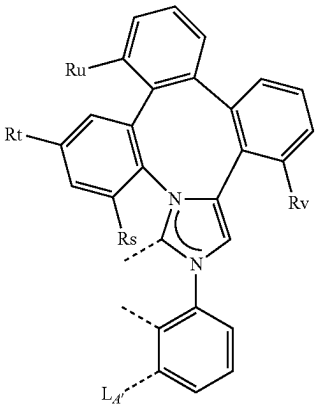
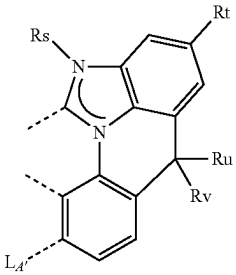
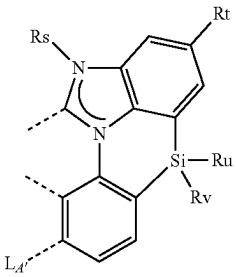
Compound	Structure of compound
L_y4-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y4-(R1)(R1)(R1)(R1) to L_y4-(R468)(R468)(R468)(R468) have the structure	
L_y5-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y5-(R1)(R1)(R1)(R1) to L_y5-(R468)(R468)(R468)(R468) have the structure	
L_y6-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y6-(R1)(R1)(R1)(R1) to L_y6-(R468)(R468)(R468)(R468) have the structure	
L_y7-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y7-(R1)(R1)(R1)(R1) to L_y7-(R468)(R468)(R468)(R468) have the structure	

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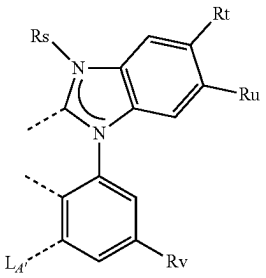
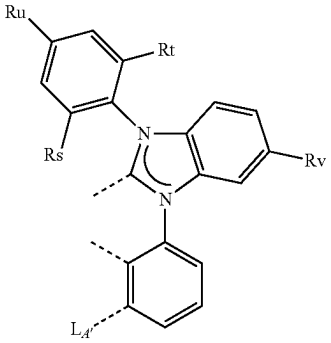
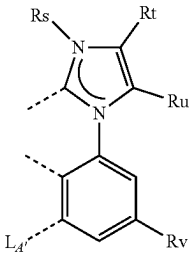
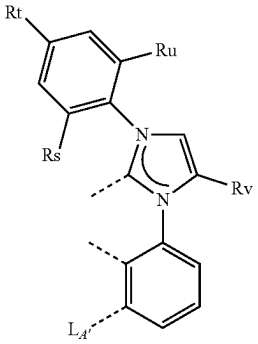
Compound	Structure of compound
L_y8-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y8-(R1)(R1)(R1)(R1) to L_y8-(R468)(R468)(R468)(R468) have the structure	
L_y9-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y9-(R1)(R1)(R1)(R1) to L_y9-(R468)(R468)(R468)(R468) have the structure	
L_y10-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y10-(R1)(R1)(R1)(R1) to L_y10-(R468)(R468)(R468)(R468) have the structure	
L_y11-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y11-(R1)(R1)(R1)(R1) to L_y11-(R468)(R468)(R468)(R468) have the structure	

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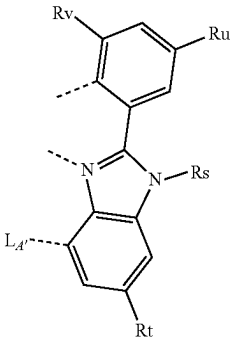
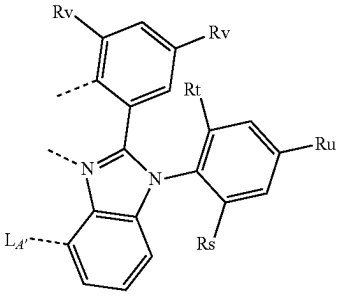
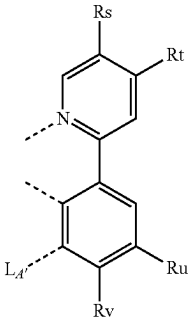
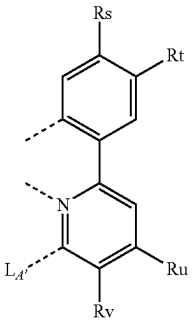
Compound	Structure of compound
L_y12-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y12-(R1)(R1)(R1)(R1) to L_y12-(R468)(R468)(R468)(R468) have the structure	
L_y13-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y13-(R1)(R1)(R1)(R1) to L_y13-(R468)(R468)(R468)(R468) have the structure	
L_y14-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y14-(R1)(R1)(R1)(R1) to L_y14-(R468)(R468)(R468)(R468) have the structure	
L_y15-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y15-(R1)(R1)(R1)(R1) to L_y15-(R468)(R468)(R468)(R468) have the structure	

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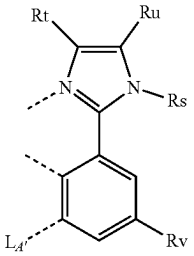
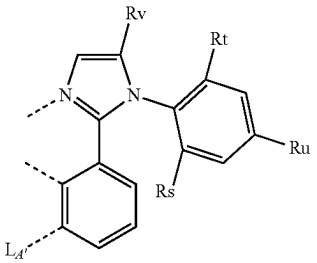
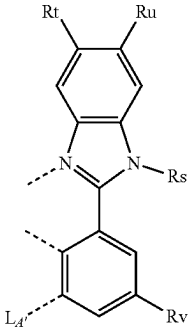
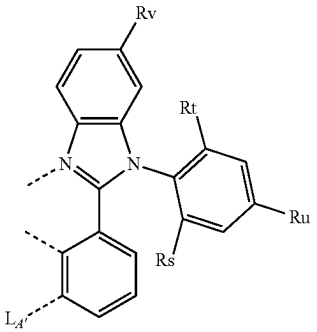
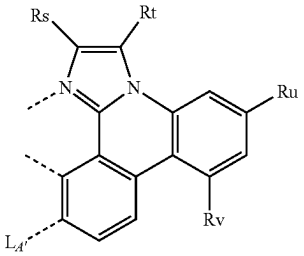
Compound	Structure of compound
L_y16-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y16-(R1)(R1)(R1)(R1) to L_y16-(R468)(R468)(R468)(R468) have the structure	
L_y17-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y17-(R1)(R1)(R1)(R1) to L_y17-(R468)(R468)(R468)(R468) have the structure	
L_y18-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y18-(R1)(R1)(R1)(R1) to L_y18-(R468)(R468)(R468)(R468) have the structure	
L_y19-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y19-(R1)(R1)(R1)(R1) to L_y19-(R468)(R468)(R468)(R468) have the structure	
L_y20-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y20-(R1)(R1)(R1)(R1) to L_y20-(R468)(R468)(R468)(R468) have the structure	

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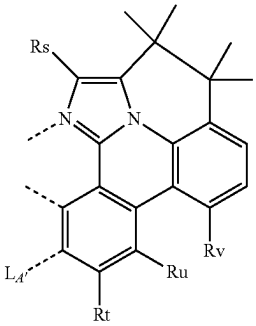
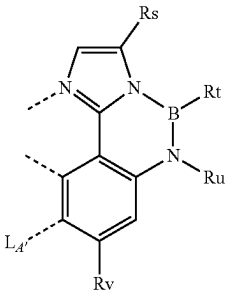
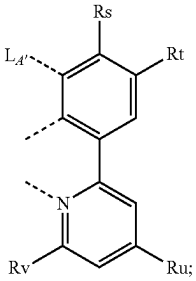
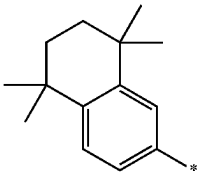
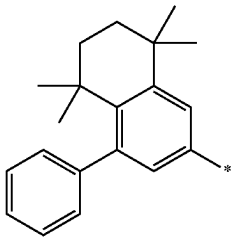
Compound	Structure of compound
L_y21-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y21-(R1)(R1)(R1)(R1) to L_y21-(R468)(R468)(R468)(R468) have the structure	
L_y22-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y22-(R1)(R1)(R1)(R1) to L_y22-(R468)(R468)(R468)(R468) have the structure	
L_y23-(R*s*)(R*t*)(R*u*)(R*v*), wherein L_y23-(R1)(R1)(R1)(R1) to L_y23-(R468)(R468)(R468)(R468) have the structure	

wherein L1 is a direct bond and L2 is —O—;

wherein each of T1 to T76 has the structures defined as follows:

Structure	
	T1
	T2

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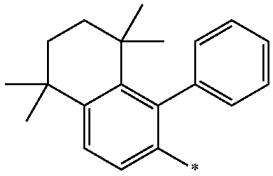
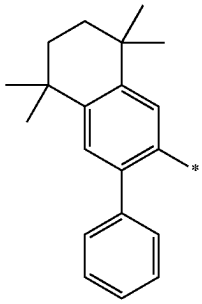
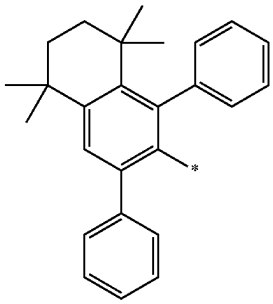
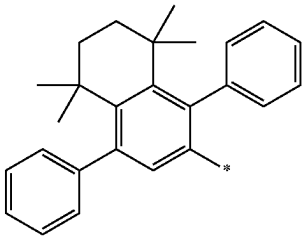
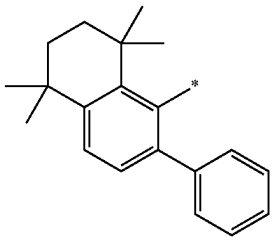
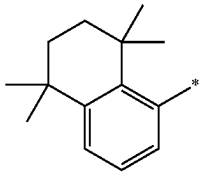
Structure	
	T3
	T4
	T5
	T6
	T7
	T8

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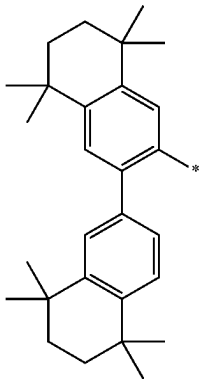
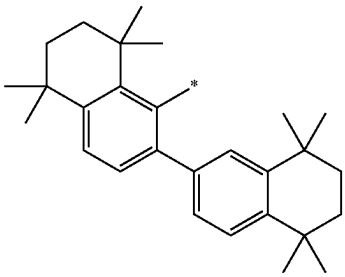
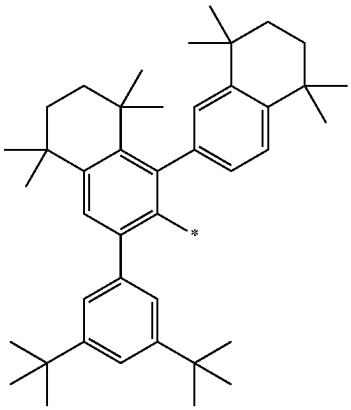
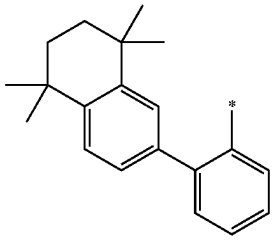
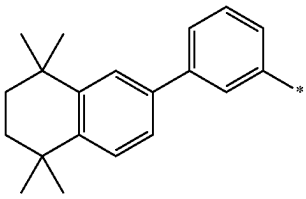
Structure	
	T9
	T10
	T11
	T12
	T13

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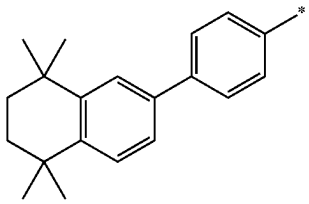
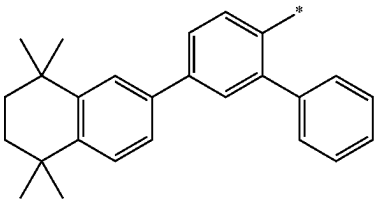
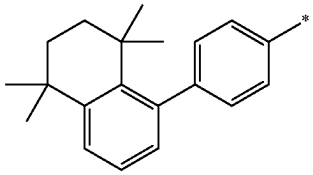
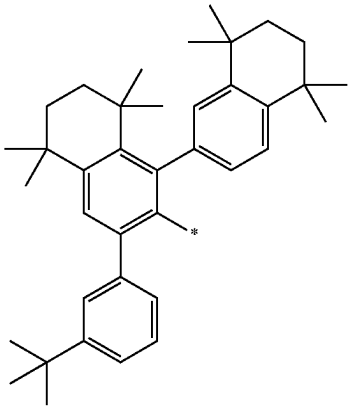
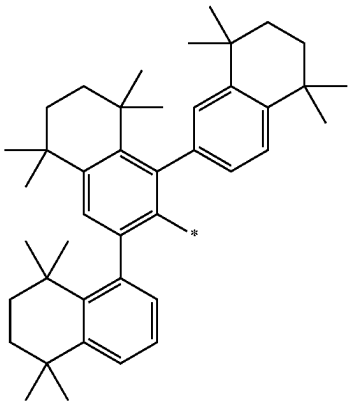
Structure	
	T14
	T15
	T16
	T17
	T18

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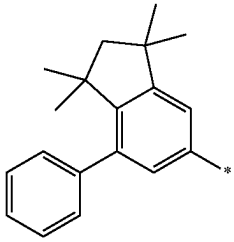
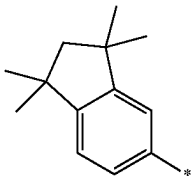
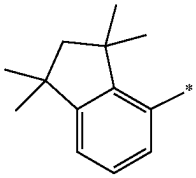
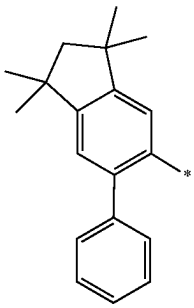
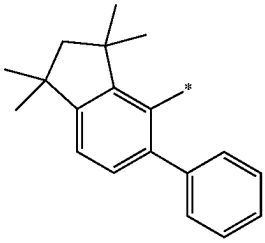
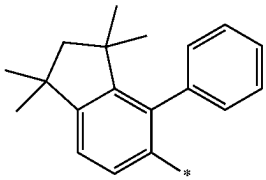
Structure	
	T19
	T20
	T21
	T22
	T23
	T24

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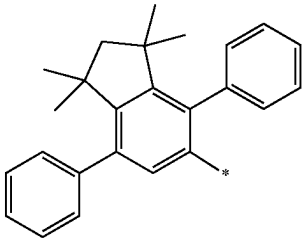
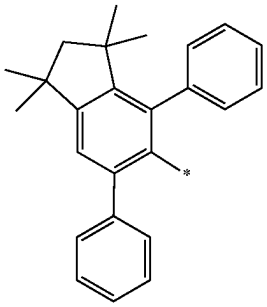
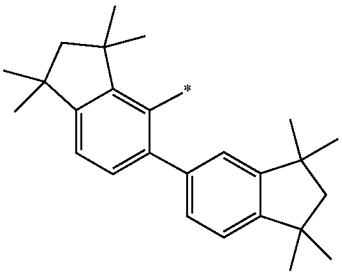
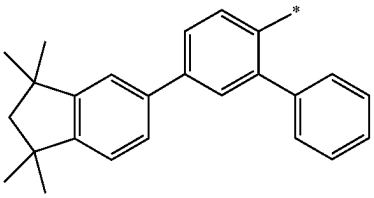
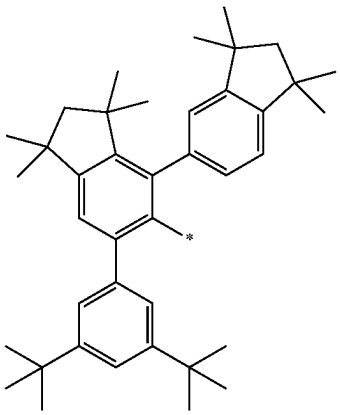
Structure	
	T25
	T26
	T27
	T28
	T29

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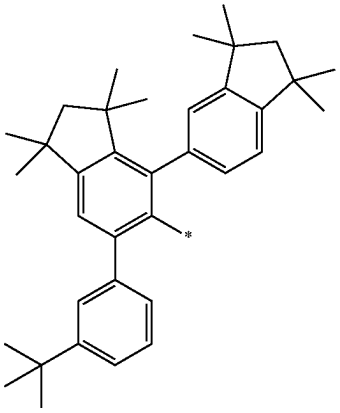
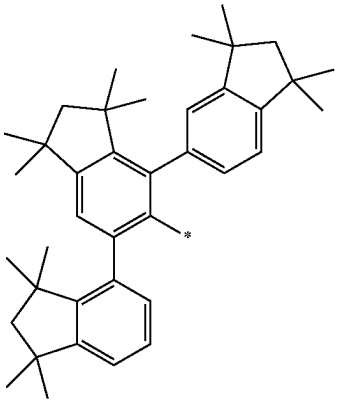
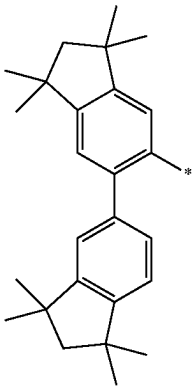
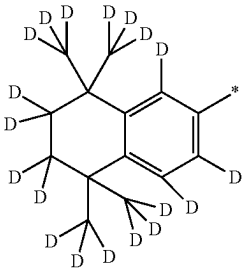
Structure	
	T30
	T31
	T32
	T33

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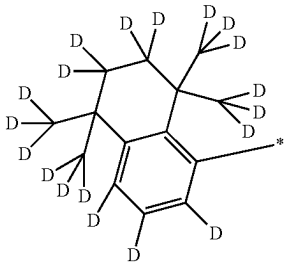
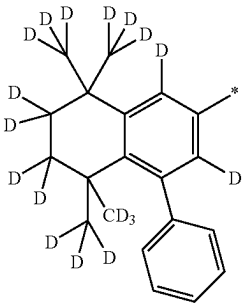
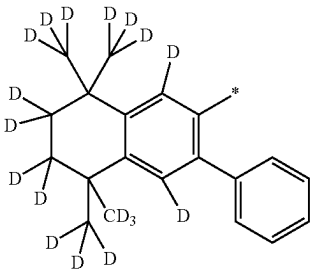
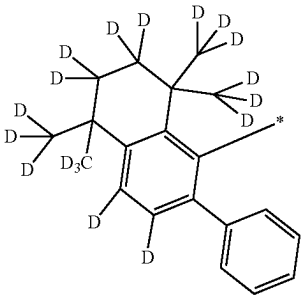
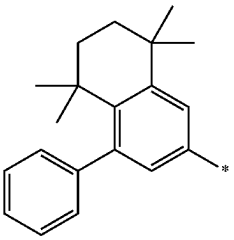
Structure	
	T34
	T35
	T36
	T37
	T38

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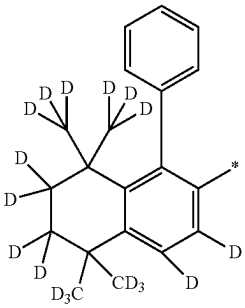
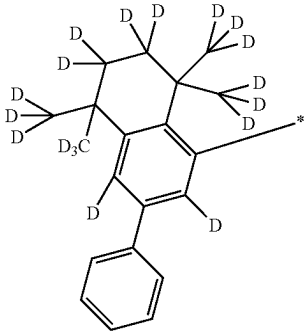
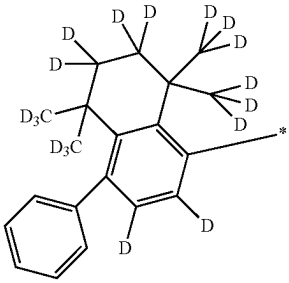
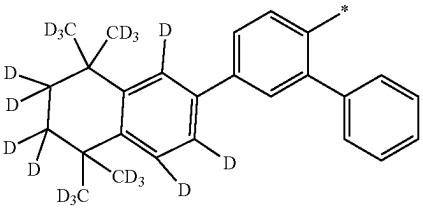
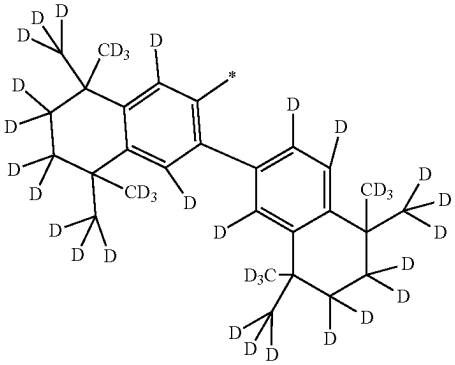
Structure	
	T39
	T40
	T41
	T42
	T43

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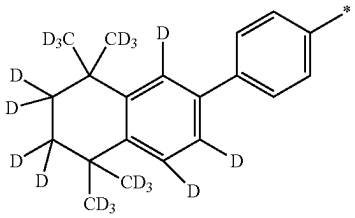
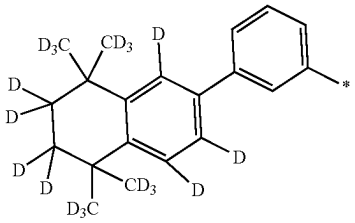
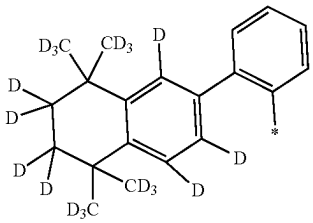
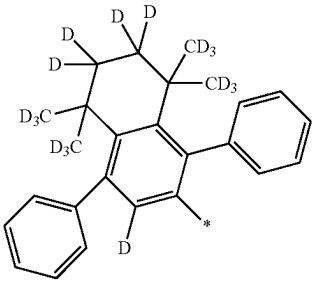
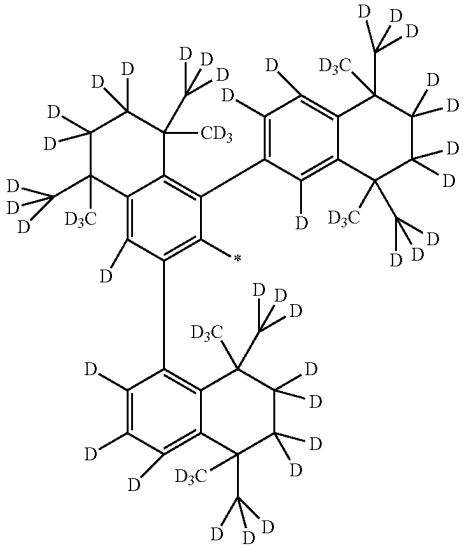
	T44
	T45
	T46
	T47
	T48

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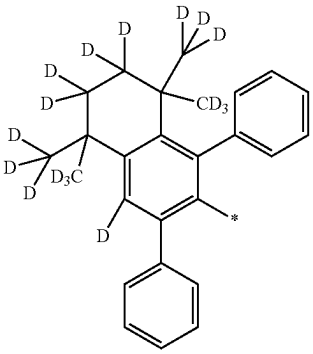
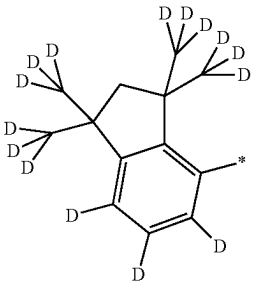
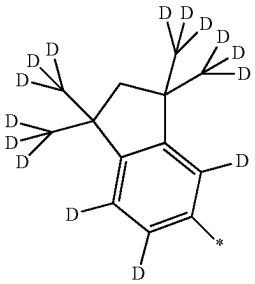
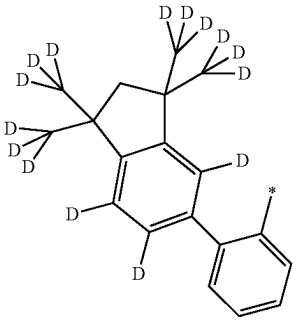
	T49
	T50
	T51
	T52

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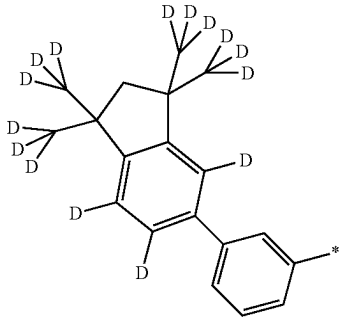
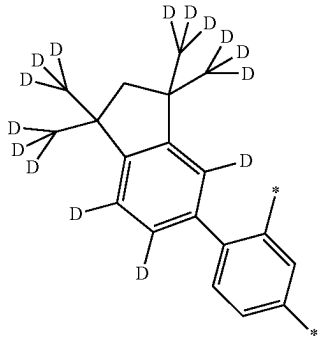
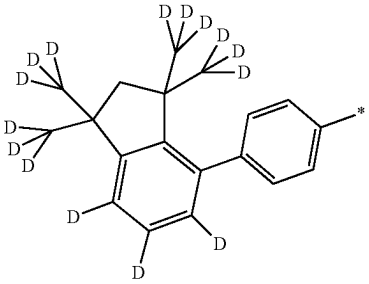
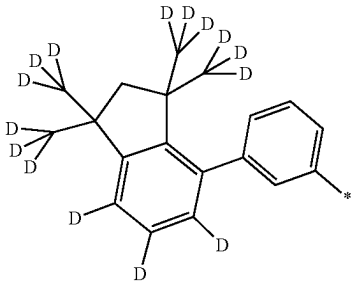
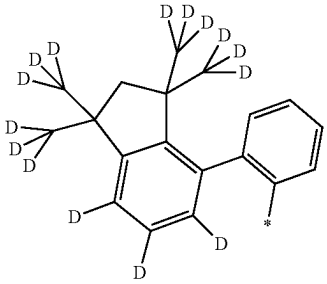
	T53
	T54
	T55
	T56
	T57

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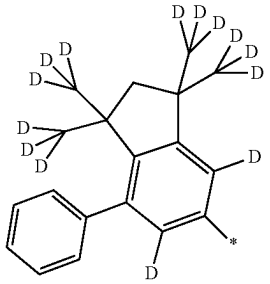
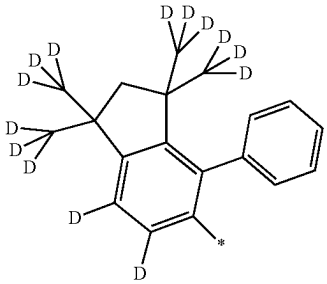
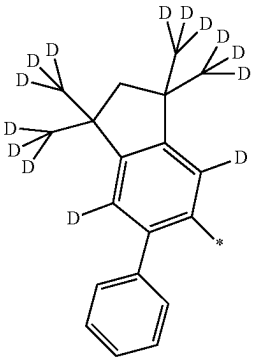
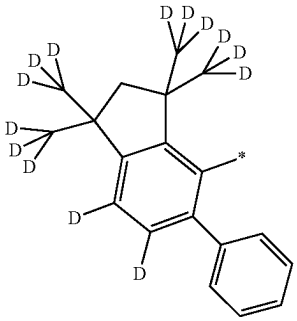
	T58
	T59
	T60
	T61

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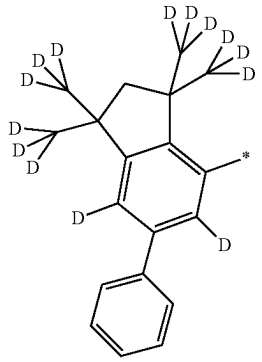
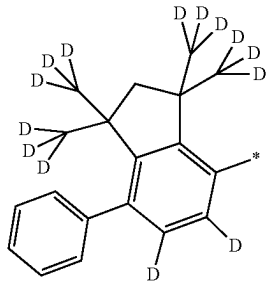
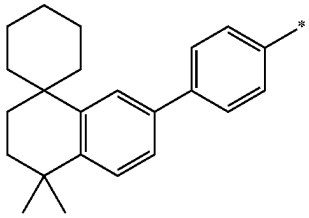
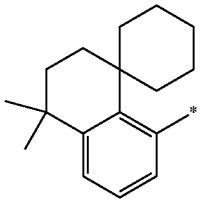
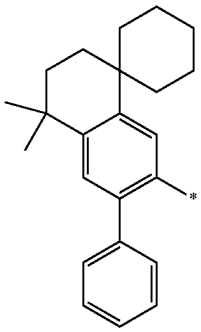
	T62
	T63
	T64
	T65
	T66

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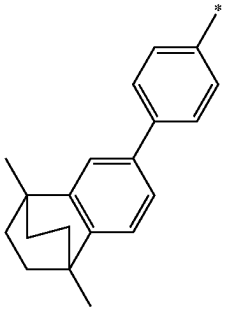
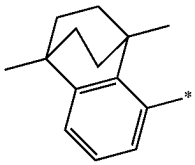
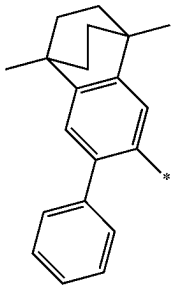
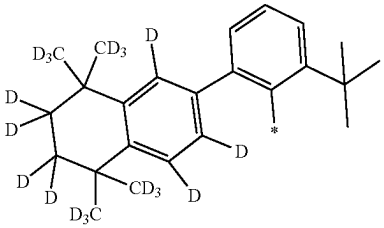
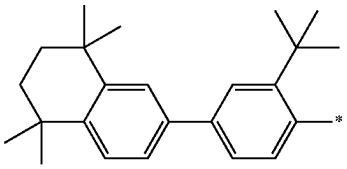
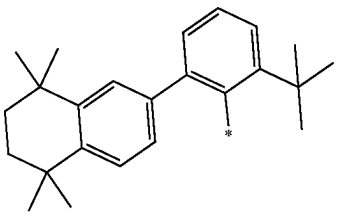
Structure	
	T67
	T68
	T69
	T70
	T71
	T72

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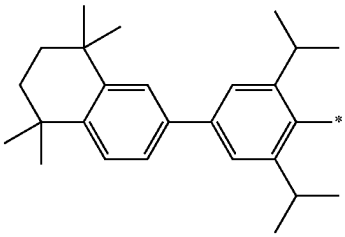
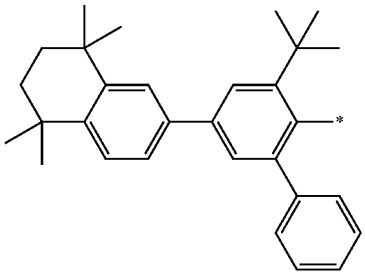
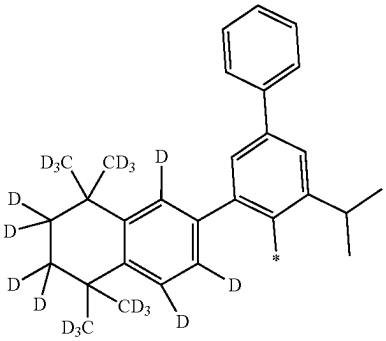
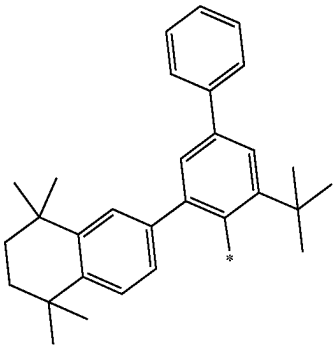
	T73
	T74
	T75
	T76

wherein R1 to R468 are defined as follows:

Structure	
	R1
	R2

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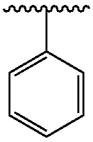
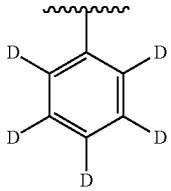
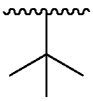
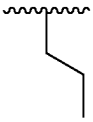
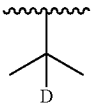
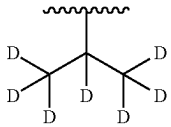
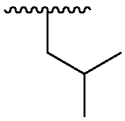
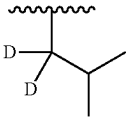
Structure	
	R3
	R4
	R5
	R6
	R7
	R8
	R9
	R10
	R11
	R12
	R13
	R14

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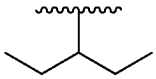
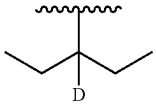
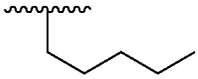
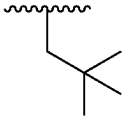
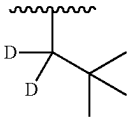
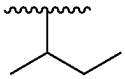
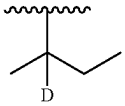
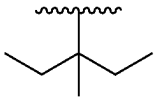
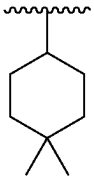
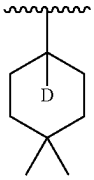
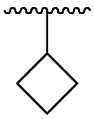
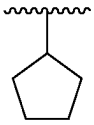
	R15
	R16
	R17
	R18
	R19
	R20
	R21
	R22
	R23
	R24
	R25
	R26

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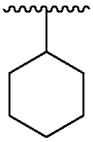
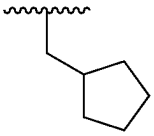
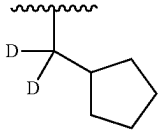
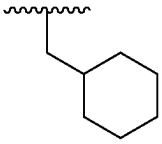
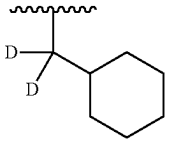
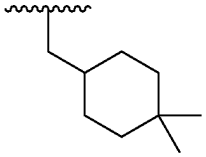
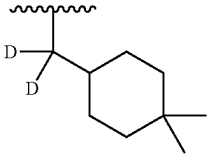
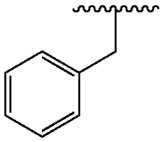
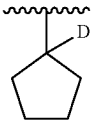
	R27
	R28
	R29
	R30
	R31
	R32
	R33
	R34
	R35

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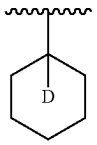
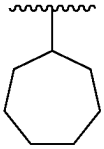
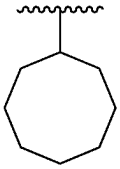
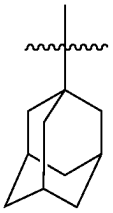
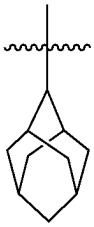
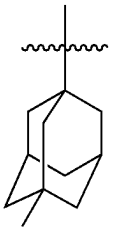
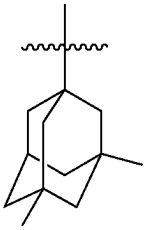
	R36
	R37
	R38
	R39
	R40
	R41
	R42

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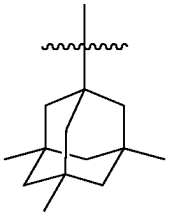
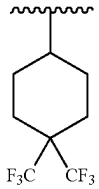
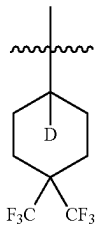
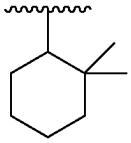
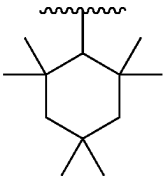
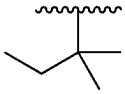
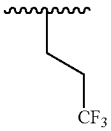
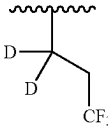
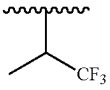
	R43
	R44
	R45
	R46
	R47
	R48
	R49
	R50
	R51

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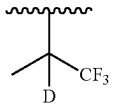
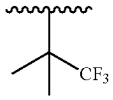
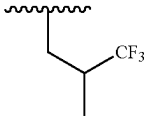
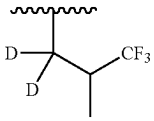
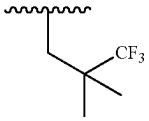
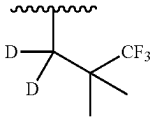
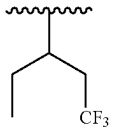
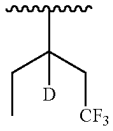
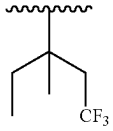
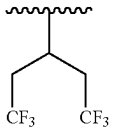
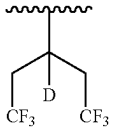
	R52
	R53
	R54
	R55
	R56
	R57
	R58
	R59
	R60
	R61
	R62

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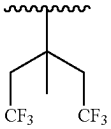	R63
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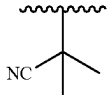
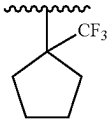
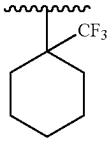
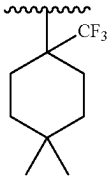
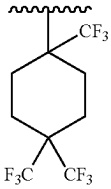
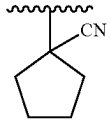
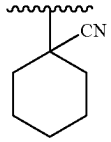
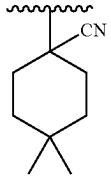
	R65
	R66
	R67
	R68
	R69
	R70
	R71
	R72

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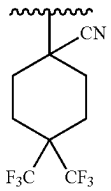
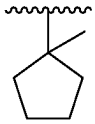
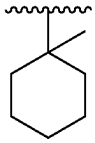
	R73
	R74
	R75
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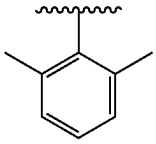
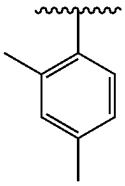
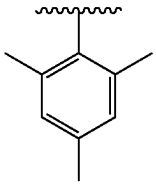
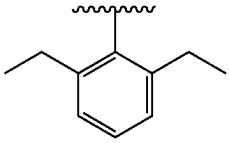
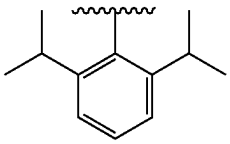
	R77
	R78
	R79
	R80
	R81

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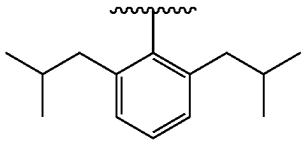
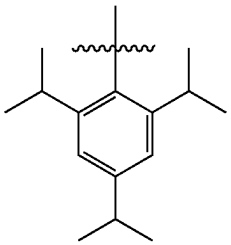
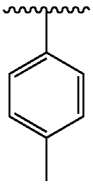
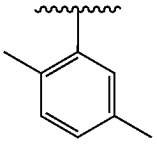
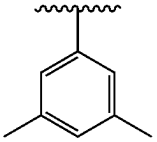
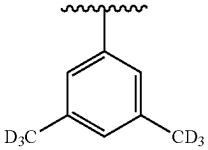
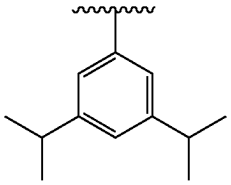
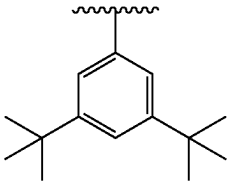
	R82
	R83
	R84
	R85
	R86
	R87
	R88
	R89

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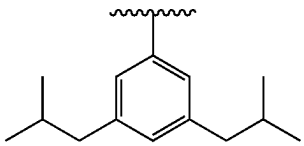
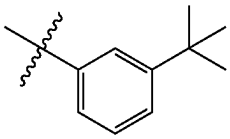
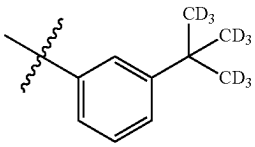
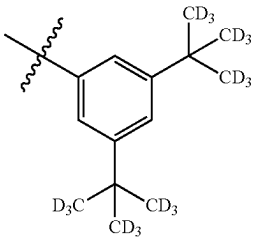
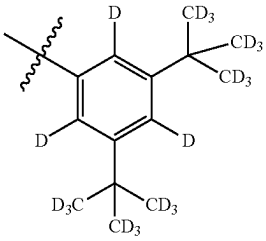
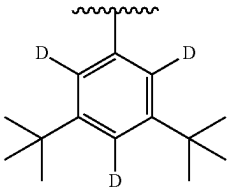
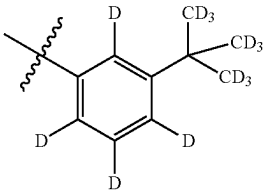
	R90
	R91
	R92
	R93
	R94
	R95
	R96

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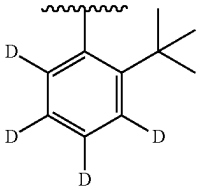
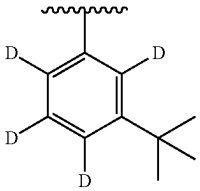
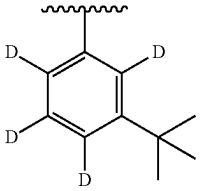
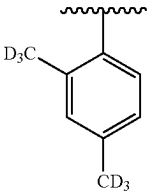
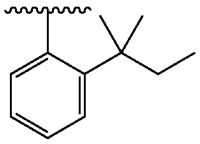
	R97
	R98
	R99
	R100
	R101
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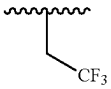
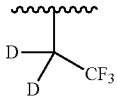
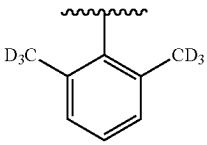
	R104
	R105
	R106

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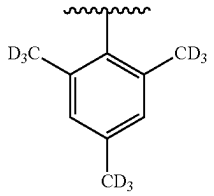
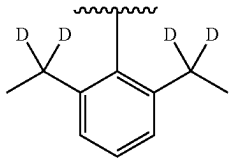
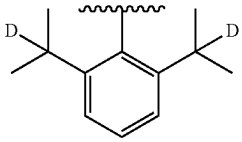
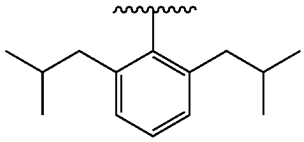
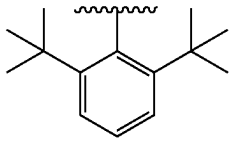
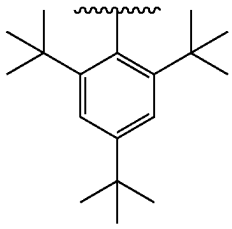
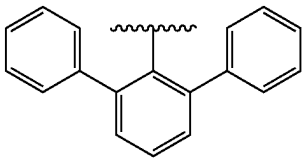
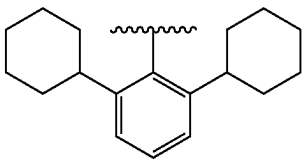
	R107
	R108
	R109
	R110
	R111
	R112
	R113
	R114

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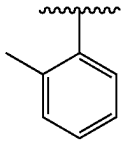
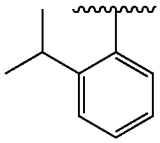
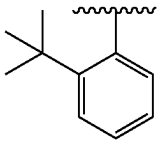
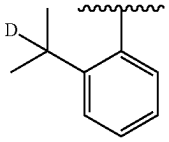
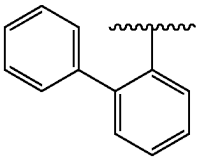
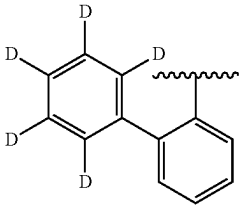
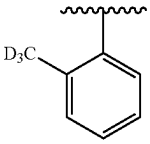
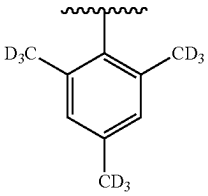
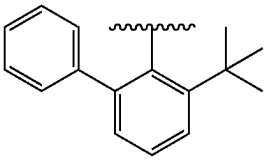
	R115
	R116
	R117
	R118
	R119
	R120
	R121
	R122
	R123

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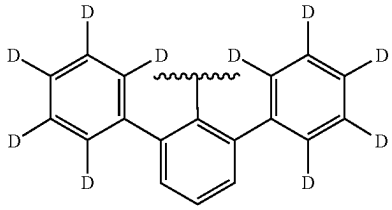
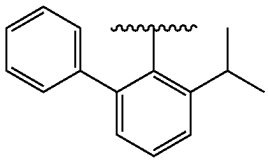
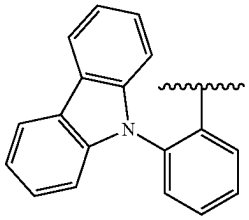
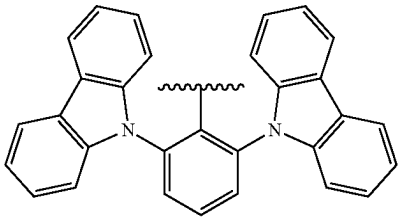
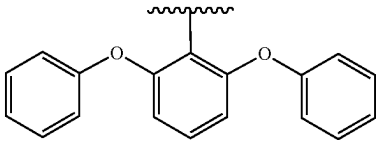
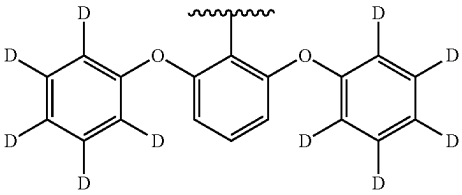
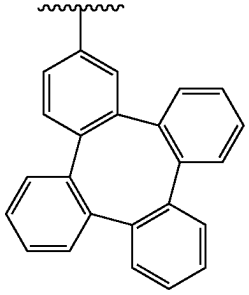
	R124
	R125
	R126
	R127
	R128
	R129
	R130

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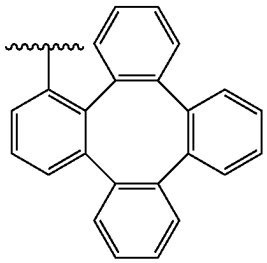
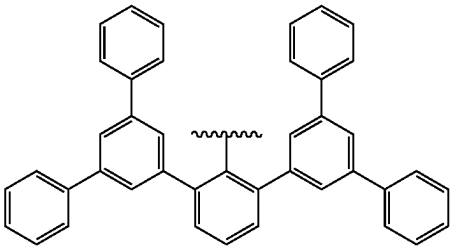
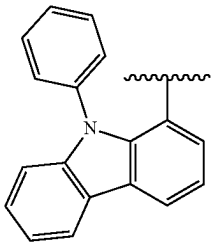
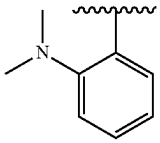
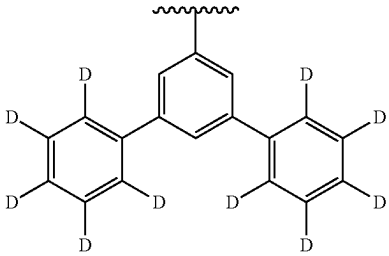
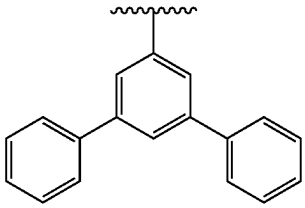
	R131
	R132
	R133
	R134
	R135
	R136

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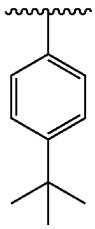
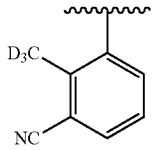
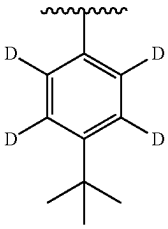
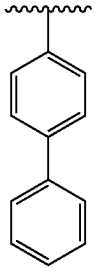
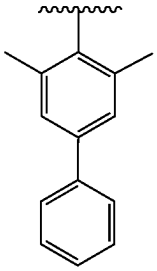
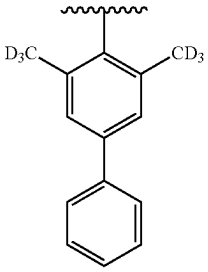
	R137
	R138
	R139
	R140
	R141
	R142

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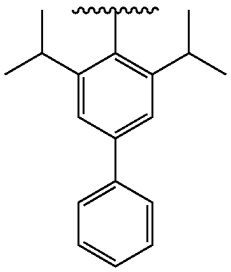
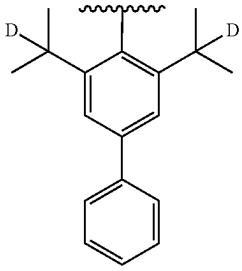
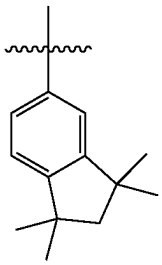
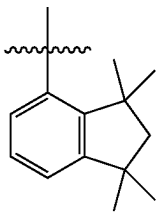
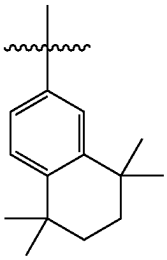
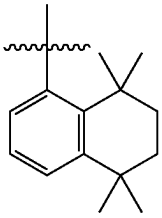
	R143
	R144
	R145
	R146
	R147
	R148

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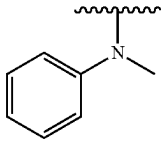
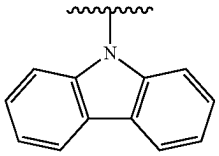
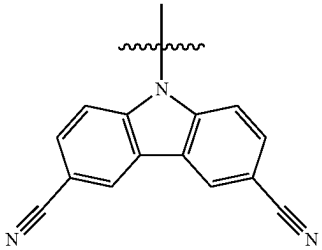
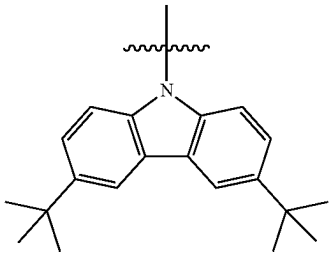
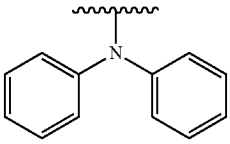
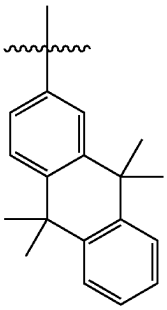
	R149
	R150
	R151
	R152
	R153
	R154

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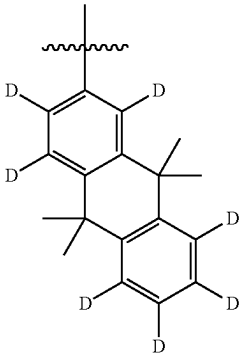
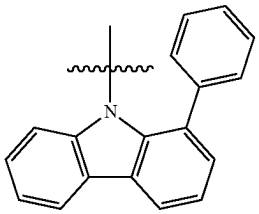
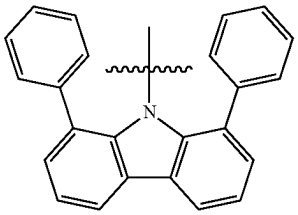
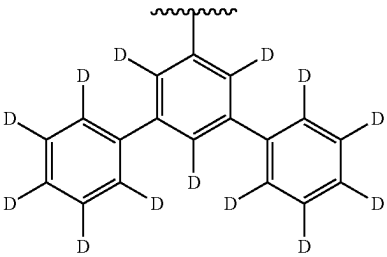
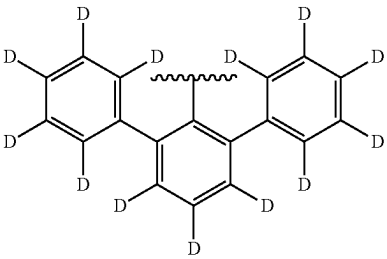
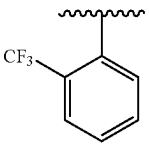
	R155
	R156
	R157
	R158
	R159
	R160

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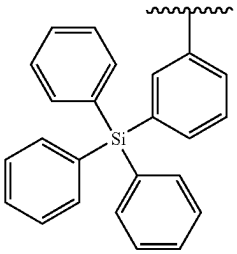
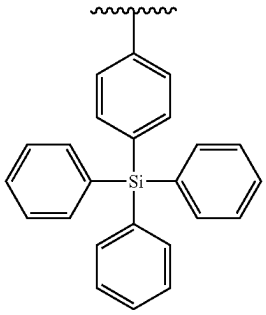
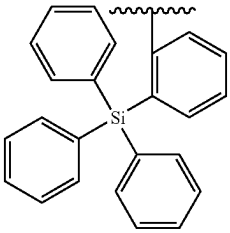
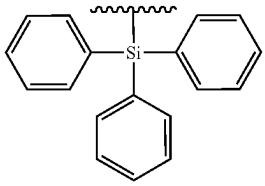
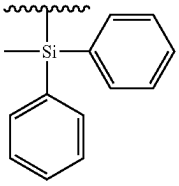
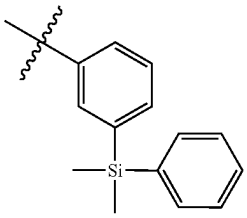
	R161
	R162
	R163
	R164
	R165
	R166

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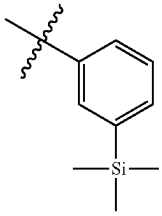
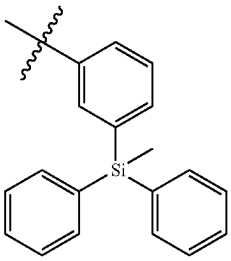
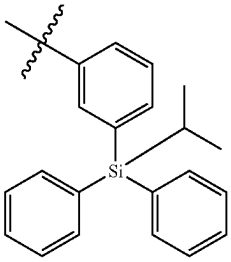
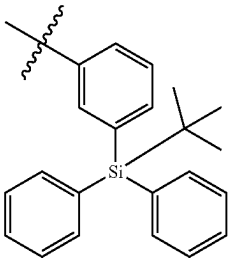
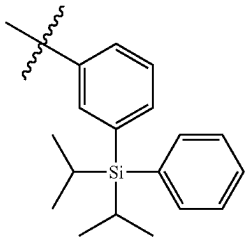
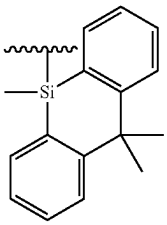
	R167
	R168
	R169
	R170
	R171
	R172

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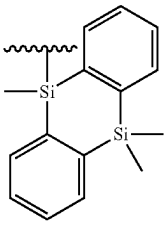	R173
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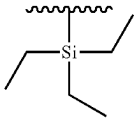
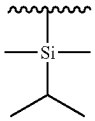
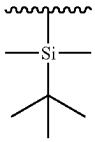
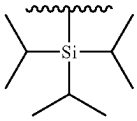
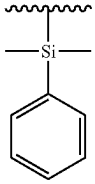
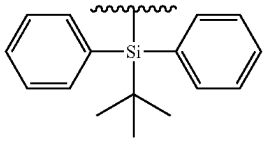
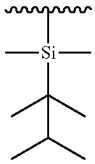
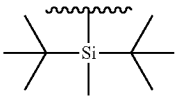
	R175
	R176
	R177
	R178
	R179
	R180
	R181
	R182

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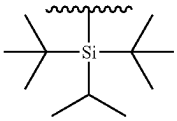
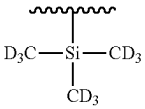
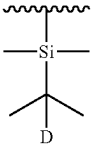
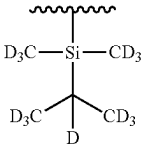
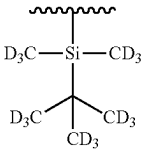
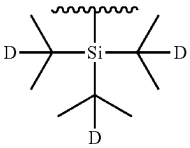
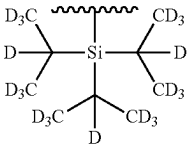
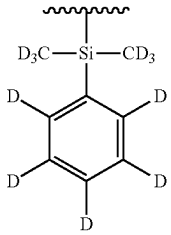
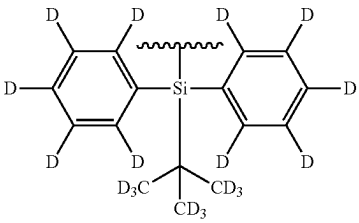
	R183
	R184
	R185
	R186
	R187
	R188
	R189
	R190
	R191

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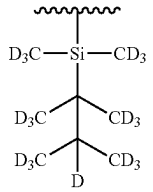
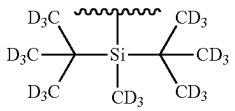
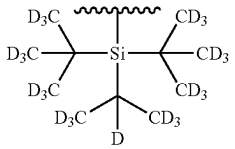
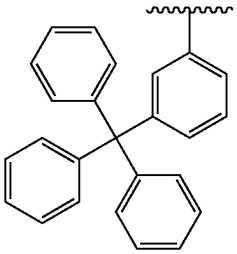
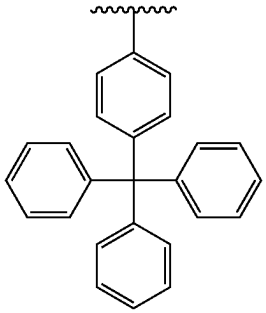
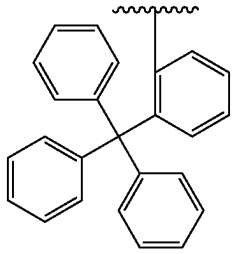
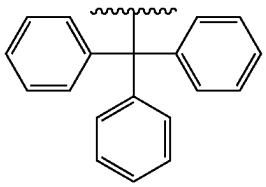
	R192
	R193
	R194
	R195
	R196
	R197
	R198

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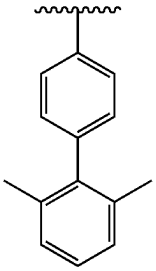
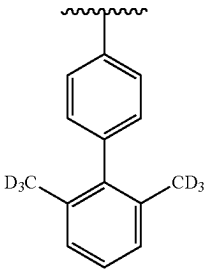
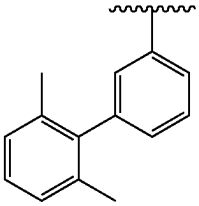
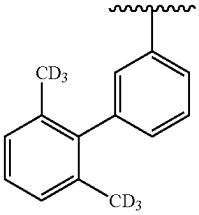
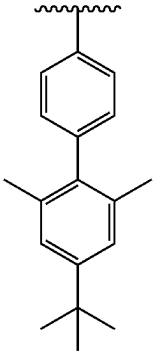
	R199
	R200
	R201
	R202
	R203

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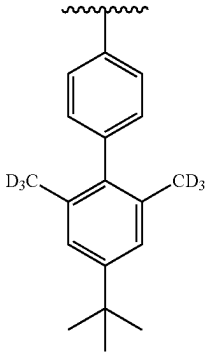
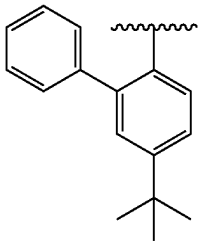
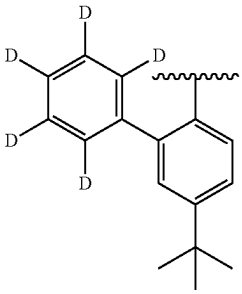
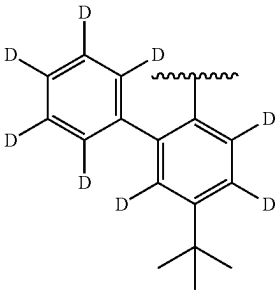
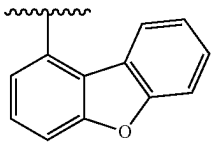
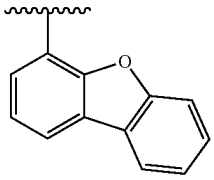
	R204
	R205
	R206
	R207
	R208
	R209

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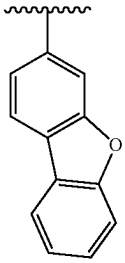
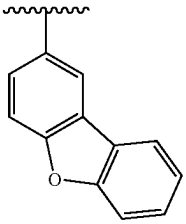
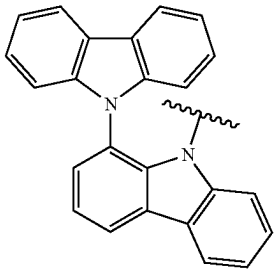
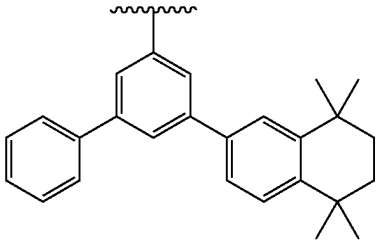
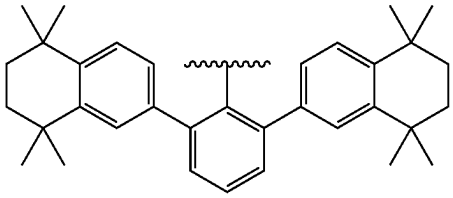
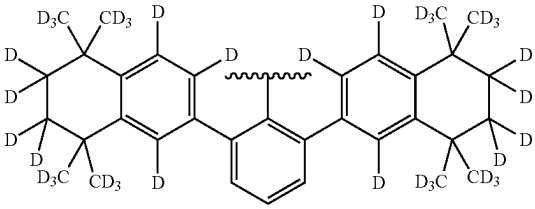
	R210
	R211
	R212
	R213
	R214
	R215

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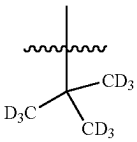
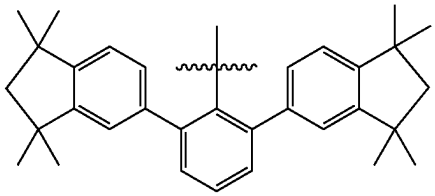
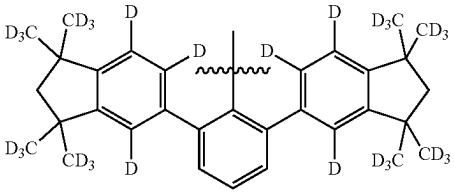
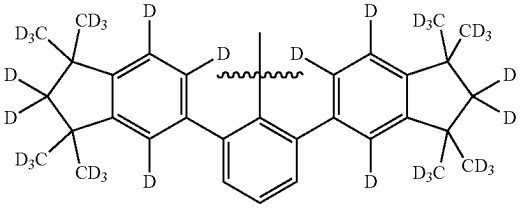
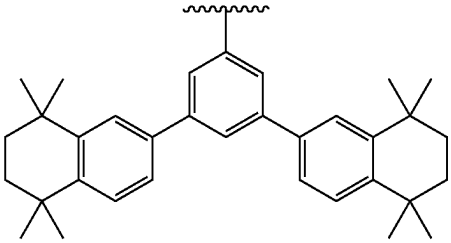
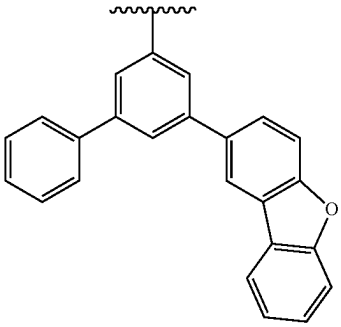
	R216
	R217
	R218
	R219
	R220
	R221

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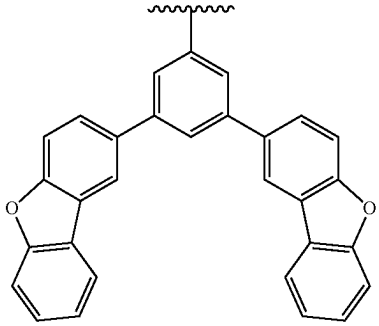
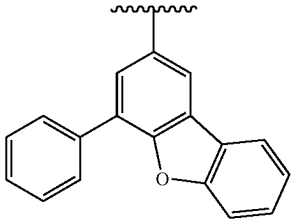
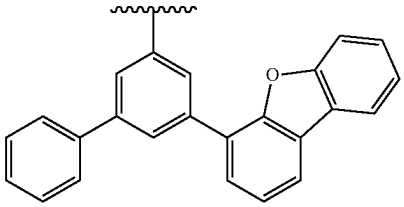
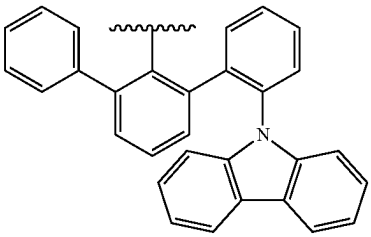
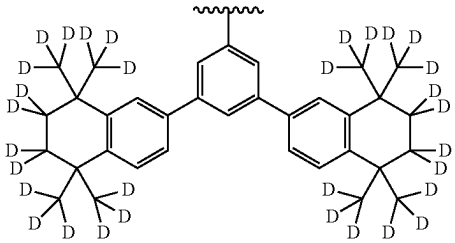
	R222
	R223
	R224
	R225
	R226

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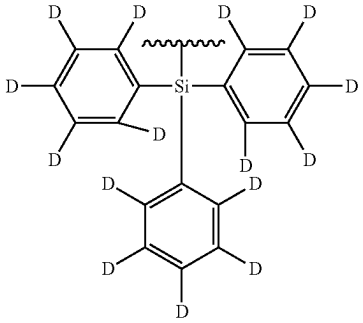
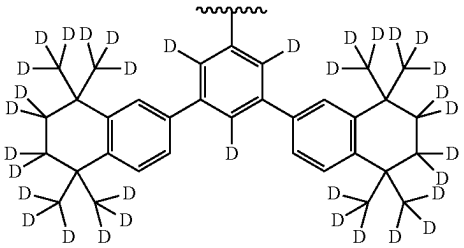
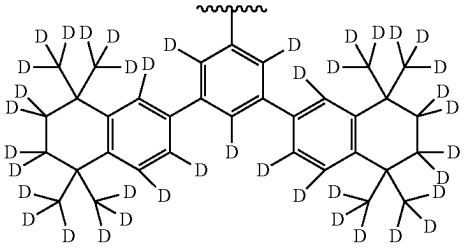
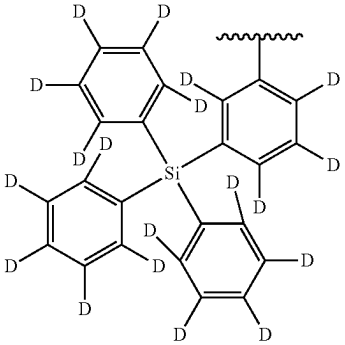
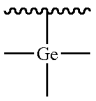
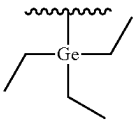
	R227
	R228
	R229
	R230
	R231
	R232

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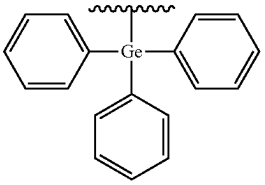
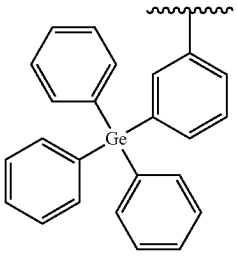
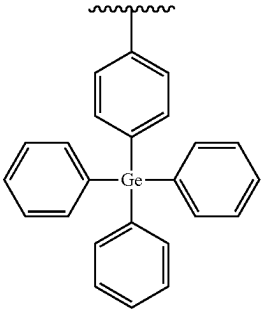
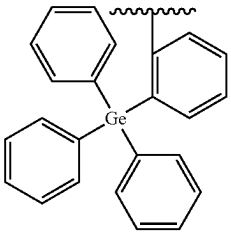
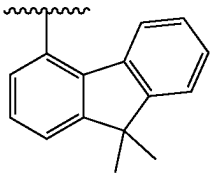
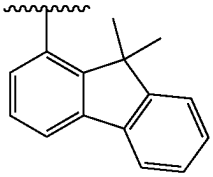
	R233
	R234
	R235
	R236
	R237
	R238

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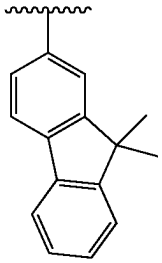
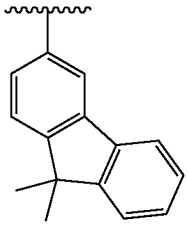
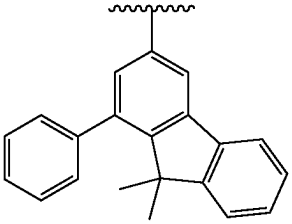
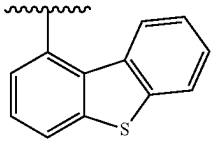
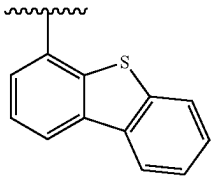
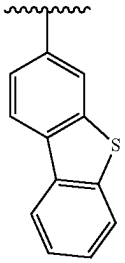
	R239
	R240
	R241
	R242
	R243
	R244

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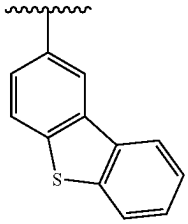
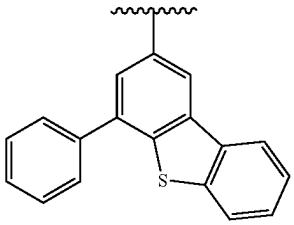
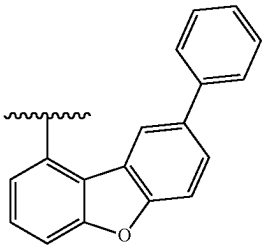
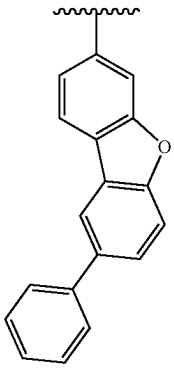
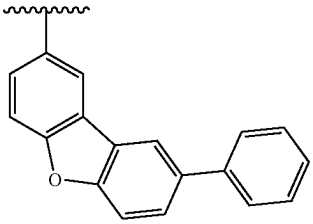
	R245
	R246
	R247
	R248
	R249

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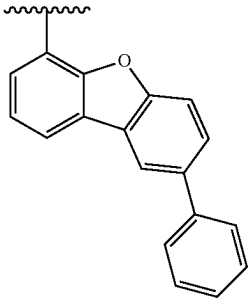
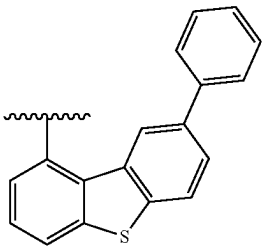
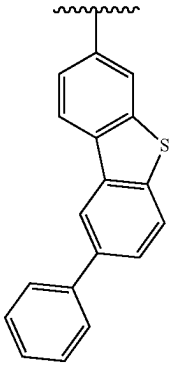
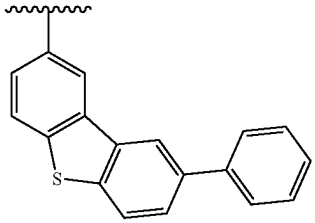
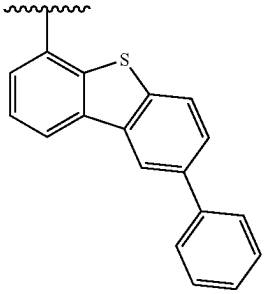
	R250
	R251
	R252
	R253
	R254

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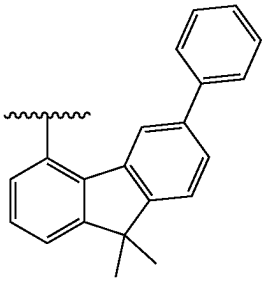
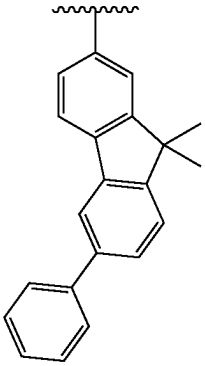
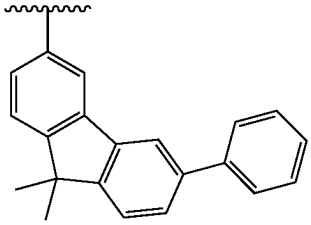
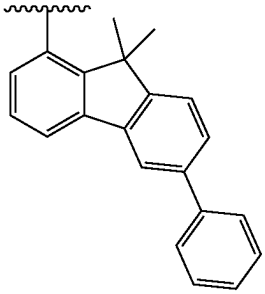
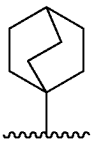
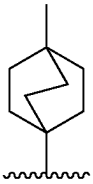
	R255
	R256
	R257
	R258
	R259
	R260

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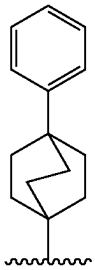
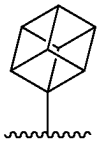
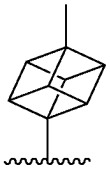
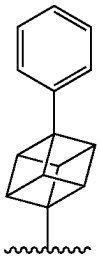
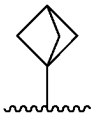
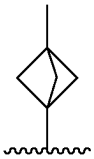
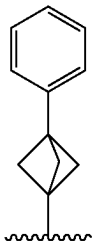
	R261
	R262
	R263
	R264
	R265
	R266
	R267

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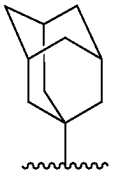
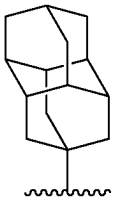
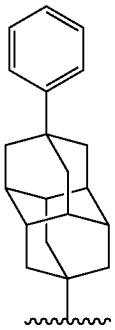
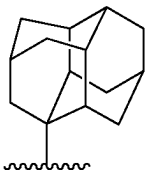
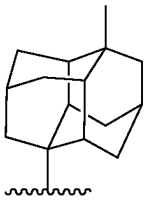
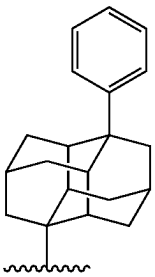
	R268
	R269
	R270
	R271
	R272
	R273

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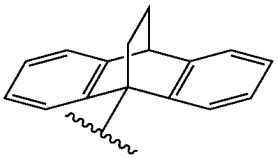
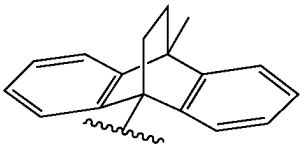
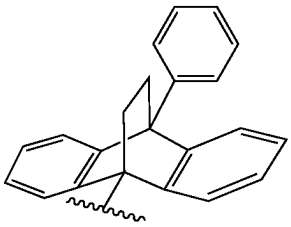
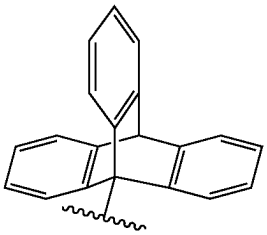
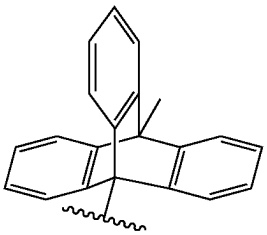
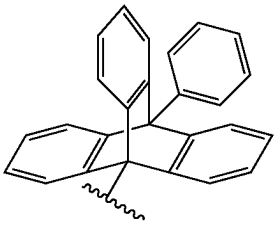
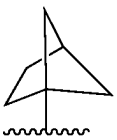
	R274
	R275
	R276
	R277
	R278
	R279
	R280

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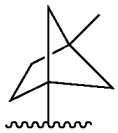
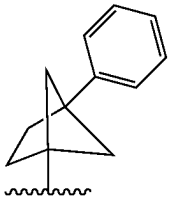
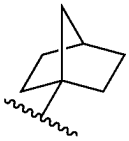
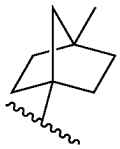
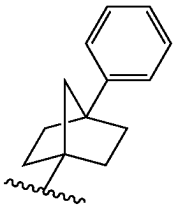
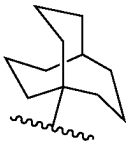
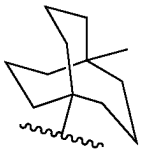
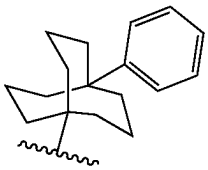
	R281
	R282
	R283
	R284
	R285
	R286
	R287
	R288

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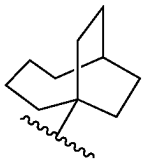
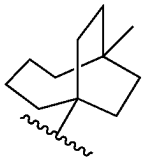
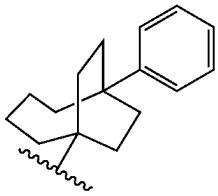
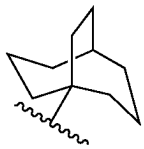
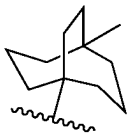
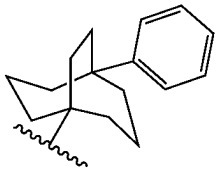
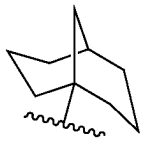
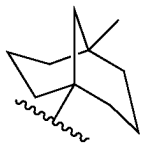
	R289
	R290
	R291
	R292
	R293
	R294
	R295
	R296

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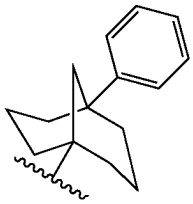
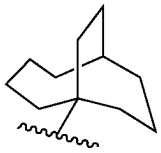
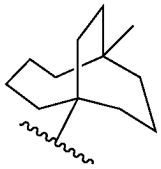
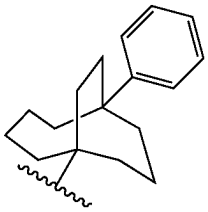
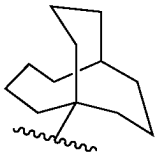
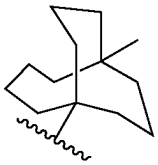
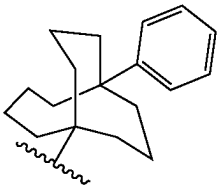
	R297
	R298
	R299
	R300
	R301
	R302
	R303
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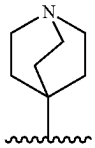
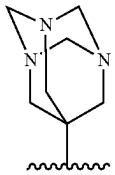
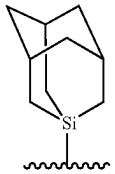
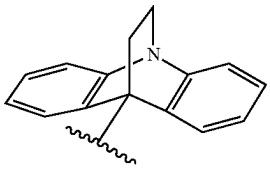
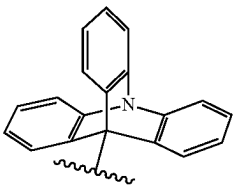
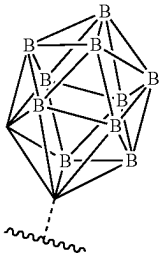
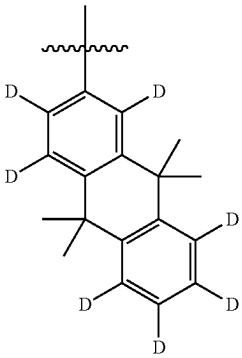
	R305
	R306
	R307
	R308
	R309
	R310
	R311

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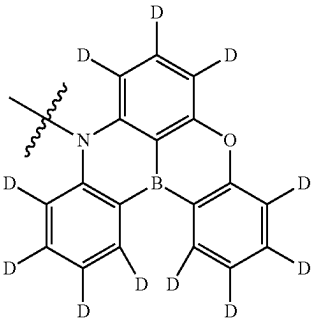
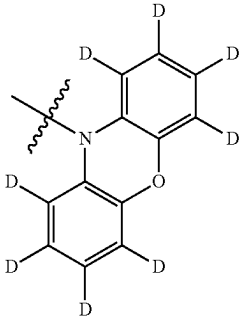
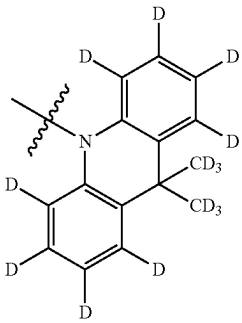
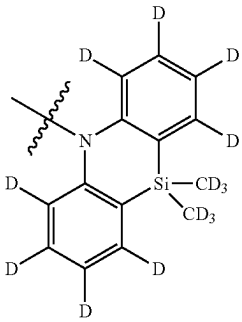
	R312
	R313
	R314
	R315

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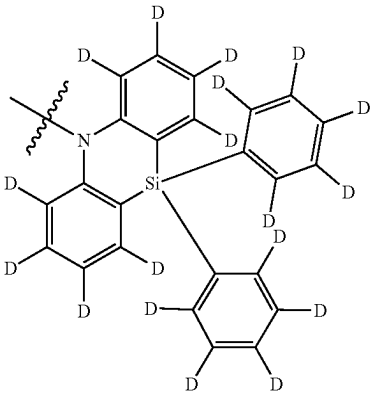
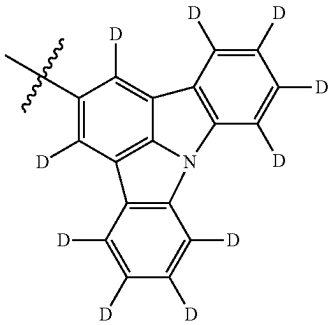
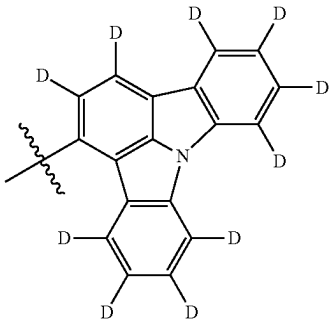
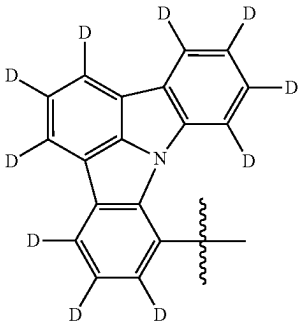
	R316
	R317
	R318
	R319

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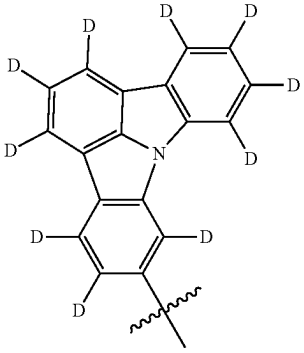
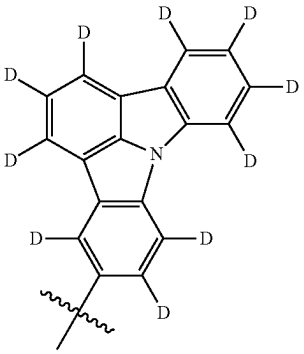
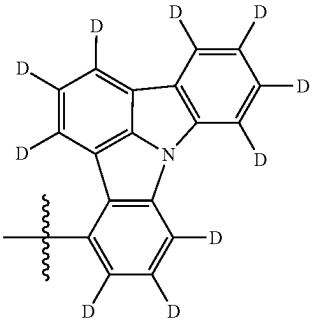
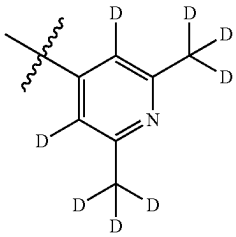
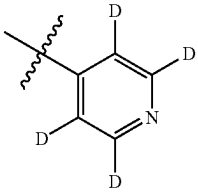
	R320
	R321
	R322
	R323
	R324

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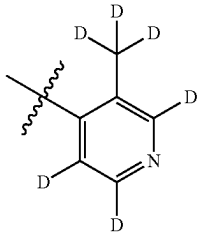
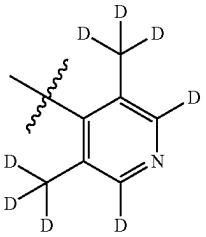
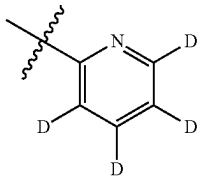
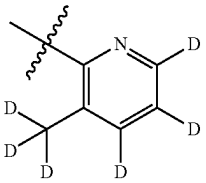
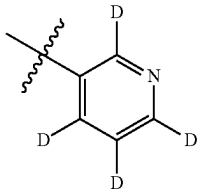
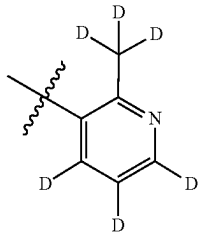
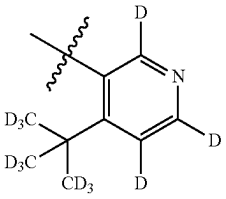
	R325
	R326
	R327
	R328
	R329
	R330
	R331

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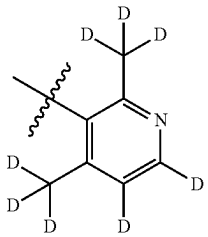
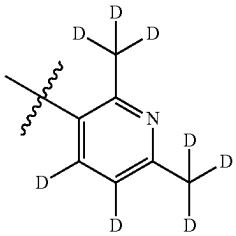
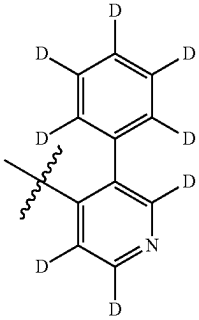
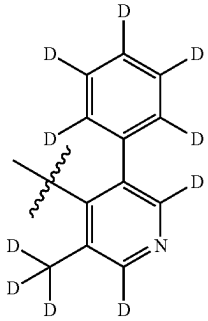
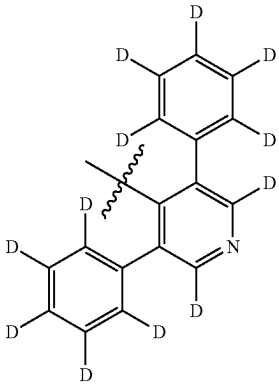
	R332
	R333
	R334
	R335
	R336

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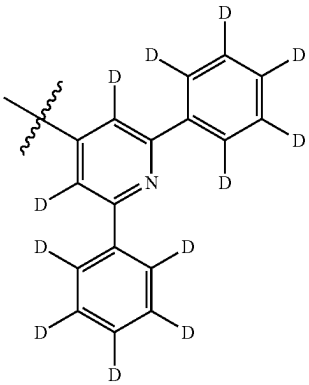
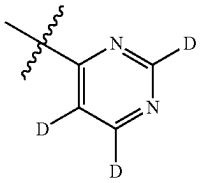
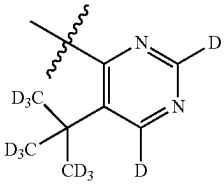
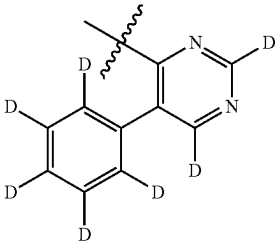
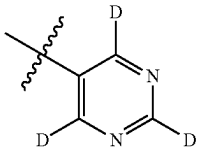
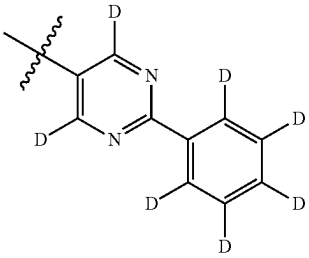
	R337
	R338
	R339
	R340
	R341
	R342

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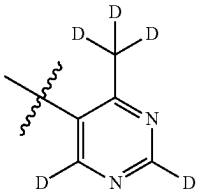
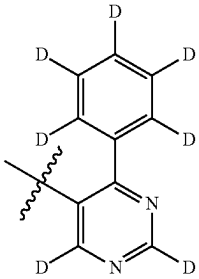
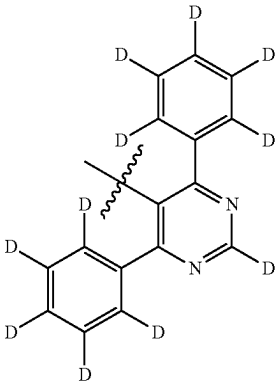
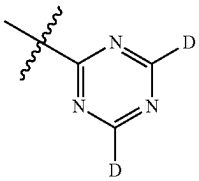
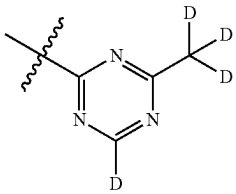
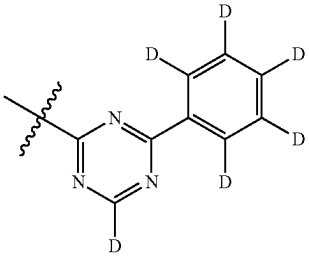
	R343
	R344
	R345
	R346
	R347
	R348

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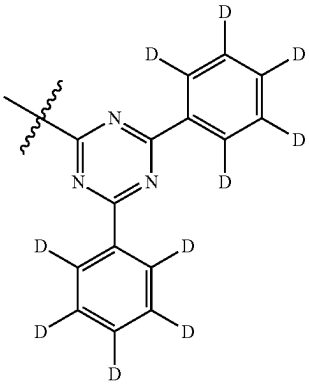
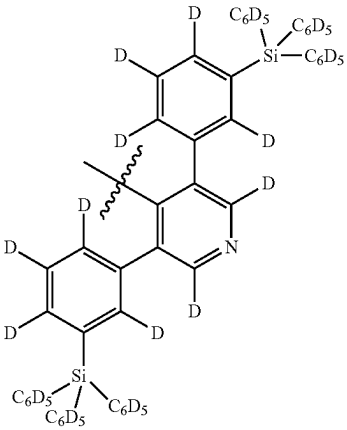
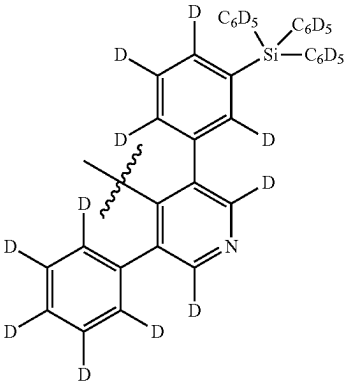
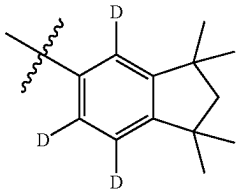
	R349
	R350
	R351
	R352

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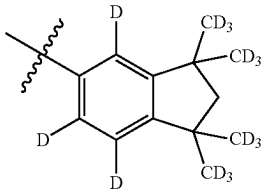
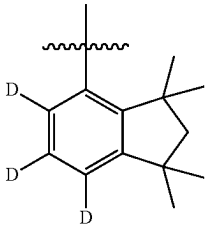
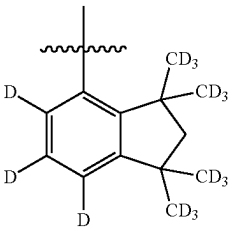
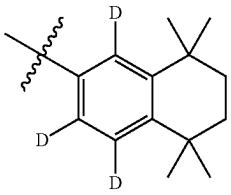
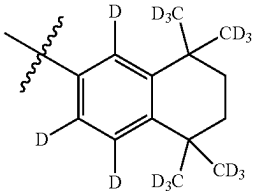
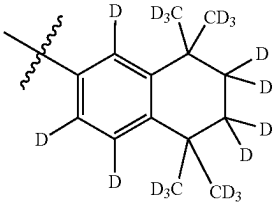
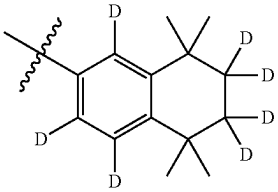
	R353
	R354
	R355
	R356
	R357
	R358
	R359

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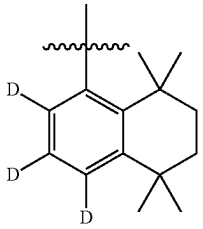
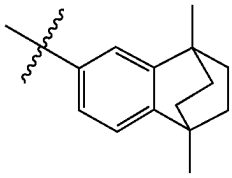
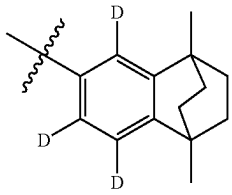
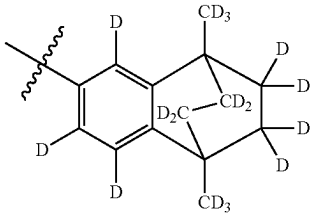
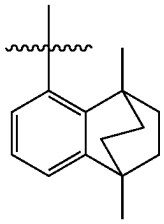
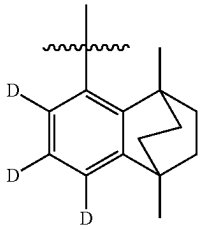
	R360
	R361
	R362
	R363
	R364
	R365

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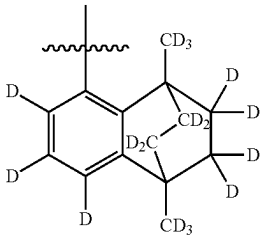
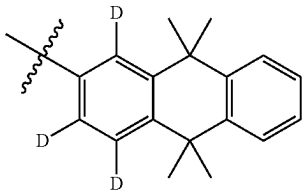
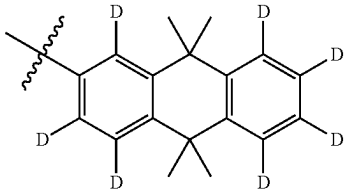
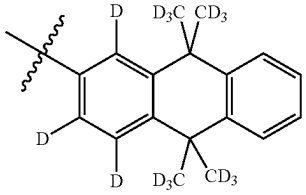
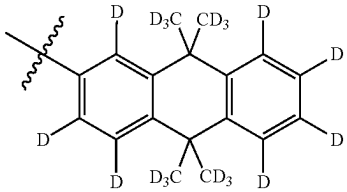
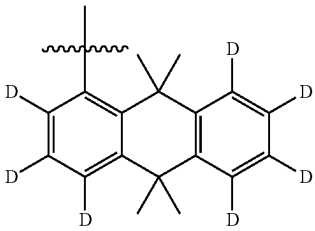
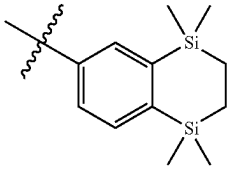
	R366
	R367
	R368
	R369
	R370
	R371
	R372

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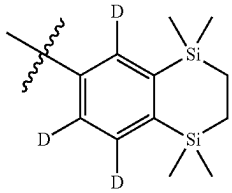
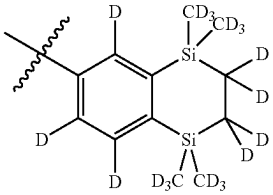
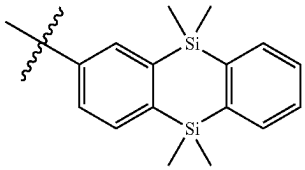
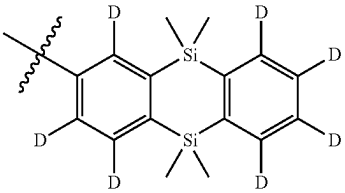
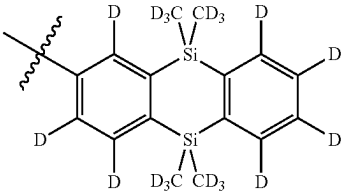
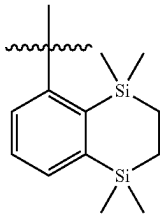
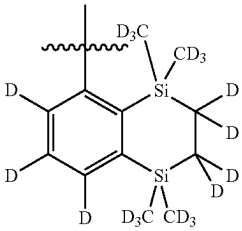
	R373
	R374
	R375
	R376
	R377
	R378
	R379

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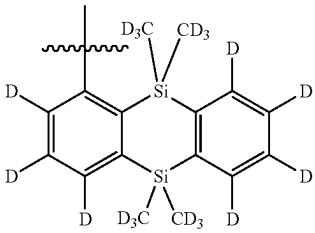
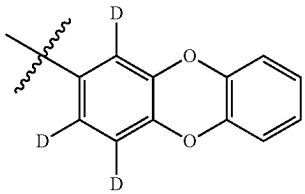
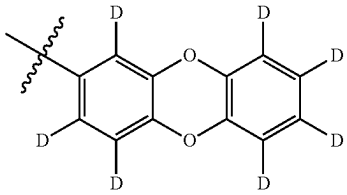
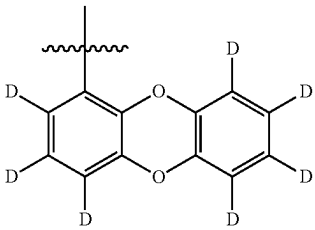
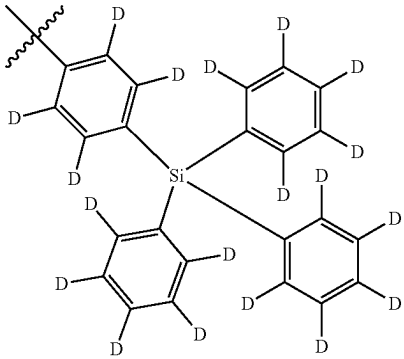
	R380
	R381
	R382
	R383
	R384

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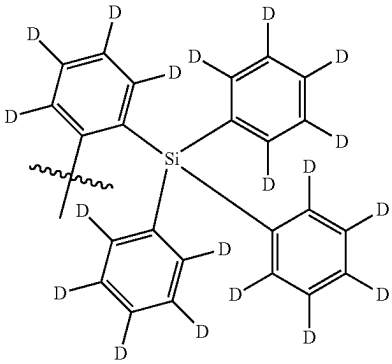
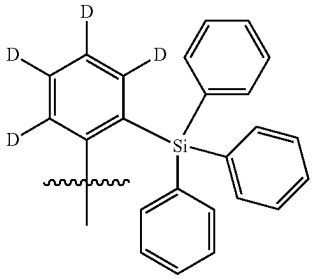
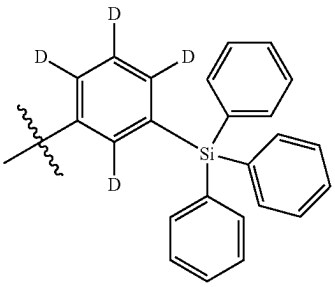
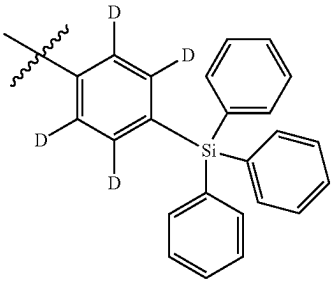
	R385
	R386
	R387
	R388

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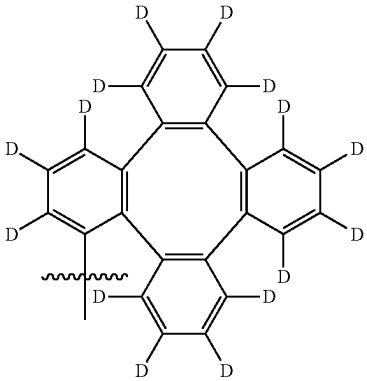
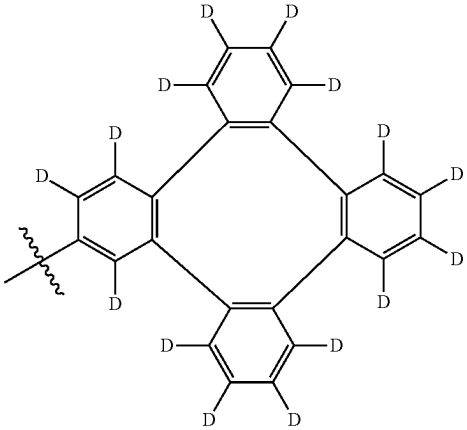
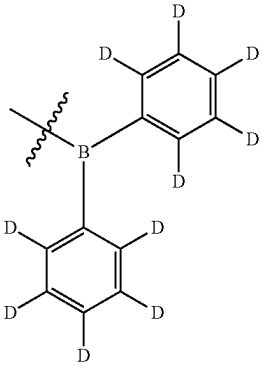
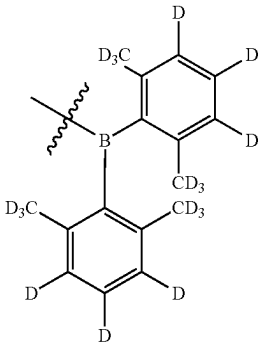
	R389
	R390
	R391
	R392

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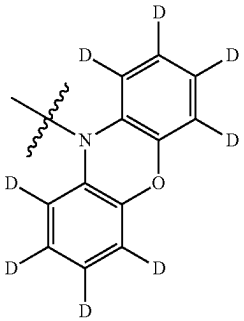
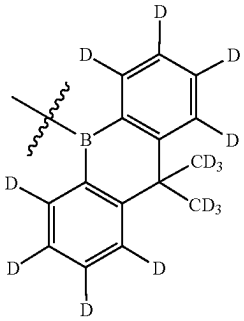
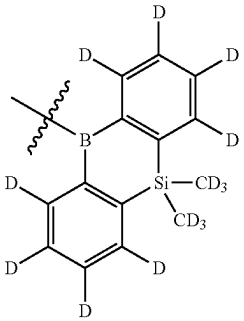
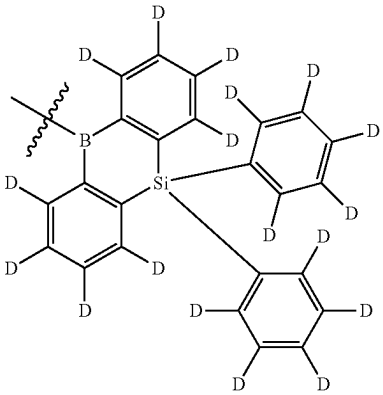
	R393
	R394
	R395
	R396

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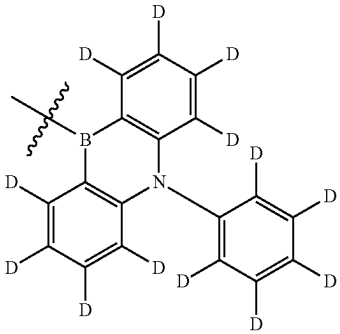
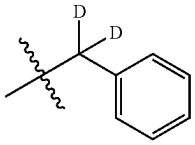
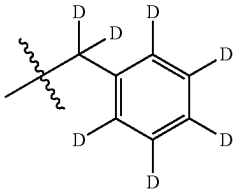
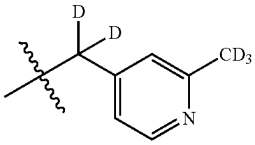
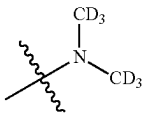
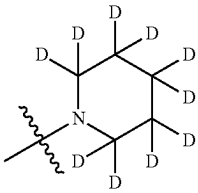
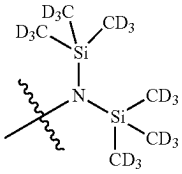
	R397
	R398
	R399
	R400
	R401
	R402
	R403

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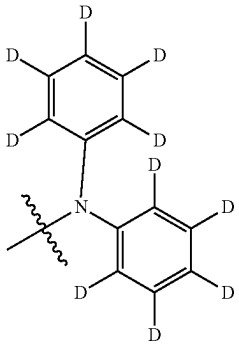
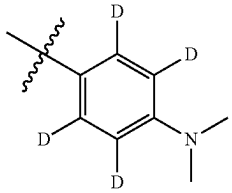
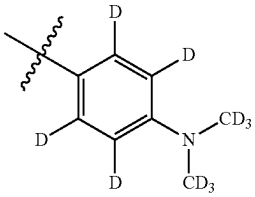
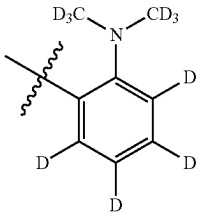
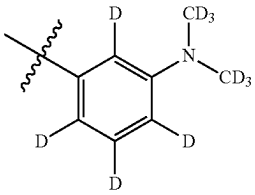
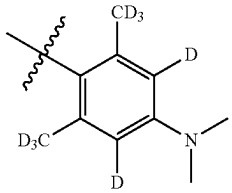
	R404
	R405
	R406
	R407
	R408
	R409

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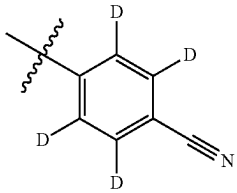
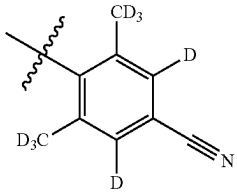
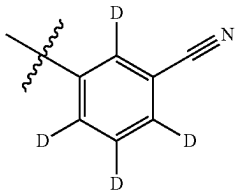
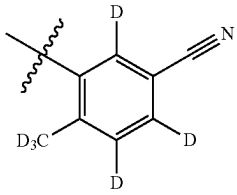
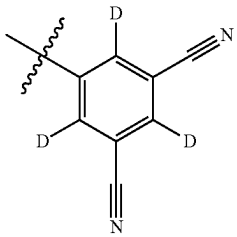
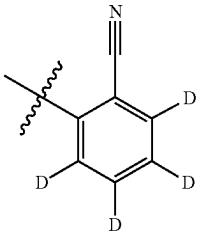
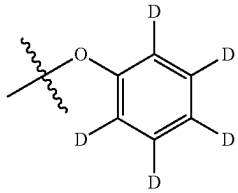
	R410
	R411
	R412
	R413
	R414
	R415
	R416

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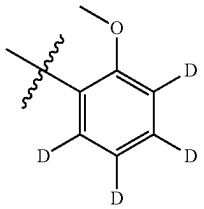
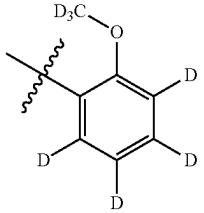
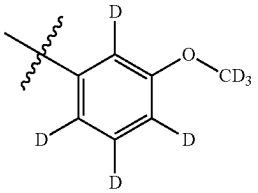
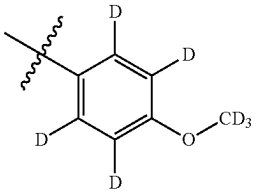
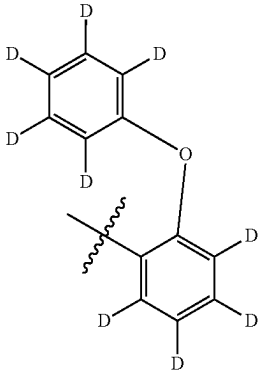
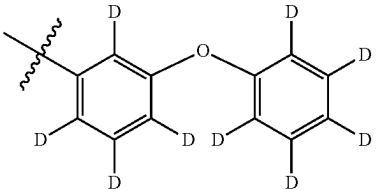
	R417
	R418
	R419
	R420
	R421
	R422

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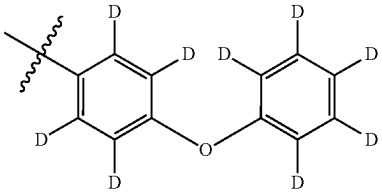
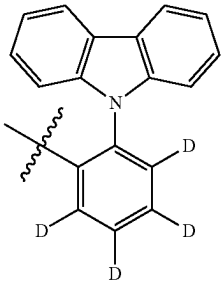
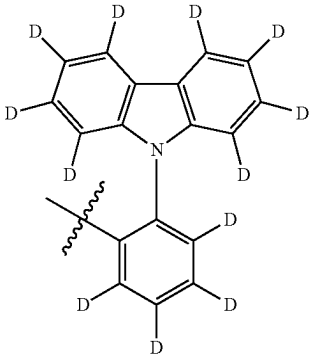
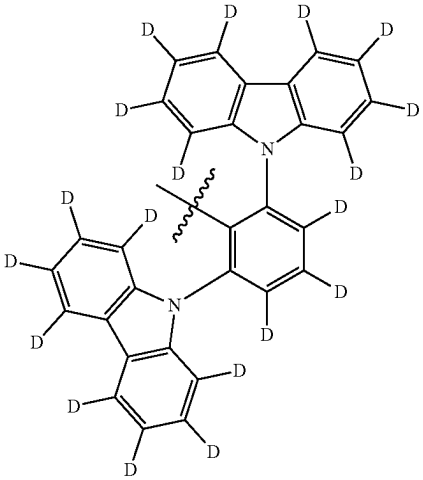
	R423
	R424
	R425
	R426

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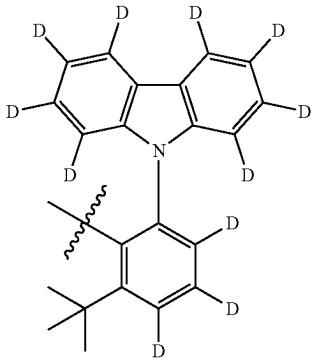
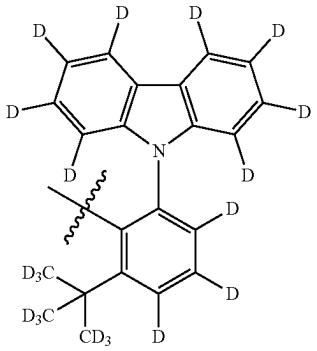
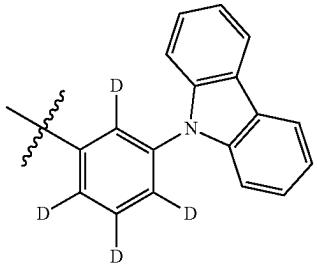
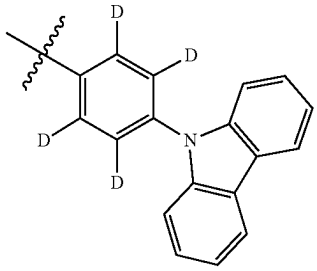
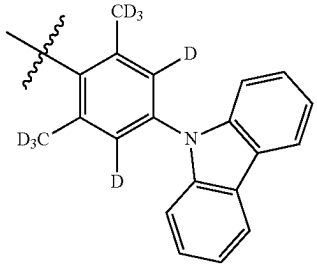
	R427
	R428
	R429
	R430
	R431

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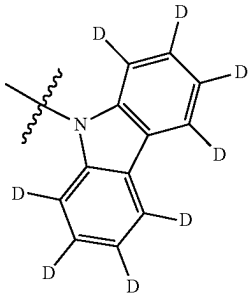
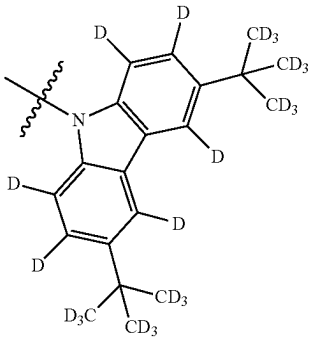
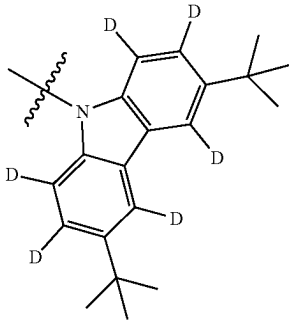
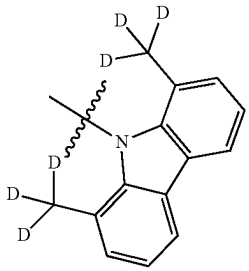
	R432
	R433
	R434
	R435

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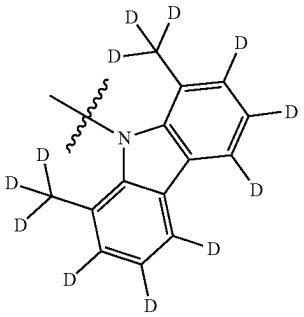
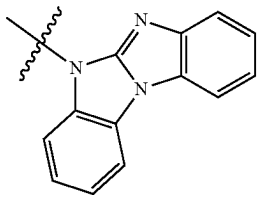
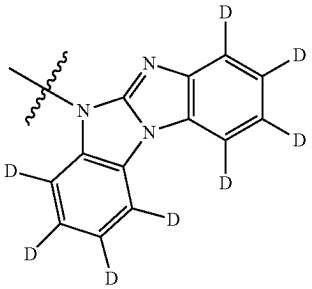
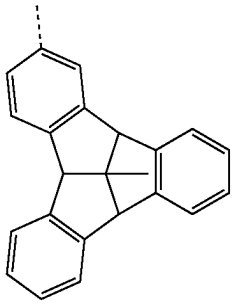
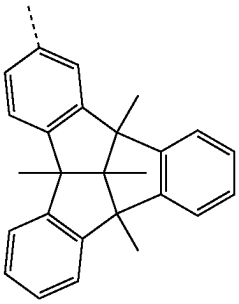
	R436
	R437
	R438
	R439
	R440

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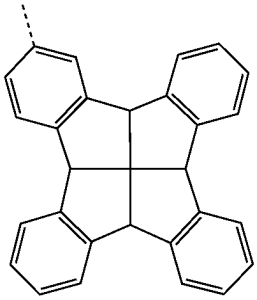
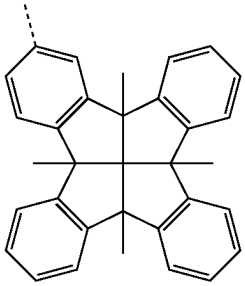
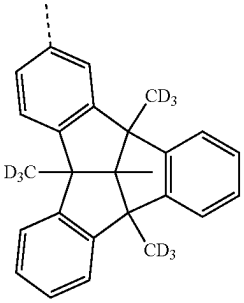
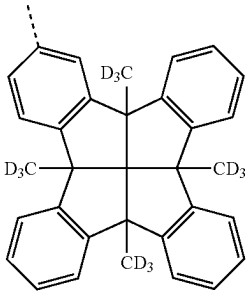
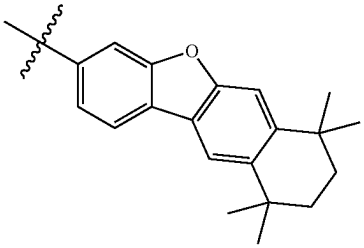
	R441
	R442
	R443
	R444
	R445

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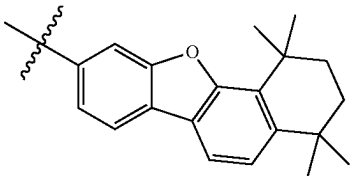
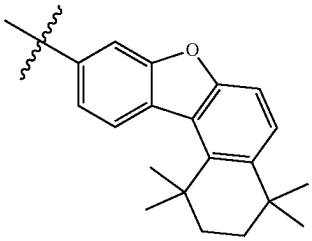
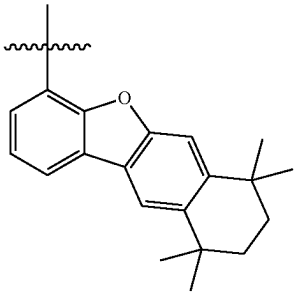
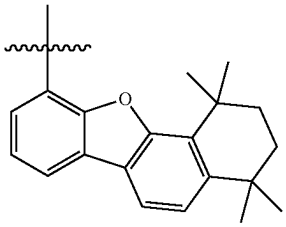
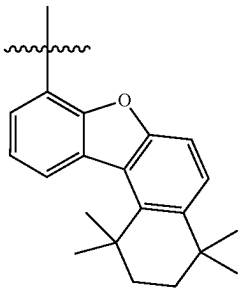
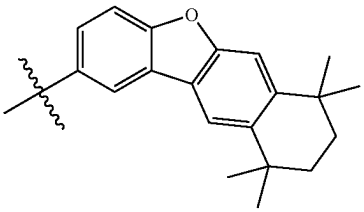
	R446
	R447
	R448
	R449
	R450
	R451

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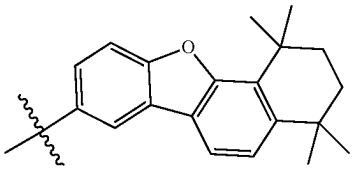
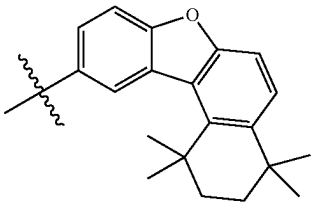
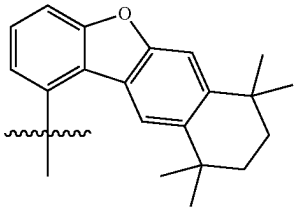
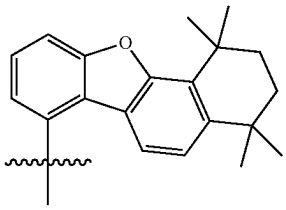
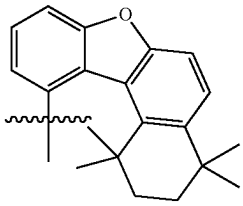
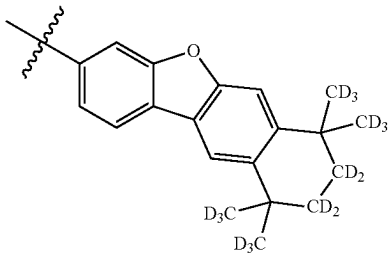
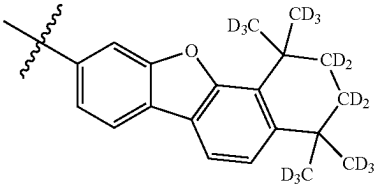
	R452
	R453
	R454
	R455
	R456
	R457
	R458

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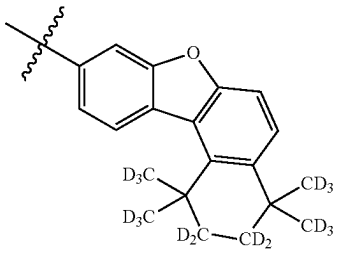
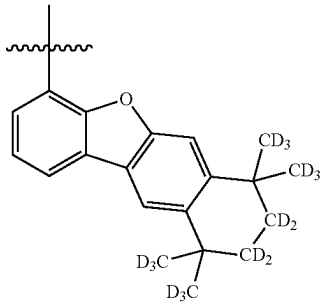
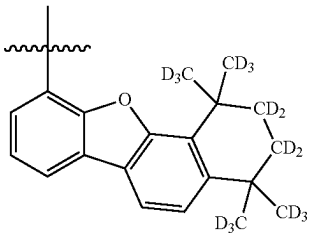
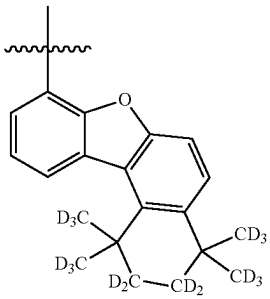
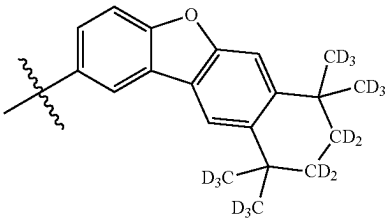
	R459
	R460
	R461
	R462
	R463

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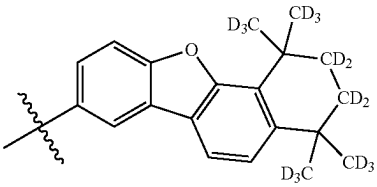
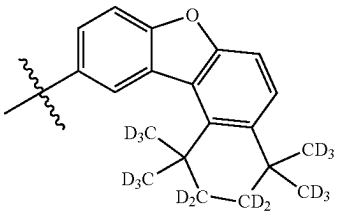
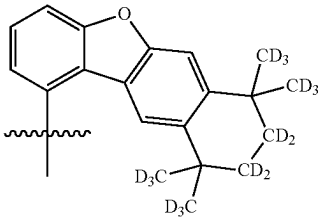
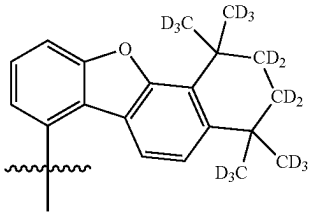
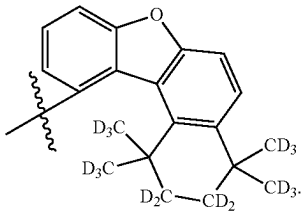
	R464
	R465
	R466
	R467
	R468

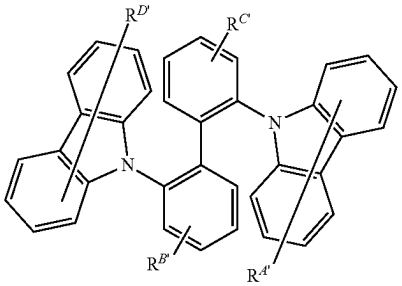
17. An organic light emitting device (OLED) comprising:

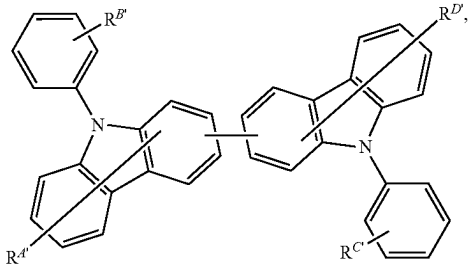
an anode;

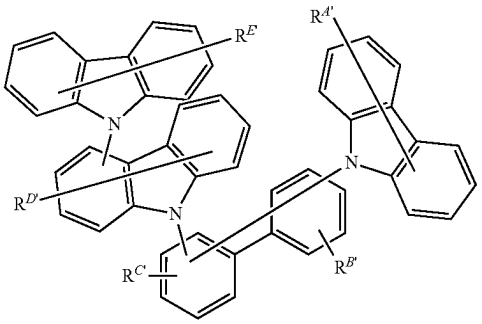
a cathode; and

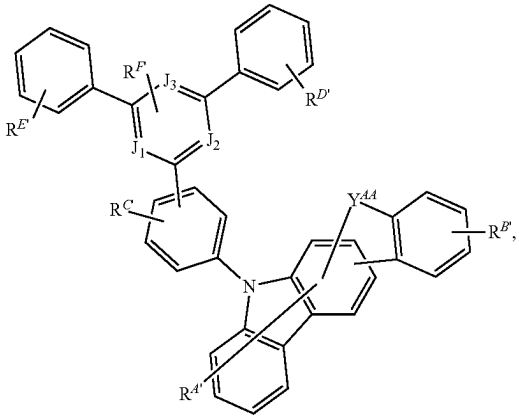
an organic layer disposed between the anode and the cathode, wherein the organic layer comprises a compound according to claim **1**.

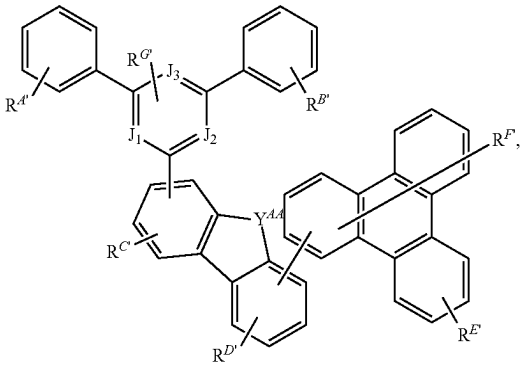
18. The OLED of claim **17**, wherein the organic layer further comprises a host, wherein the host is selected from the group consisting of:











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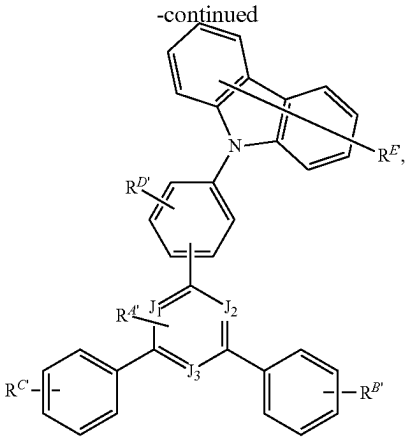

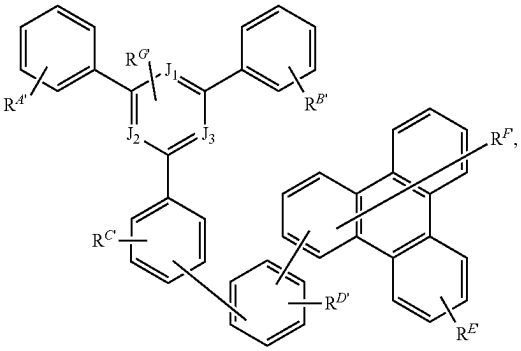

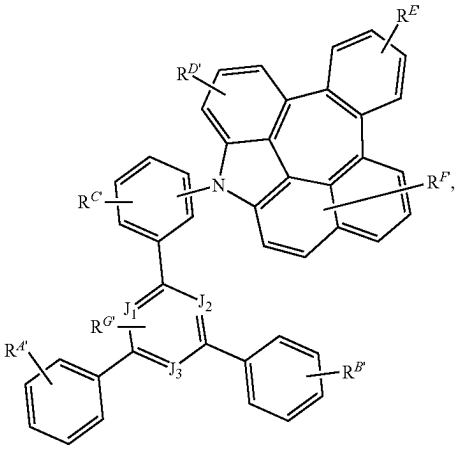

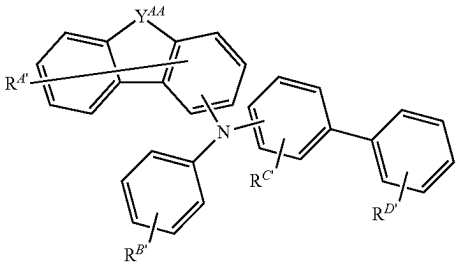

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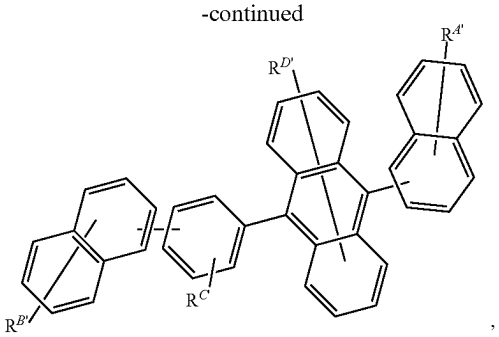

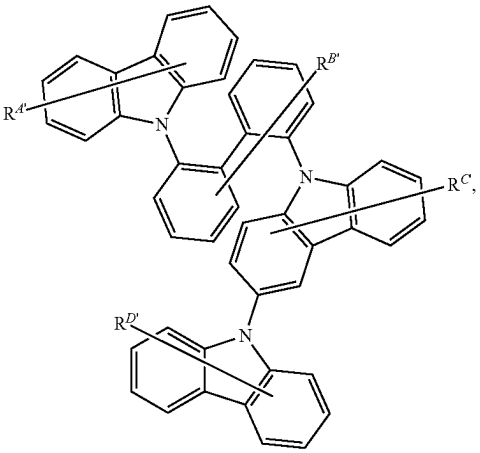

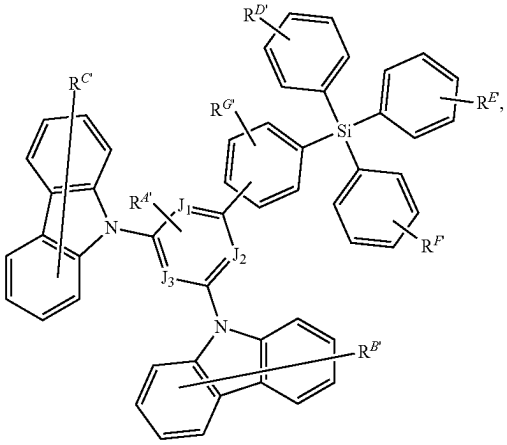

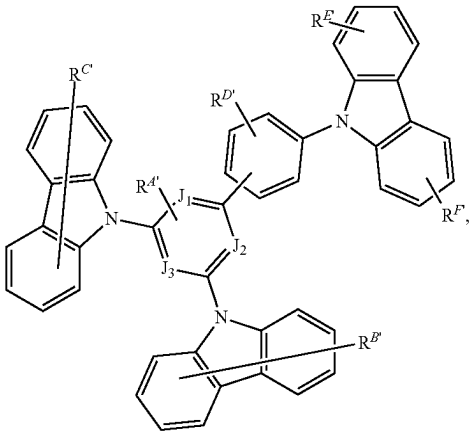

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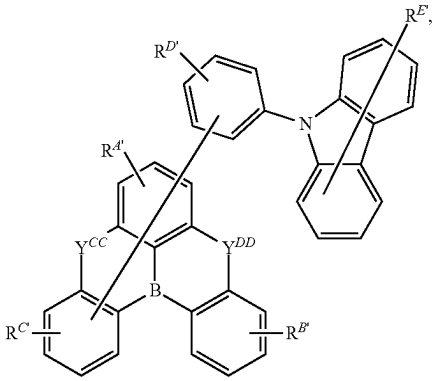

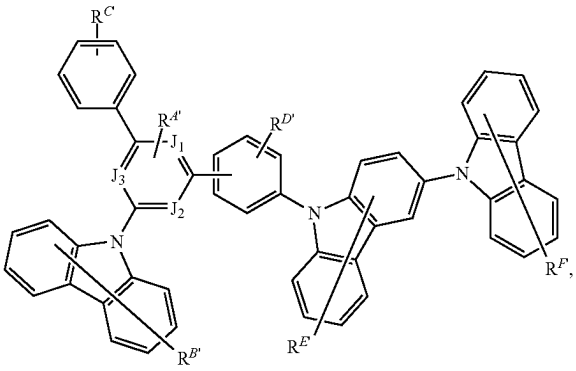

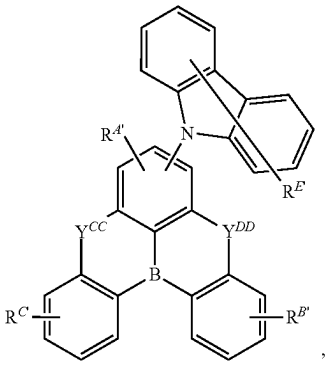

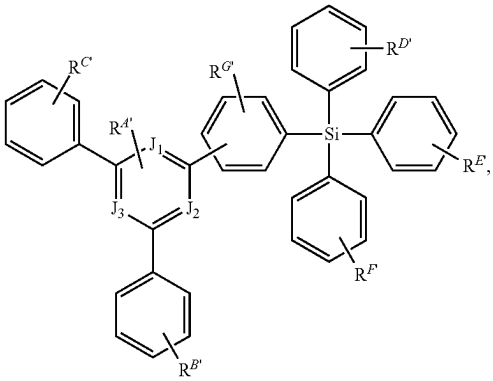

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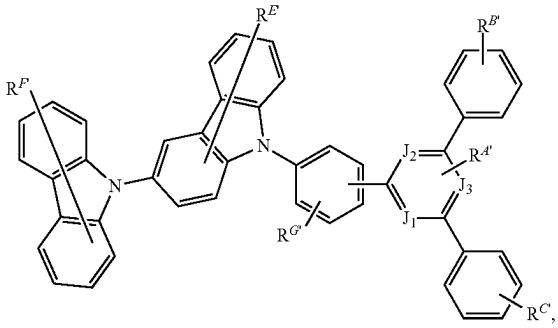

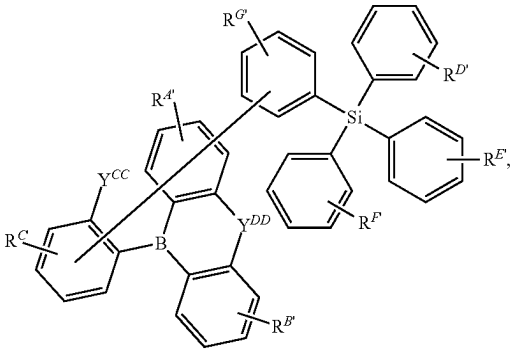

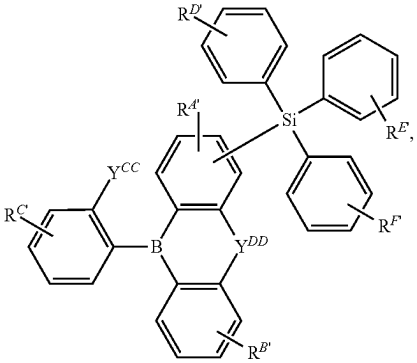

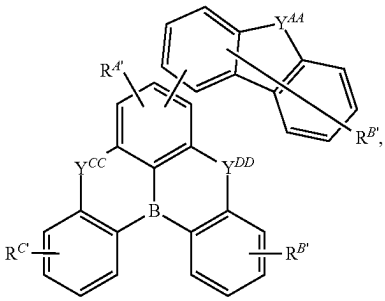

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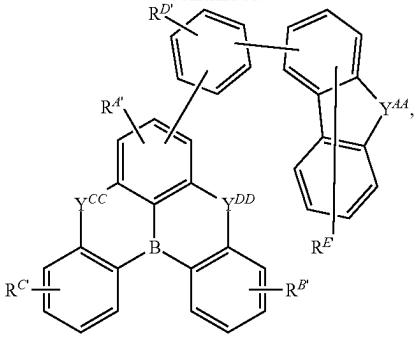

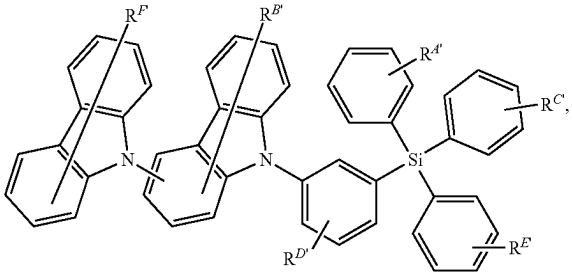

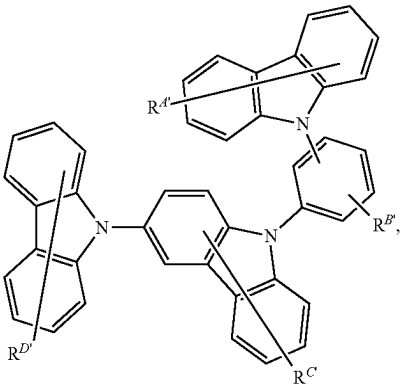

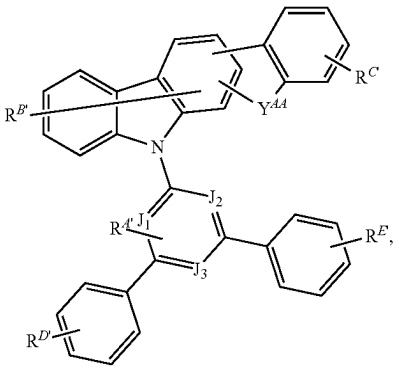

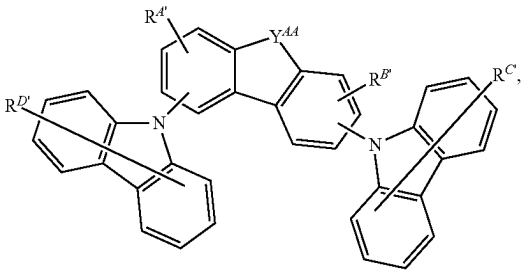

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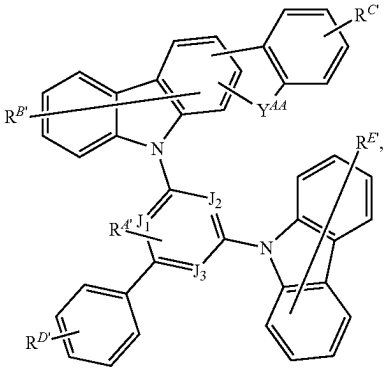

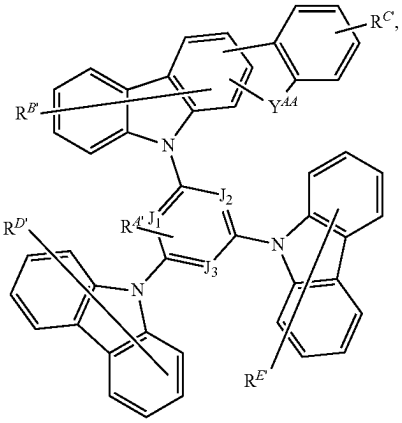

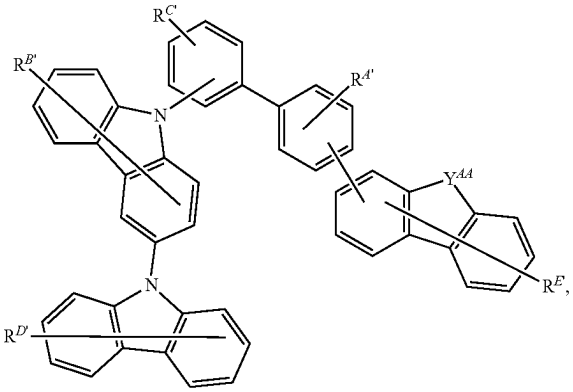

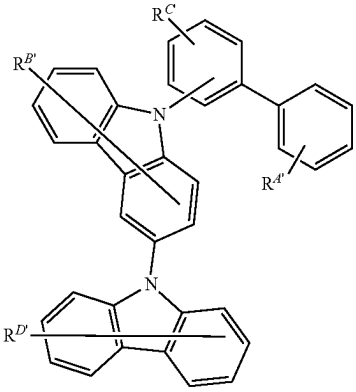

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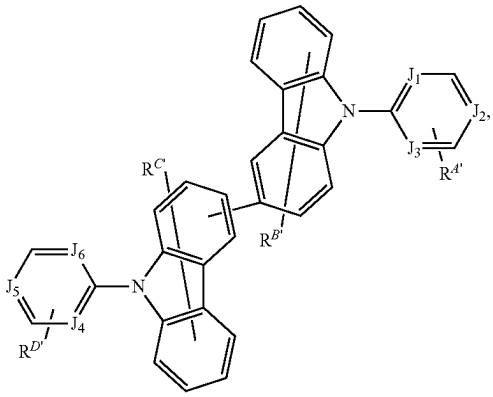

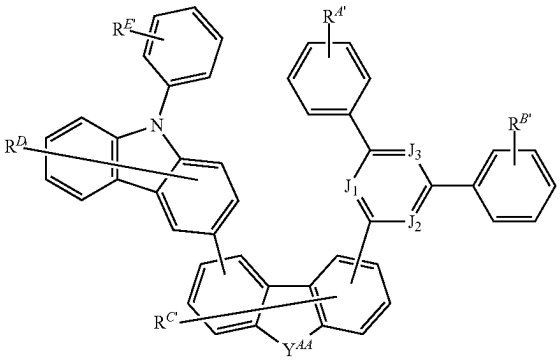

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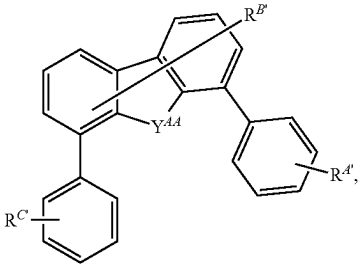

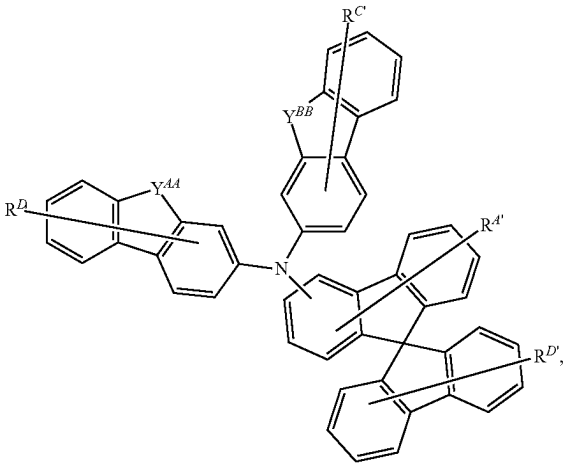

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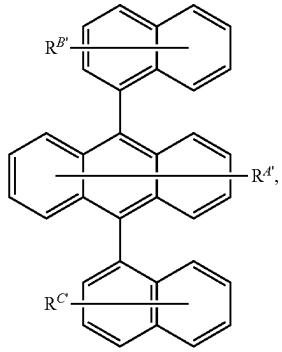

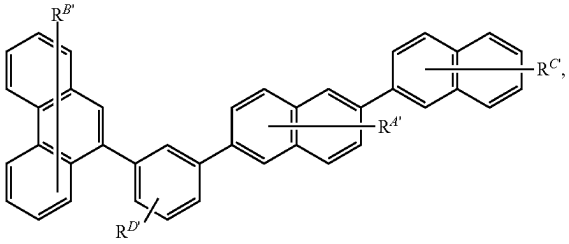

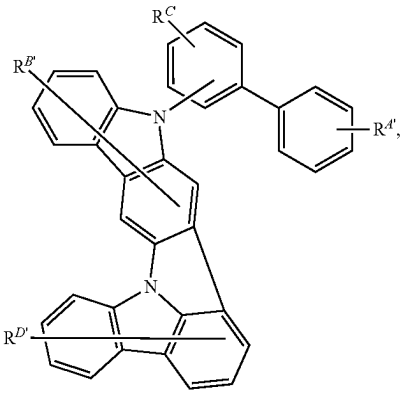

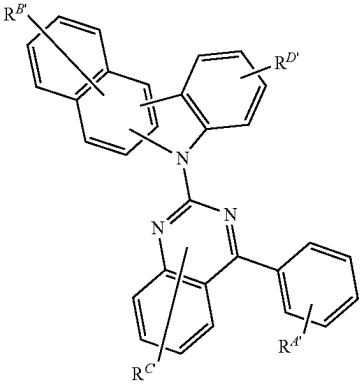

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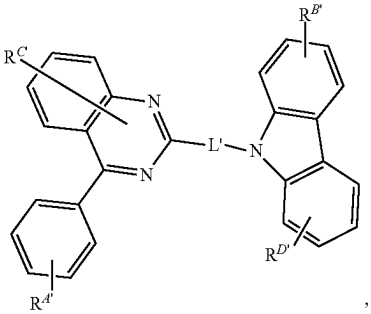

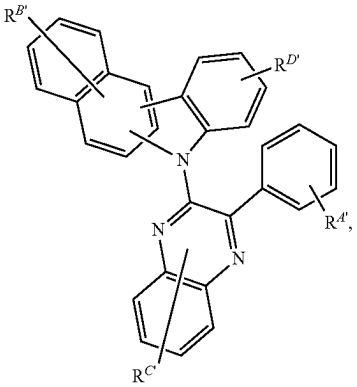

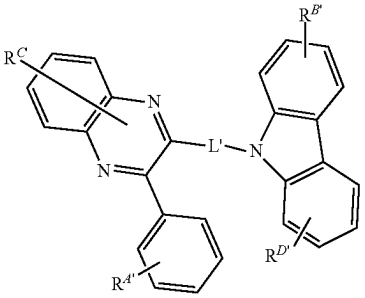

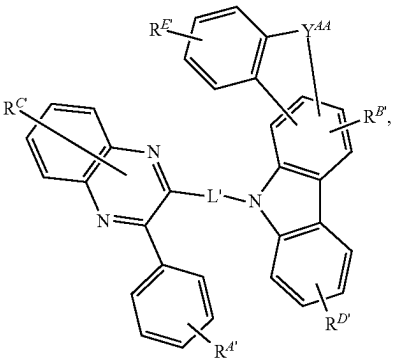

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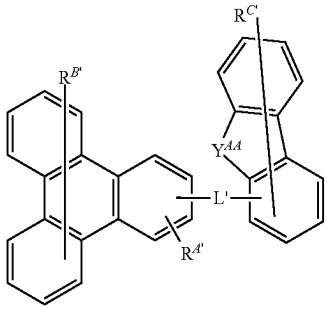

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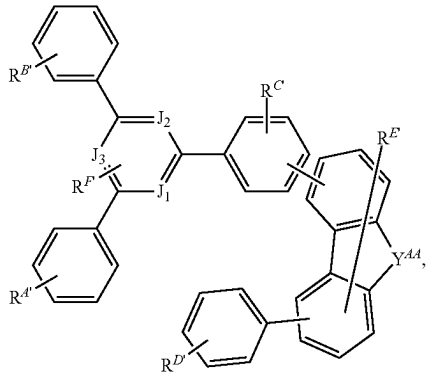

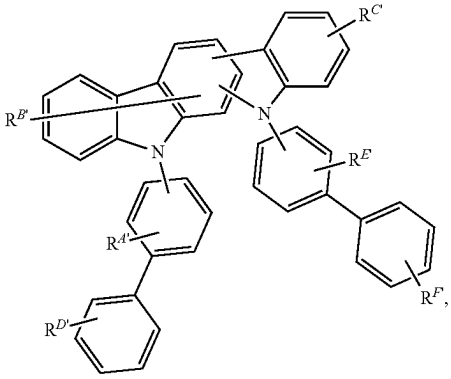

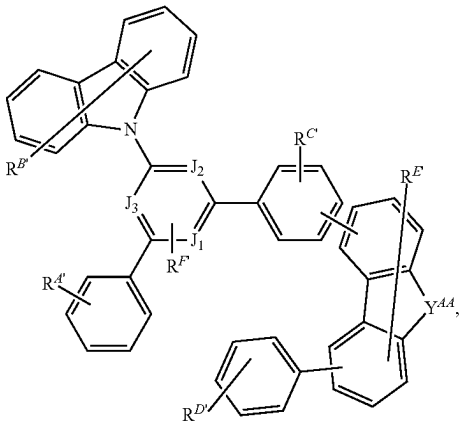

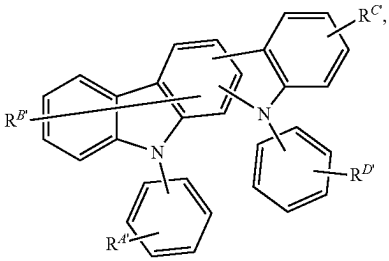

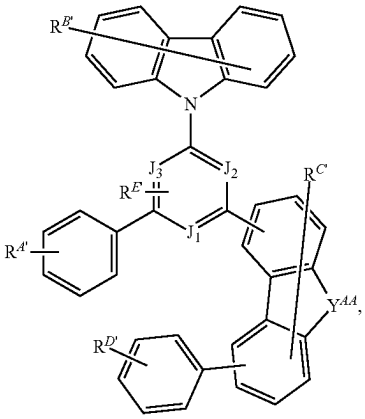

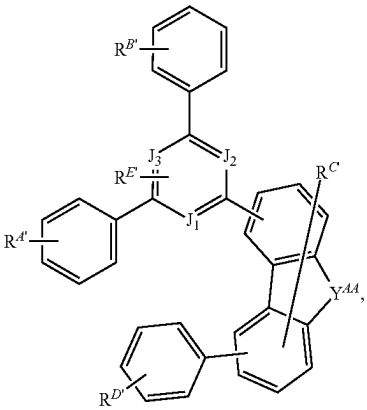

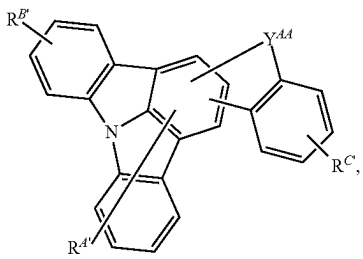

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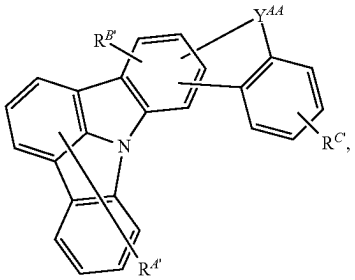

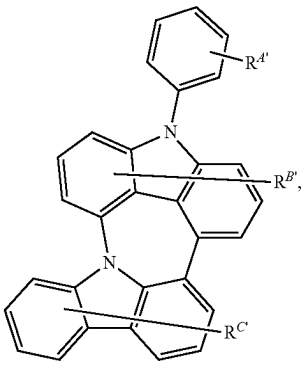

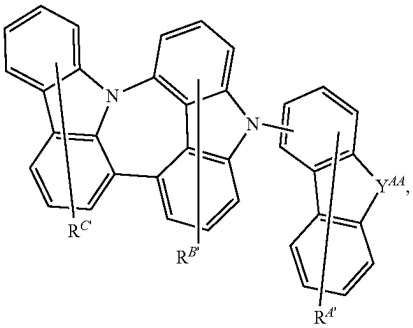

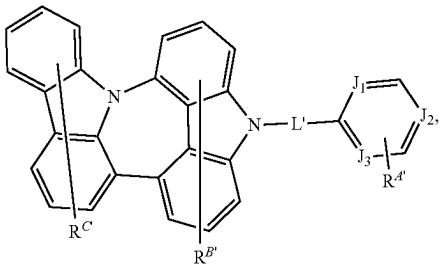

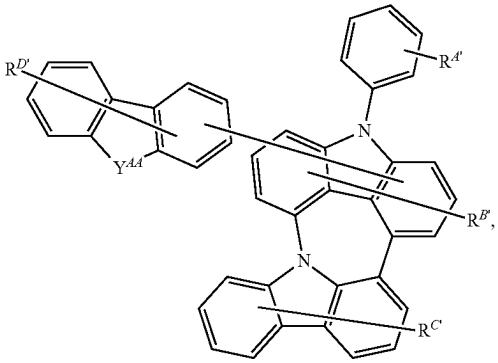

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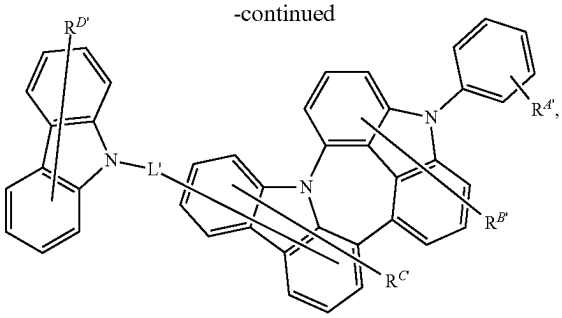

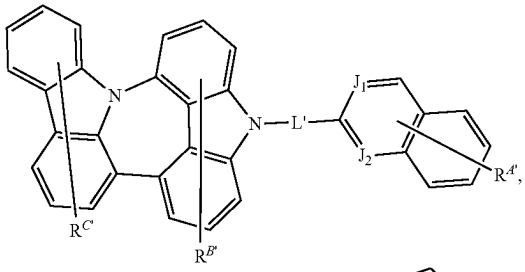

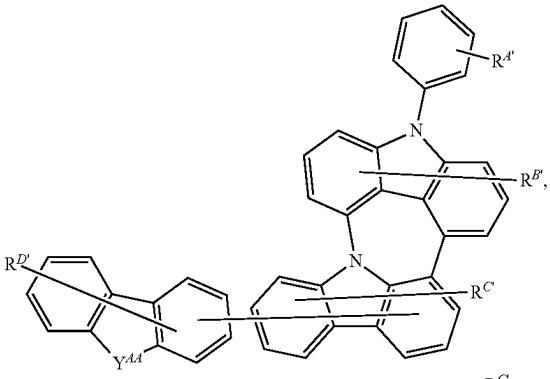

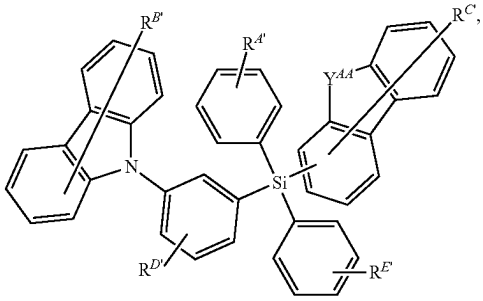

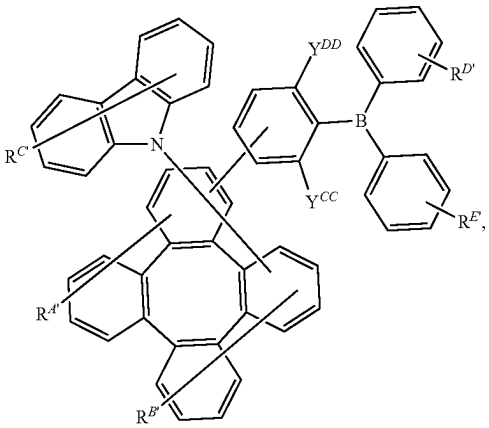

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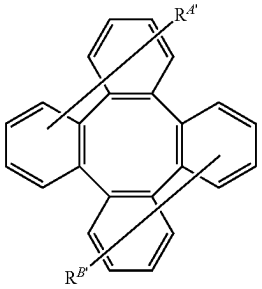

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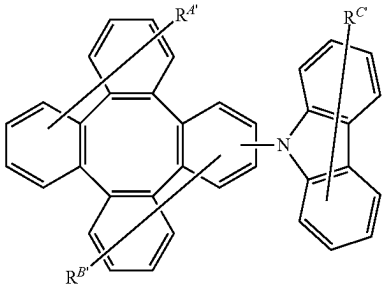

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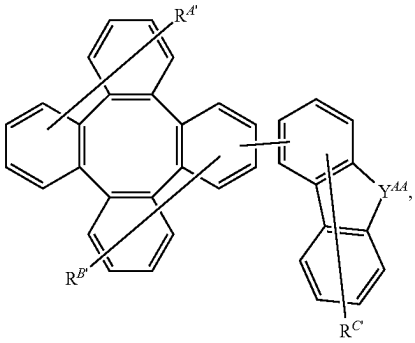

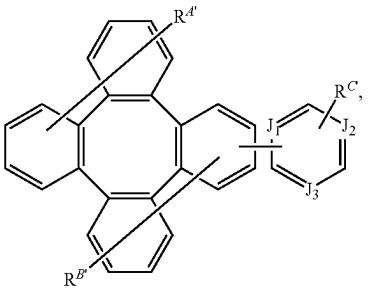

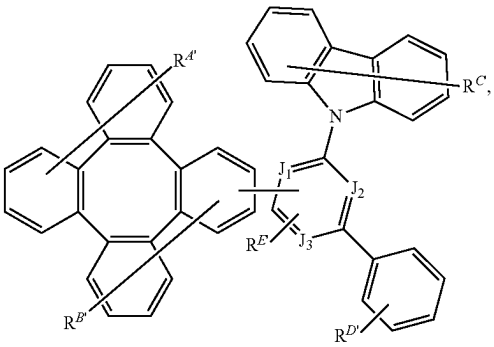

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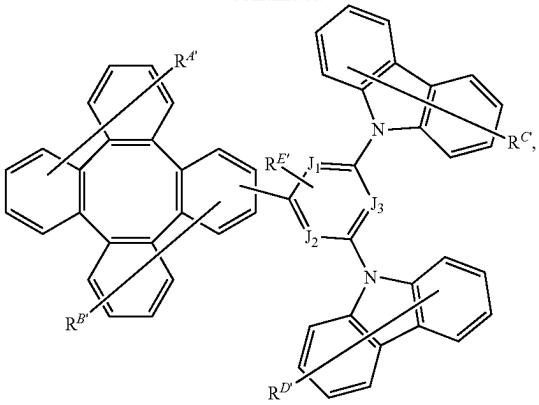

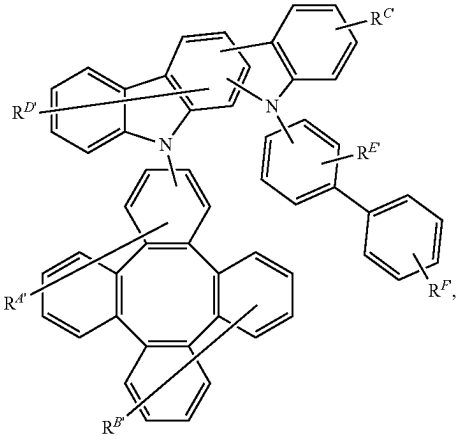

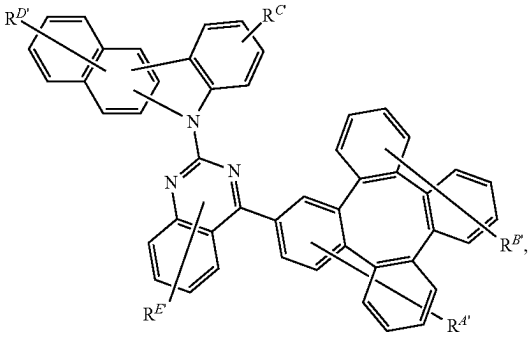

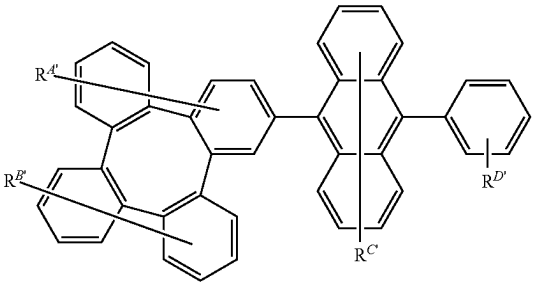

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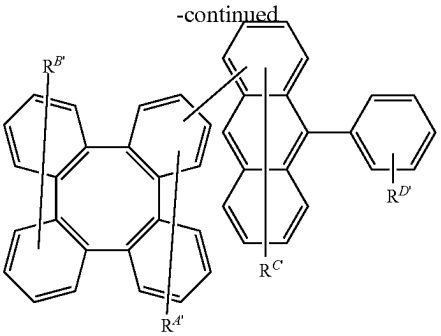

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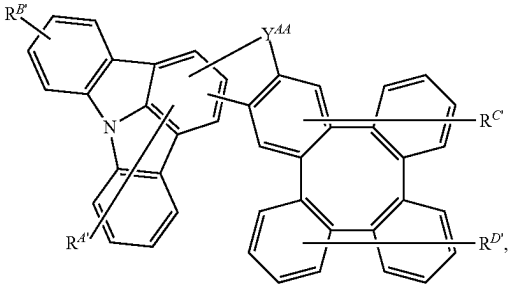

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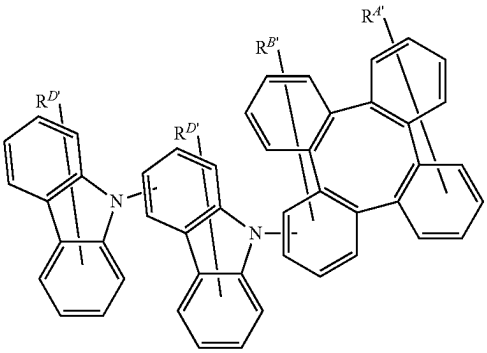

,

wherein:

each of J_1 to J_6 is independently C or N;

L' is a direct bond or an organic linker;

each Y^{AA}, Y^{BB}, Y^{CC}, and Y^{DD} is independently selected from the group consisting of absent a bond, direct bond, O, S, Se, CRR', SiRR', GeRR', NR, BR, BRR';

each of $R^{A'}$, $R^{B'}$, $R^{C'}$, $R^{D'}$, $R^{E'}$, $R^{F'}$, and $R^{G'}$ independently represents mono, up to the maximum substitutions, or no substitutions;

each R, R', $R^{A'}$, $R^{B'}$, $R^{C'}$, $R^{D'}$, $R^{E'}$, $R^{F'}$, and $R^{G'}$ is independently a hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, germyl, boryl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, selenyl, sulfinyl, sulfonyl, phosphino, and combinations thereof;

any two substituents can be joined or fused to form a ring; and

where possible, each unsubstituted aromatic carbon atom can be replaced with one or more N to form an aza-substituted ring.

19. The OLED of claim **17**, wherein the compound is a sensitizer, and the OLED further comprises an acceptor selected from the group consisting of a fluorescent emitter, a delayed fluorescence emitter, and combination thereof.

20. A consumer product comprising an organic light-emitting device (OLED) comprising:

an anode;

a cathode; and

an organic layer disposed between the anode and the cathode, wherein the organic layer comprises a compound according to claim **1**.

* * * * *