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

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C09K 11/06	(2006.01)
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(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,769,292	A	9/1988	Tang et al.
5,061,569	A	10/1991	VanSlyke et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN	103896990 A	7/2014
EP	650955	5/1995

(Continued)

OTHER PUBLICATIONS

Baldo et al., "Highly Efficient Phosphorescent Emission from Organic Electroluminescent Devices," Nature, vol. 395, 151-154, (1998).

(Continued)

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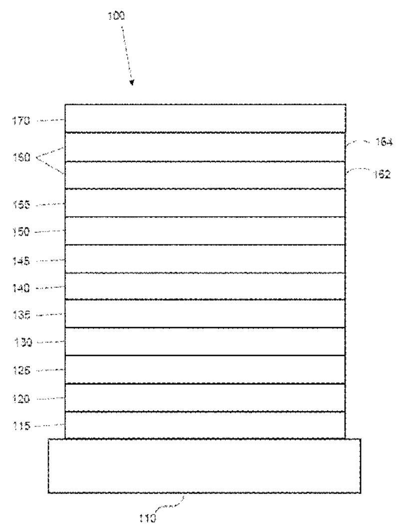
(57) **ABSTRACT**

The present invention includes a new series of benzofused heterocyclic ligands for metal complexes. These complexes show promising photophysical performance when incorporated into OLEDs.

15 Claims, 2 Drawing Sheets



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(56) **References Cited**

U.S. PATENT DOCUMENTS

5,247,190 A 9/1993 Friend
5,703,436 A 12/1997 Forrest et al.
5,707,745 A 1/1998 Forrest et al.
5,834,893 A 11/1998 Bulovic et al.
5,844,363 A 12/1998 Gu et al.
6,013,982 A 1/2000 Thompson et al.
6,087,196 A 7/2000 Sturm et al.
6,091,195 A 7/2000 Forrest et al.
6,097,147 A 8/2000 Baldo et al.
6,294,398 B1 9/2001 Kim et al.
6,303,238 B1 10/2001 Thompson et al.
6,337,102 B1 1/2002 Forrest et al.
6,468,819 B1 10/2002 Kim et al.
6,528,187 B1 3/2003 Okada
6,687,266 B1 2/2004 Ma et al.
6,835,469 B2 12/2004 Kwong et al.
6,921,915 B2 7/2005 Takiguchi et al.
7,087,321 B2 8/2006 Kwong et al.
7,090,928 B2 8/2006 Thompson et al.
7,154,114 B2 12/2006 Brooks et al.
7,250,226 B2 7/2007 Tokito et al.
7,279,704 B2 10/2007 Walters et al.
7,332,232 B2 2/2008 Ma et al.
7,338,722 B2 3/2008 Thompson et al.
7,393,599 B2 7/2008 Thompson et al.
7,396,598 B2 7/2008 Takeuchi et al.
7,431,968 B1 10/2008 Shtein et al.
7,445,855 B2 11/2008 Mackenzie et al.
7,534,505 B2 5/2009 Lin et al.
7,968,146 B2 6/2011 Wanger et al.
8,692,241 B1* 4/2014 Zeng C09K 11/06 257/40
8,722,205 B2 5/2014 Xia et al.
8,946,697 B1* 2/2015 Ma C07F 15/0033 257/40
2002/0034656 A1 3/2002 Thompson et al.
2002/0134984 A1 9/2002 Igarashi
2002/0158242 A1 10/2002 Son et al.
2003/0138657 A1 7/2003 Li et al.
2003/0152802 A1 8/2003 Tsuboyama et al.
2003/0162053 A1 8/2003 Marks et al.
2003/0175553 A1 9/2003 Thompson et al.
2003/0230980 A1 12/2003 Forrest et al.
2004/0036077 A1 2/2004 Ise
2004/0137267 A1 7/2004 Igarashi et al.
2004/0137268 A1 7/2004 Igarashi et al.
2004/0174116 A1 9/2004 Lu et al.
2005/0025993 A1 2/2005 Thompson et al.
2005/0112407 A1 5/2005 Ogasawara et al.
2005/0238919 A1 10/2005 Ogasawara
2005/0244673 A1 11/2005 Satoh et al.
2005/0260441 A1 11/2005 Thompson et al.
2005/0260449 A1 11/2005 Walters et al.
2006/0008670 A1 1/2006 Lin et al.
2006/0202194 A1 9/2006 Jeong et al.
2006/0240279 A1 10/2006 Adamovich et al.
2006/0251923 A1 11/2006 Lin et al.
2006/0263635 A1 11/2006 Ise
2006/0280965 A1 12/2006 Kwong et al.
2007/0190359 A1 8/2007 Knowles et al.
2007/0278938 A1 12/2007 Yabunouchi et al.
2008/0015355 A1 1/2008 Schafer et al.
2008/0018221 A1 1/2008 Egen et al.
2008/0106190 A1 5/2008 Yabunouchi et al.
2008/0124572 A1 5/2008 Mizuki et al.
2008/0220265 A1 9/2008 Xia et al.
2008/0297033 A1 12/2008 Knowles et al.
2009/0008605 A1 1/2009 Kawamura et al.
2009/0009065 A1 1/2009 Nishimura et al.
2009/0017330 A1 1/2009 Iwakuma et al.
2009/0030202 A1 1/2009 Iwakuma et al.
2009/0039776 A1 2/2009 Yamada et al.
2009/0045730 A1 2/2009 Nishimura et al.
2009/0045731 A1 2/2009 Nishimura et al.
2009/0101870 A1 4/2009 Prakash et al.
2009/0108737 A1 4/2009 Kwong et al.
2009/0115316 A1 5/2009 Zheng et al.
2009/0165846 A1 7/2009 Johannes et al.
2009/0167162 A1 7/2009 Lin et al.
2009/0179554 A1 7/2009 Kuma et al.
2010/0219407 A1* 9/2010 Kamatani C07C 17/14 257/40
2010/0244004 A1* 9/2010 Xia C07F 15/0033 257/40
2011/0204333 A1* 8/2011 Xia C07F 15/0033 257/40
2012/0061654 A1* 3/2012 Rayabarapu C07F 15/0033 257/40
2012/0205645 A1* 8/2012 Fuchs C07F 15/0033 257/40
2012/0292601 A1* 11/2012 Kottas H01L 51/0085 257/40
2013/0026452 A1 1/2013 Kottas et al.
2013/0119354 A1* 5/2013 Ma C07F 15/0033 257/40
2013/0306940 A1 11/2013 Zeng et al.
2014/0131663 A1 5/2014 Beers et al.
2014/0131676 A1 5/2014 Beers et al.
2014/0131687 A1* 5/2014 Lin C07F 15/0033 257/40
2014/0361252 A1 12/2014 Dyatkin et al.
2015/0105556 A1 4/2015 Li et al.
2015/0137096 A1* 5/2015 Xia H01L 51/0085 257/40
2015/0236276 A1* 8/2015 Boudreault H01L 51/0085 257/40
2015/0364702 A1* 12/2015 Abe C09K 11/06 257/40
2016/0359123 A1* 12/2016 Thompson H01L 51/0085

FOREIGN PATENT DOCUMENTS

EP 1238981 9/2002
EP 1725079 11/2006
EP 2034538 3/2009
JP 200511610 1/2005
JP 2007123392 5/2007
JP 2009076624 A 9/2007
JP 2007254297 10/2007
JP 2008074939 10/2009
JP 2010/135467 6/2010
JP 5707818 B2 4/2015
KR 20100114749 A 10/2010
WO 2001039234 5/2001
WO 2002002714 1/2002
WO 0215645 2/2002
WO 2003040257 5/2003
WO 2003060956 7/2003
WO 2004093207 10/2004
WO 2004/111066 12/2004
WO 2004107822 12/2004
WO 2005014551 2/2005
WO 2005019373 3/2005
WO 2005030900 4/2005
WO 2005089025 9/2005
WO 2005123873 12/2005
WO 2006009024 1/2006
WO 2006056418 6/2006
WO 2006/072002 7/2006

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	2006082742	8/2006
WO	2006098120	9/2006
WO	2006100298	9/2006
WO	2006103874	10/2006
WO	2006114966	11/2006
WO	2006132173	12/2006
WO	2007/002683	1/2007
WO	2007004380	1/2007
WO	2007063754	6/2007
WO	2007063796	6/2007
WO	2008/044723	4/2008
WO	2008057394	5/2008
WO	2008101842	8/2008
WO	2008132085	11/2008
WO	2009000673	12/2008
WO	2009/003898	1/2009
WO	2009/008311	1/2009
WO	2009/018009	2/2009
WO	2009050290	4/2009
WO	2008/056746	5/2009
WO	2009/021126	5/2009
WO	2009/062578	5/2009
WO	2009/063833	5/2009
WO	2009/066778	5/2009
WO	2009/066779	5/2009
WO	2009/086028	7/2009
WO	2009100991	8/2009
WO	2010011390	1/2010
WO	2010/111175	9/2010

OTHER PUBLICATIONS

Baldo et al., "Very high-efficiency green organic light-emitting devices based on electrophosphorescence," Appl. Phys. Lett., vol. 75, No. 1, 4-6 (1999).

Kuwabara, Yoshiyuki et al., "Thermally Stable Multilayered Organic Electroluminescent Devices Using Novel Starburst Molecules, 4,4',4"-Tri(N-carbazolyl)triphenylamine (TCTA) and 4,4',4"-Tris(3-methylphenylphenyl-amino)triphenylarnine (m-MTDATA), as Hole-Transport Materials," *Adv. Mater.*, 6(9):677-679 (1994).

Paulose, Betty Marie Jennifer S. et al., "First Examples of Alkenyl Pyridines as Organic Ligands for Phosphorescent Iridium Complexes," *Adv. Mater.*, 16(22):2003-2007 (2004).

Tung, Yung-Liang et al., "Organic Light-Emitting Diodes Based on Charge-Neutral Ru^{II} PHosphorescent Emitters," Adv. Mater., 17(8):1059-1064 (2005).

Huang, Jinsong et al., "Highly Efficient Red-Emission Polymer Phosphorescent Light-Emitting Diodes Based on Two Novel Tris(1-phenylisoquinolinato-C2,N)iridium(III) Derivatives," *Adv. Mater.*, 19:739-743 (2007).

Wong, Wai-Yeung, "Multifunctional Iridium Complexes Based on Carbazole Modules as Highly Efficient Electrophosphors," *Angew. Chem. Int. Ed.*, 45:7800-7803 (2006).

Tang, C.W. and VanSlyke, S.A., "Organic Electroluminescent Diodes," *Appl. Phys. Lett.*, 51(12):913-915 (1987).

Adachi, Chihaya et al., "Organic Electroluminescent Device Having a Hole Conductor as an Emitting Layer," *Appl. Phys. Lett.*, 55(15):1489-1491 (1989).

Ma, Yuguang et al., "Triplet Luminescent Dinuclear-Gold(I) Complex-Based Light-Emitting Diodes with Low Turn-On voltage," *Appl. Phys. Lett.*, 74(10):1361-1363 (1999).

Gao, Zhiqiang et al., "Bright-Blue Electroluminescence From a Silyl-Substituted ter-(phenylene-vinylene) derivative," *Appl. Phys. Lett.*, 74(6):865-867 (1999).

Lee, Chang-Lyoul et al., "Polymer Phosphorescent Light-Emitting Devices Doped with Tris(2-phenylpyridine) Iridium as a Triplet Emitter," *Appl. Phys. Lett.*, 77(15):2280-2282 (2000).

Hung, L.S. et al., "Anode Modification in Organic Light-Emitting Diodes by Low-Frequency Plasma Polymerization of CHF_3," *Appl. Phys. Lett.*, 78(5):673-675 (2001).

Ikai, Masamichi and Tokito, Shizuo, "Highly Efficient Phosphorescence From Organic Light-Emitting Devices with an Exciton-Block Layer," *Appl. Phys. Lett.*, 79(2):156-158 (2001).

Wang, Y. et al., "Highly Efficient Electroluminescent Materials Based on Fluorinated Organometallic Iridium Compounds," *Appl. Phys. Lett.*, 79(4):449-451 (2001).

Kwong, Raymond C. et al., "High Operational Stability of Electrophosphorescent Devices," *Appl. Phys. Lett.*, 81(1):162-164 (2002).

Holmes, R.J. et al., "Blue Organic Electrophosphorescence Using Exothermic Host-Guest Energy Transfer," *Appl. Phys. Lett.*, 82(15):2422-2424 (2003).

Sotoyama, Wataru et al., "Efficient Organic Light-Emitting Diodes with Phosphorescent Platinum Complexes Containing NCN-Coordinating Tridentate Ligand," *Appl. Phys. Lett.*, 86:153505-1-153505-3 (2005).

Okumoto, Kenji et al., "Green Fluorescent Organic Light-Emitting Device with External Quantum Efficiency of Nearly 10%," *Appl. Phys. Lett.*, 89:063504-1-063504-3 (2006).

Kanno, Hiroshi et al., "Highly Efficient and Stable Red Phosphorescent Organic Light-Emitting Device Using bis[2-(2-benzothiazoyl)phenolato]zinc(II) as host material," *Appl. Phys. Lett.*, 90:123509-1-123509-3 (2007).

Aonuma, Masaki et al., "Material Design of Hole Transport Materials Capable of Thick-Film Formation in Organic Light Emitting Diodes," *Appl. Phys. Lett.*, 90:183503-1-183503-3 (2007).

Sun, Yiru and Forrest, Stephen R., "High-Efficiency White Organic Light Emitting Devices with Three Separate Phosphorescent Emission Layers," *Appl. Phys. Lett.*, 91:263503-1-263503-3 (2007).

Adachi, Chihaya et al., "High-Efficiency Red Electrophosphorescence Devices," *Appl. Phys. Lett.*, 78(11):1622-1624 (2001).

Wong, Keith Man-Chung et al., "A Novel Class of Phosphorescent Gold(III) Alkynyl-Based Organic Light-Emitting Devices with Tunable Colour," *Chem. Commun.*, 2906-2908 (2005).

Hamada, Yuji et al., "High Luminance in Organic Electroluminescent Devices with Bis(10-hydroxybenzo[h]quinolinato)beryllium as an Emitter," *Chem. Lett.*, 905-906 (1993).

Nishida, Jun-ichi et al., "Preparation, Characterization, and Electroluminescence Characteristics of α-Diimine-type Platinum(II) Complexes with Perfluorinated Phenyl Groups as Ligands," *Chem. Lett.*, 34(4):592-593 (2005).

Mi, Bao-Xiu et al., "Thermally Stable Hole-Transporting Material for Organic Light-Emitting Diode: an Isoindole Derivative," *Chem. Mater.*, 15(16):3148-3151 (2003).

Huang, Wei-Sheng et al., "Highly Phosphorescent Bis-Cyclometalated Iridium Complexes Containing Benzoimidazole-Based Ligands," *Chem. Mater.*, 16(12):2480-2488 (2004).

Niu, Yu-Hua et al., "Highly Efficient Electrophosphorescent Devices with Saturated Red Emission from a Neutral Osmium Complex," *Chem. Mater.*, 17(13):3532-3536 (2005).

Lo, Shih-Chun et al., "Blue Phosphorescence from Iridium(III) Complexes at Room Temperature," *Chem. Mater.*, 18(21):5119-5129 (2006).

Takizawa, Shin-ya et al., "Phosphorescent Iridium Complexes Based on 2-Phenylimidazo[1,2- α]pyridine Ligands: Tuning of Emission Color toward the Blue Region and Application to Polymer Light-Emitting Devices," *Inorg. Chem.*, 46(10):4308-4319 (2007).

Lamansky, Sergey et al., "Synthesis and Characterization of Phosphorescent Cyclometalated Iridium Complexes," *Inorg. Chem.*, 40(7):1704-1711 (2001).

Ranjan, Sudhir et al., "Realizing Green Phosphorescent Light-Emitting Materials from Rhenium(I) Pyrazolato Diimine Complexes," *Inorg. Chem.*, 42(4):1248-1255 (2003).

Noda, Tetsuya and Shirota,Yasuhiko, "5,5'-Bis(dimesitylboryl)-2,2'-bithiophene and 5,5"-Bis(dimesitylboryl)-2,2':5',2"-terthiophene as a Novel Family of Electron-Transporting Amorphous Molecular Materials," *J. Am. Chem. Soc.*, 120 (37):9714-9715 (1998).

Sakamoto, Youichi et al., "Synthesis, Characterization, and Electron-Transport Property of Perfluorinated Phenylene Dendrimers," *J. Am. Chem. Soc.*, 122(8):1832-1833 (2000).

Adachi, Chihaya et al., "Nearly 100% Internal Phosphorescence Efficiency in an Organic Light Emitting Device," *J. Appl. Phys.*, 90(10):5048-5051 (2001).

(56) **References Cited**

OTHER PUBLICATIONS

Shirota, Yasuhiko et al., "Starburst Molecules Based on p-Electron Systems as Materials for Organic Electroluminescent Devices," *Journal of Luminescence*, 72-74:985-991 (1997).

Inada, Hiroshi and Shirota, Yasuhiko, "1,3,5-Tris[4-(diphenylamino)phenyl]benzene and its Methylsubstituted Derivatives as a Novel Class of Amorphous Molecular Materials," *J. Mater. Chem.*, 3(3):319-320 (1993).

Kido, Junji et al., 1,2,4-Triazole Derivative as an Electron Transport Layer in Organic Electroluminescent Devices, *Jpn. J. Appl. Phys.*, 32:L917-L920 (1993).

Van Slyke, S. A. et al., "Organic Electroluminescent Devices with Improved Stability," *Appl. Phys. Lett.*, 69(15):2160-2162 (1996).

Guo, Tzung-Fang et al., "Highly Efficient Electrophosphorescent Polymer Light-Emitting Devices," *Organic Electronics*, 1:15-20 (2000).

Palilis, Leonidas C., "High Efficiency Molecular Organic Light-Emitting Diodes Based on Silole Derivatives and Their Exciplexes," *Organic Electronics*, 4:113-121 (2003).

Ikeda, Hisao et al., "P-185: Low-Drive-Voltage OLEDs with a Buffer Layer Having Molybdenum Oxide," *SID Symposium Digest*, 37:923-926 (2006).

T. Östergård et al., "Langmuir-Blodgett Light-Emitting Diodes of Poly(3-Hexylthiophene): Electro-Optical Characteristics Related to Structure," *Synthetic Metals*, 87:171-177 (1997).

Hu, Nan-Xing et al., "Novel High T_g Hole-Transport Molecules Based on Indolo[3,2-b]carbazoles for Organic Light-Emitting Devices," *Synthetic Metals*, 111-112:421-424 (2000).

Salbeck, J. et al., "Low Molecular Organic Glasses for Blue Electroluminescence," *Synthetic Metals*, 91:209-215 (1997).

* cited by examiner

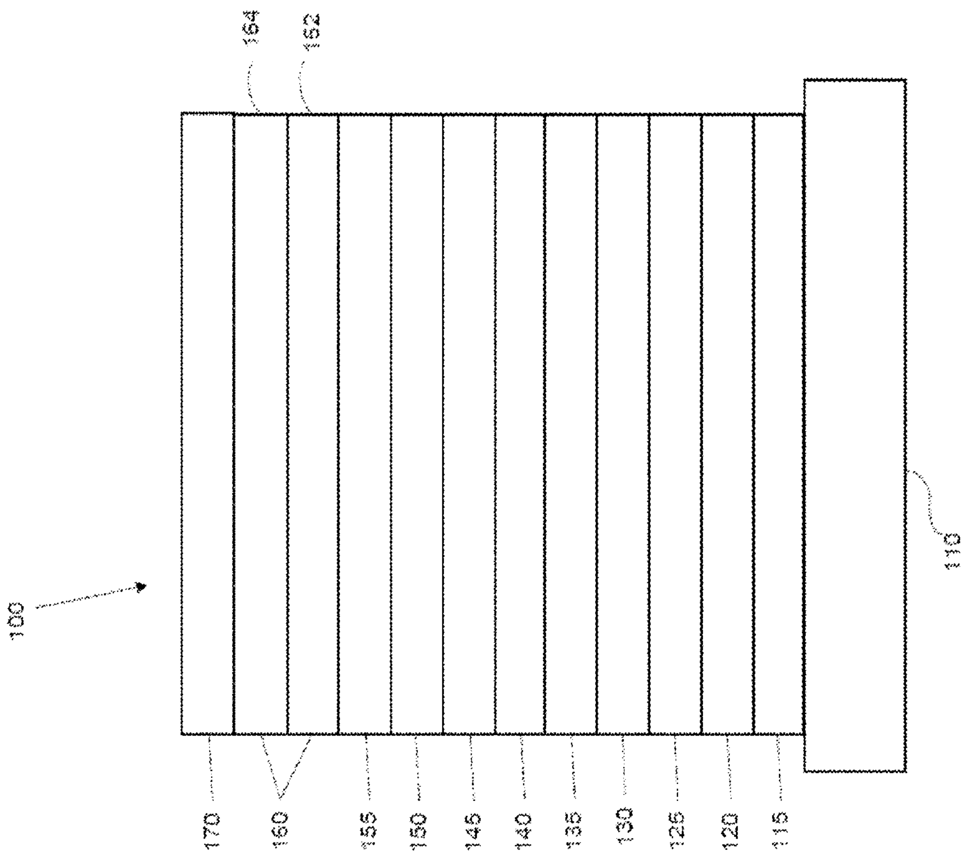


Figure 1

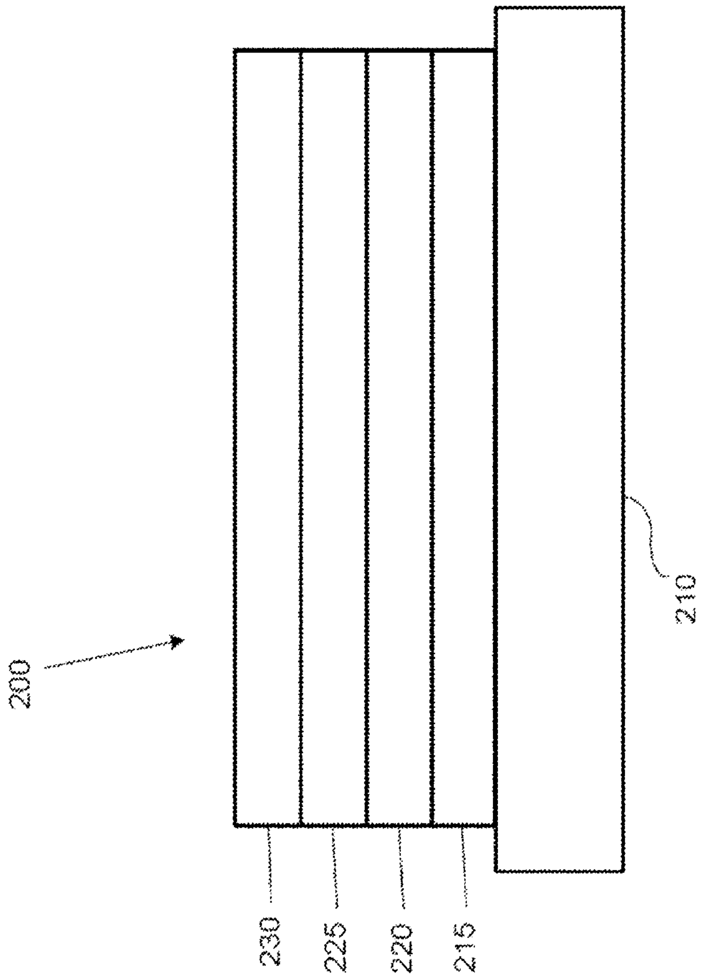


Figure 2

ORGANIC ELECTROLUMINESCENT MATERIALS AND DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 15/619,159, filed on Jun. 9, 2017, which claims priority to U.S. Provisional Patent Application Ser. No. 62/352,119, filed Jun. 20, 2016, the entire contents of all of which are incorporated herein by reference.

FIELD

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

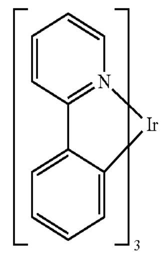
BACKGROUND

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

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

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

One example of a green emissive molecule is tris(2-phenylpyridine) iridium, denoted $Ir(ppy)_3$, which has the following structure:



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

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

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

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

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

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

HOMO or LUMO energy level appears closer to the top of such a diagram than a "lower" HOMO or LUMO energy level.

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

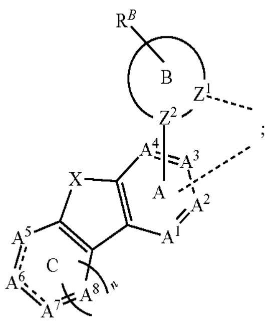
More details on OLEDs, and the definitions described above, can be found in U.S. Pat. No. 7,279,704, which is incorporated herein by reference in its entirety.

There is a need in the art for novel metal complexes useful as dopants for OLEDs. The present invention addresses this need in the art.

SUMMARY

According to an embodiment, a compound is provided that includes a first ligand L_A having Formula I shown below:

Formula I



wherein ring B is a 5 or 6-membered carbocyclic or heterocyclic ring;

wherein R^B represents mono to the possible maximum number of substitution, or no substitution;

wherein Z^1 and Z^2 are each independently selected from the group consisting of carbon or nitrogen;

wherein A^1, A^2, A^3, and A^4 are each independently CR or N;

wherein ring C is a 5 or 6-membered aromatic ring;

n is 0 or 1;

wherein when n is 0, A^8 is not present, and A^5, A^6, and A^7 are each independently selected from the group consisting of CR, NR', O, S, and Se;

wherein when n is 1, A^5, A^6, A^7, and A^8 are each independently CR or N, and at least two adjacent A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 are CR and the Rs are joined together to form a six-membered ring fused to ring A or ring C;

wherein each R and R' in CR or NR' can be the same or different;

wherein X is O, S, or Se;

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

wherein any adjacent substituents are optionally joined or fused into a ring;

wherein the ligand L_A is coordinated to a metal M;

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

wherein the metal M can be coordinated to other ligands; and

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

According to another embodiment, an organic light emitting diode/device (OLED) is also provided. The OLED can include an anode, a cathode, and an organic layer, disposed between the anode and the cathode. The organic layer can include a compound that includes a first ligand L_A having Formula I. According to yet another embodiment, the organic light emitting device is incorporated into a device selected from a consumer product, an electronic component module, and/or a lighting panel.

According to another embodiment, a consumer product comprising one or more organic light emitting devices is also provided. The organic light emitting device can include an anode, a cathode, and an organic layer, disposed between the anode and the cathode, wherein the organic layer can include a compound that includes a first ligand L_A having Formula I. The consumer product can be a flat panel display, a computer monitor, a medical monitors television, a billboard, a light for interior or exterior illumination and/or signaling, a heads-up display, a fully or partially transparent display, a flexible display, a laser printer, a telephone, a cell phone, tablet, a phablet, a personal digital assistant (PDA), a wearable device, a laptop computer, a digital camera, a camcorder, a viewfinder, a micro-display that is less than 2 inches diagonal, a 3-D display, a virtual reality or augmented reality display, a vehicle, a video wall comprising multiple displays tiled together, a theater or stadium screen, and/or a sign.

According to another embodiment, a formulation containing a compound that includes a first ligand L_A having Formula I is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an organic light emitting device.

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

DETAILED DESCRIPTION

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

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

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

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

More examples for each of these layers are available. For example, a flexible and transparent substrate-anode combination is disclosed in U.S. Pat. No. 5,844,363, which is incorporated by reference in its entirety. An example of a p-doped hole transport layer is m-MTDATA doped with 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.

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

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

Structures and materials not specifically described may also be used, such as OLEDs comprised of polymeric materials (PLEDs) such as disclosed in U.S. Pat. No. 5,247,190 to Friend et al., which is incorporated by reference in its entirety. By way of further example, OLEDs having a single organic layer may be used. OLEDs may be stacked, for example as described in U.S. Pat. No. 5,707,745 to Forrest et al, which is incorporated by reference in its entirety. The OLED structure may deviate from the simple layered structure illustrated in FIGS. **1** and **2**. For example, the substrate may include an angled reflective surface to improve 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.

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

Devices fabricated in accordance with embodiments of the present invention may further optionally comprise a barrier layer. One purpose of the barrier layer is to protect the electrodes and organic layers from damaging exposure to harmful species in the environment including moisture, vapor and/or gases, etc. The barrier layer may be deposited over, under or next to a substrate, an electrode, or over any other parts of a device including an edge. The barrier layer may comprise a single layer, or multiple layers. The barrier layer may be formed by various known chemical vapor deposition techniques and may include compositions having a single phase as well as compositions having multiple phases. Any suitable material or combination of materials may be used for the barrier layer. The barrier layer may incorporate an inorganic or an organic compound or both. The preferred barrier layer comprises a mixture of a polymeric material and a non-polymeric material as described in U.S. Pat. No. 7,968,146, PCT Pat. Application Nos. PCT/US2007/023098 and PCT/US2009/042829, which are herein incorporated by reference in their entireties. To be considered a "mixture", the aforesaid polymeric and non-polymeric materials comprising the barrier layer should be deposited under the same reaction conditions and/or at the same time. The weight ratio of polymeric to non-polymeric material may be in the range of 95:5 to 5:95. The polymeric material and the non-polymeric material may be created from the same precursor material. In one example, the mixture of a polymeric material and a non-polymeric material consists essentially of polymeric silicon and inorganic silicon.

Devices fabricated in accordance with embodiments of the invention can be incorporated into a wide variety of electronic component modules (or units) that can be incorporated into a variety of electronic products or intermediate components. Examples of such electronic products or intermediate components include display screens, lighting devices such as discrete light source devices or lighting panels, etc. that can be utilized by the end-user product manufacturers. Such electronic component modules can optionally include the driving electronics and/or power source(s). Devices fabricated in accordance with embodiments of the invention can be incorporated into a wide variety of consumer products that have one or more of the electronic component modules (or units) incorporated therein. 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, 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, laser printers, telephones, cell phones, tablets, phablets, personal digital assistants (PDAs), wearable device, laptop computers, digital cameras, camcorders, viewfinders, micro-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, or a sign. Various control mechanisms may be used to control devices fabricated in accordance with the present invention, including passive matrix and active matrix. Many of the devices are intended for use in a temperature range comfortable to humans, such as 18 degrees C. to 30 degrees C., and more preferably at room temperature (20-25 degrees C.), but could be used outside this temperature range, for example, from −40 degree C. to +80 degree C.

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

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

The term "alkyl" as used herein contemplates both straight and branched chain alkyl radicals. Preferred alkyl groups are those containing from one to fifteen carbon atoms and includes methyl, ethyl, propyl, 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 may be optionally substituted.

The term "cycloalkyl" as used herein contemplates cyclic alkyl radicals. Preferred cycloalkyl groups are those containing 3 to 10 ring carbon atoms and includes cyclopropyl, cyclopentyl, cyclohexyl, adamantyl, and the like. Additionally, the cycloalkyl group may be optionally substituted.

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

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

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

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

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

The term "heteroaryl" as used herein contemplates single-ring hetero-aromatic groups that may include from one to five heteroatoms. The term heteroaryl also includes polycyclic hetero-aromatic systems having two or more rings in which two atoms are common to two adjoining rings (the rings are "fused") wherein at least one of the rings is a heteroaryl, e.g., the other rings can be cycloalkyls, cycloalkenyls, aryl, heterocycles, and/or heteroaryls. Preferred heteroaryl groups are those containing three to thirty carbon atoms, preferably three to twenty carbon atoms, more preferably three to twelve carbon atoms. Suitable heteroaryl groups include dibenzothiophene, dibenzofuran, dibenzoselenophene, furan, thiophene, benzofuran, benzothiophene, benzoselenophene, carbazole, indolocarbazole, pyridylindole, 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, preferably dibenzothiophene, dibenzofuran, dibenzoselenophene, carbazole, indolocarbazole, imidazole, pyridine, triazine, benzimidazole, 1,2-azaborine, 1,3-azaborine, 1,4-azaborine, borazine, and aza-analogs thereof. Additionally, the heteroaryl group may be optionally substituted.

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

As used herein, "substituted" indicates that a substituent other than H is bonded to the relevant position, such as carbon. Thus, for example, where R^1 is mono-substituted, then one R^1 must be other than H. Similarly, where R^1 is di-substituted, then two of R^1 must be other than H. Similarly, where R^1 is unsubstituted, R^1 is hydrogen for all available positions.

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

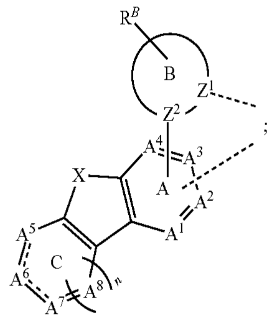
It is to be understood that when a molecular fragment is described as being a substituent or otherwise attached to another moiety, its name may be written as if it were a fragment (e.g. phenyl, phenylene, naphthyl, dibenzofuryl) or as if it were the whole molecule (e.g. benzene, naphthalene, dibenzofuran).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

Molecular modification made to the metal complexes can alter OLEDs performance. In one aspect, the present invention includes metal complexes with ligands containing an aromatic ring fused to the heterocyclic ligands, such as DBF, DBT, and aza-DBF, which further extend the conjugation of the ligand. Data described herein demonstrates that these complexes may be useful as dopants for OLEDs.

Compounds of the Invention

In one aspect, the present invention includes a compound comprising a first ligand L_A having Formula I:

Formula I



wherein ring B is a 5 or 6-membered carbocyclic or heterocyclic ring;

wherein R^B represents mono to the possible maximum number of substitution, or no substitution;

wherein Z^1 and Z^2 are each independently selected from the group consisting of carbon or nitrogen;

wherein A^1, A^2, A^3, and A^4 are each independently CR or N;

wherein ring C is a 5 or 6-membered aromatic ring;

n is 0 or 1;

wherein when n is 0, A^8 is not present, and A^5, A^6, and A^7 are each independently selected from the group consisting of CR, NR', O, S, and Se;

wherein when n is 1, A^5, A^6, A^7, and A^8 are each independently CR or N, and at least two adjacent A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 are CR and the Rs are joined together to form a six-membered ring fused to ring A or ring C;

wherein each R and R' in CR or NR' can be the same or different;

wherein X is O, S, or Se;

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

wherein any adjacent substituents are optionally joined or fused into a ring;

wherein the ligand L_A is coordinated to a metal M;

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

wherein the metal M can be coordinated to other ligands; and

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

In one embodiment, M is selected from the group consisting of Ir, Rh, Re, Ru, Os, Pt, Au, and Cu. In one embodiment, M is Ir or Pt.

In one embodiment, the compound is homoleptic. In one embodiment, the compound is heteroleptic.

In one embodiment, X is O.

In one embodiment, n is 0. In one embodiment, n is 1.

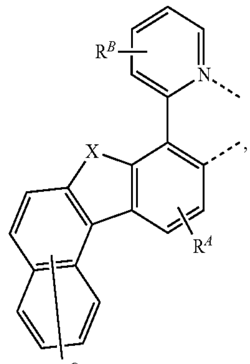
In one embodiment, n is 1, and each A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 is independently a CR. In one embodiment, n is 1, and at least one of A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 is N. In one embodiment, n is 1, and at least two adjacent A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 are CR and the Rs are joined together to form a phenyl ring fused to ring A or ring C.

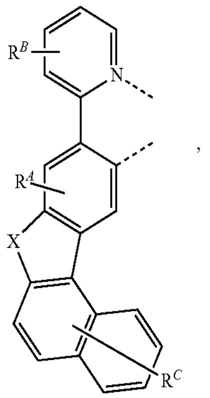
In one embodiment, n is 0, and there is no additional ring fused to ring C. In one embodiment, n is 0, and there is an additional ring fused to ring C.

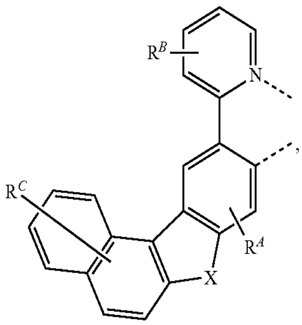
Any 5 or 6-membered carbocyclic or heterocyclic ring is contemplated by the present invention, as would be understood by one of ordinary skill in the art. In one embodiment, the ring is a N-heterocyclic ring. In one embodiment, Z^1 is an sp^2 neutral nitrogen atom of a N-heterocyclic ring selected from the group consisting of pyridine, pyrimidine, imidazole, benzimidazole, pyrazole, oxazole, and triazole. In one embodiment, Z^1 is a neutral carbon atom of a N-heterocyclic carbene.

In one embodiment, ring B connects to ring A through a C—C bond.

In one embodiment, the ligand L_A is selected from the group consisting of:







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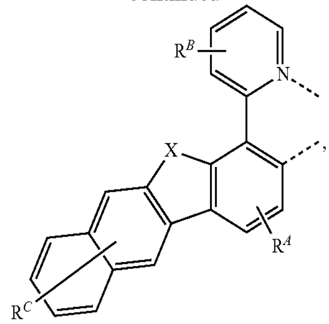

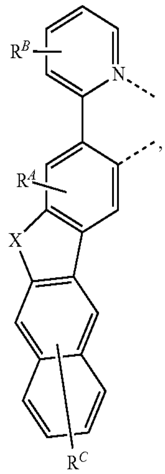

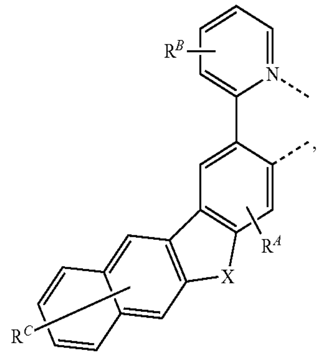

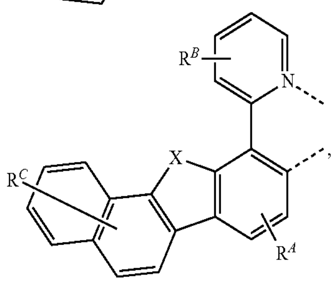

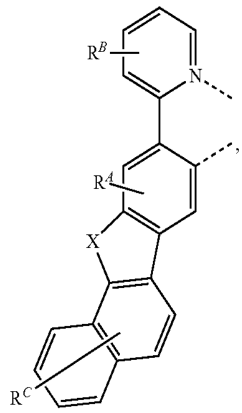

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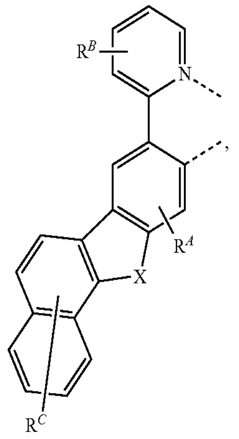

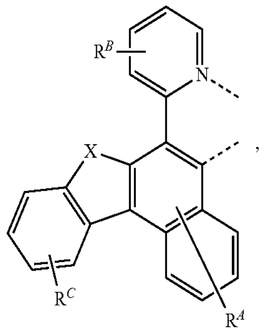

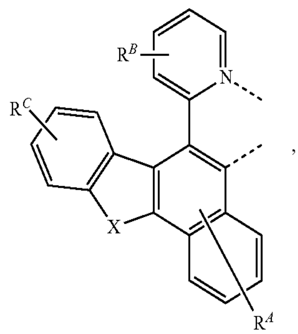

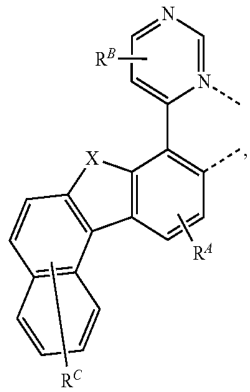

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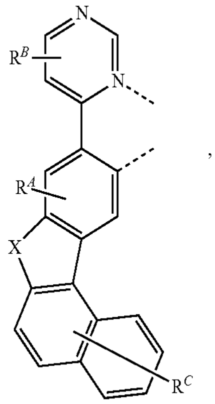

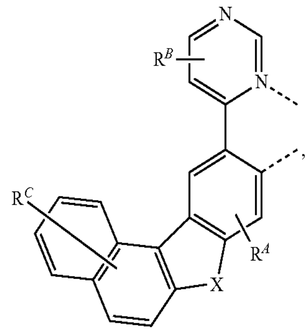

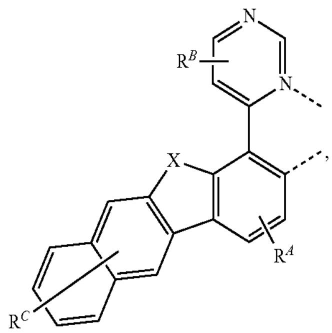

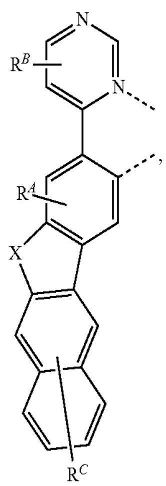

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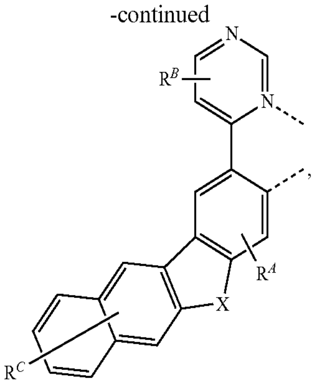

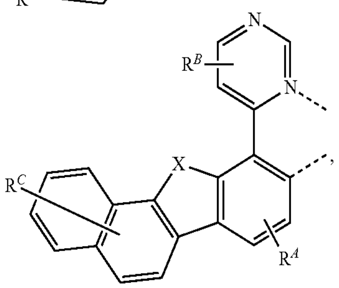

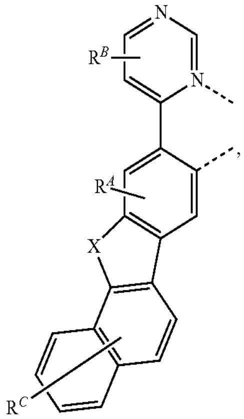

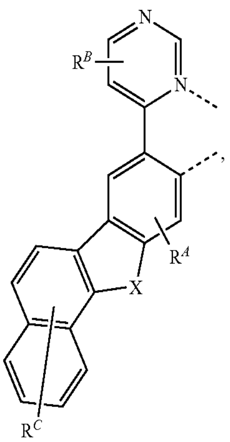

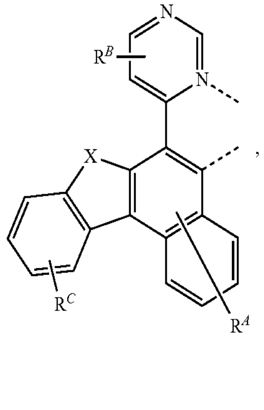

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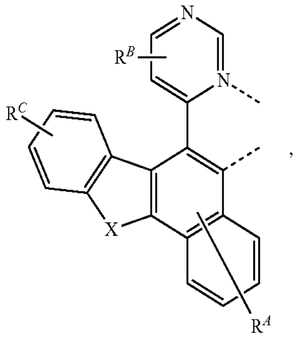

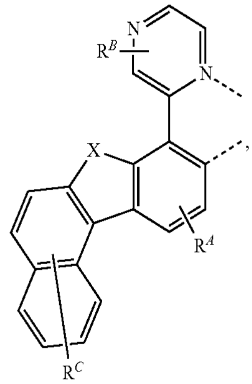

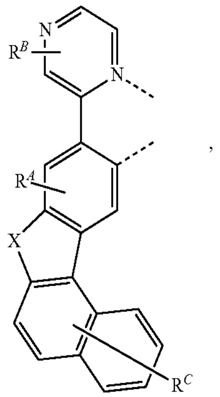

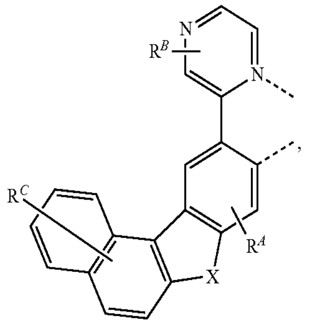

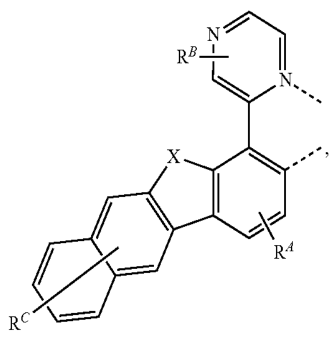

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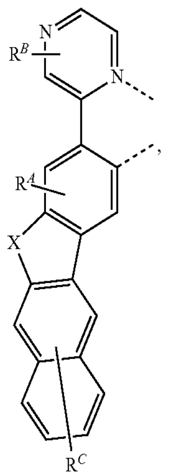

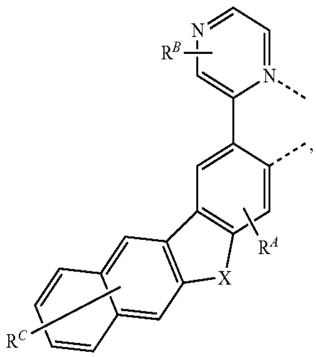

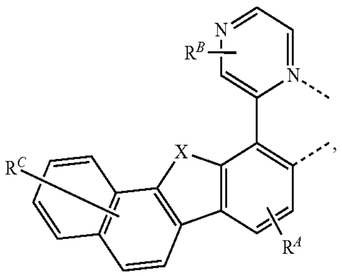

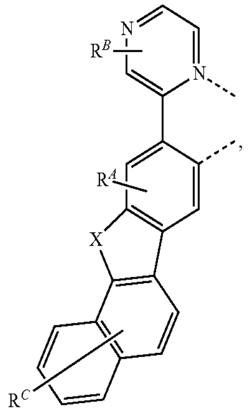

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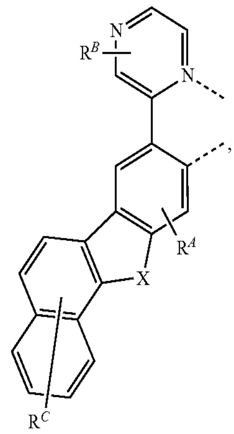

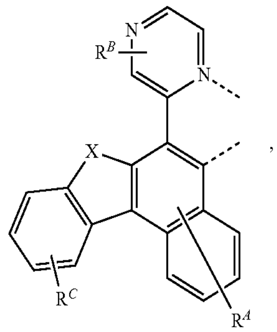

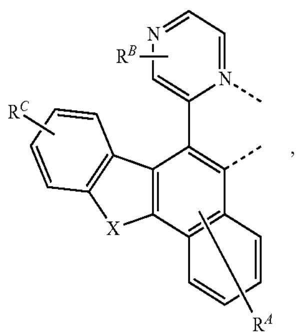

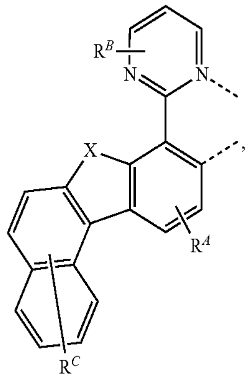

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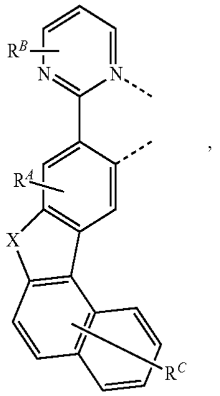

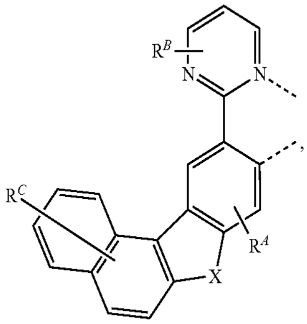

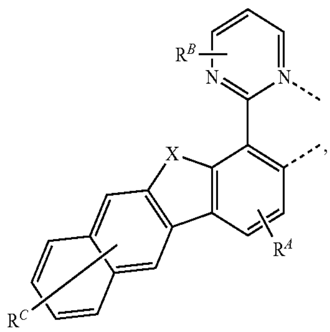

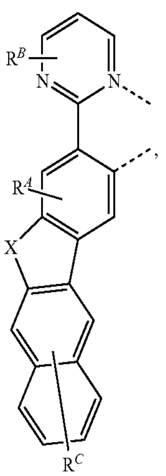

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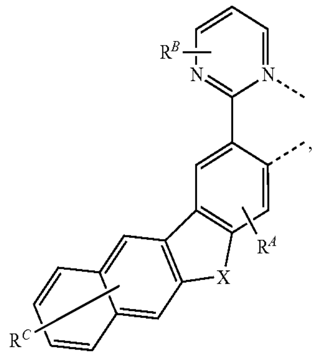

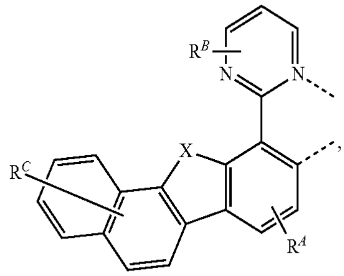

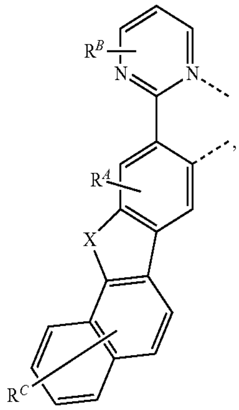

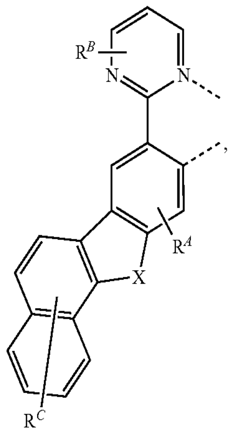

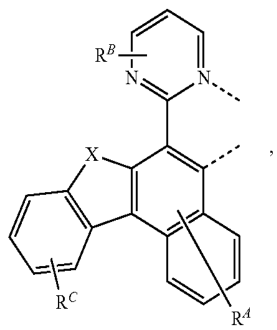

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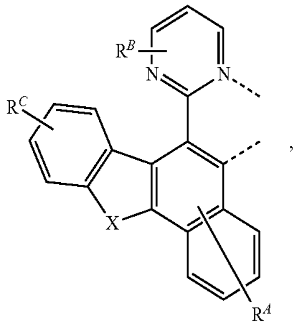

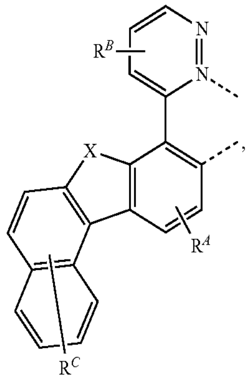

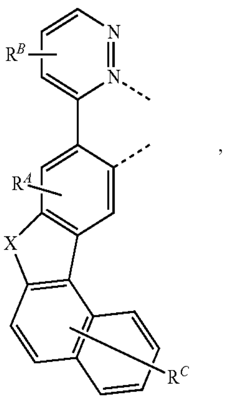

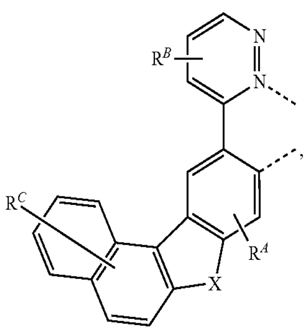

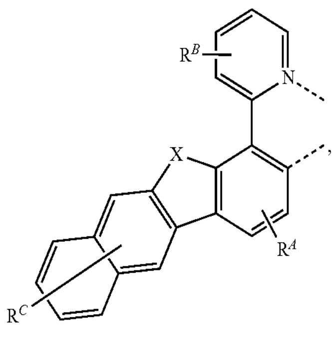

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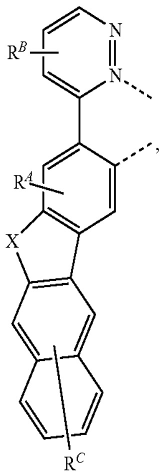

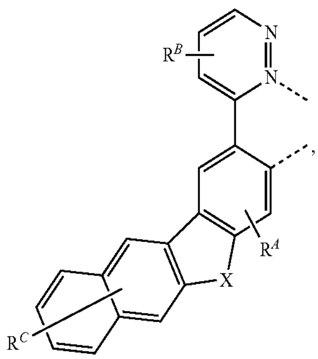

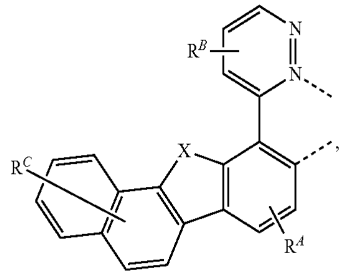

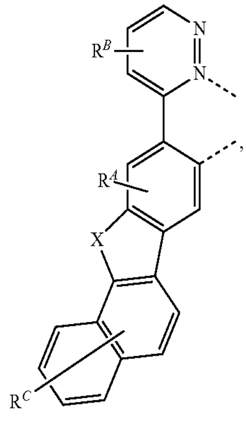

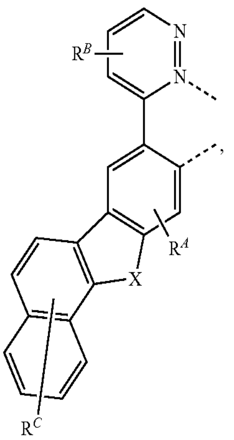
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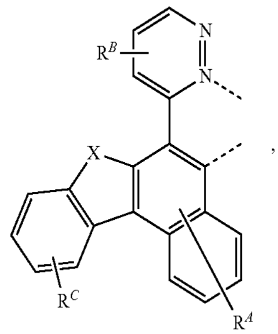
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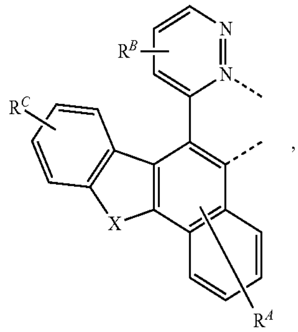
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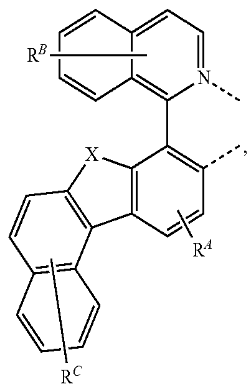
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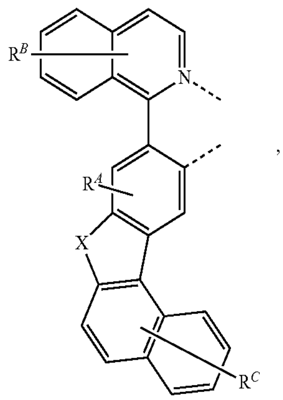
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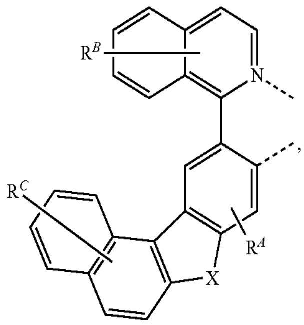
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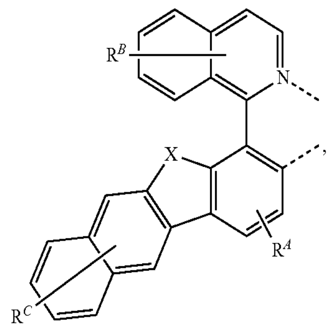
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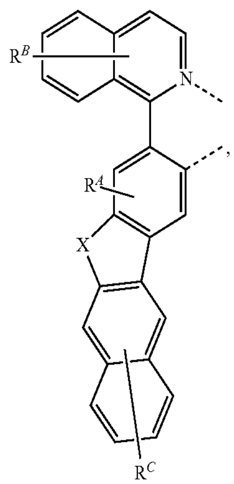
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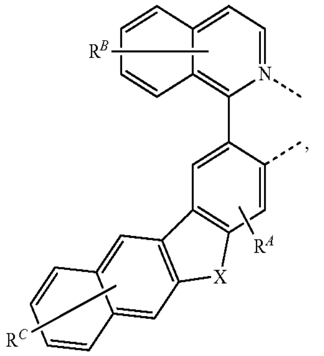

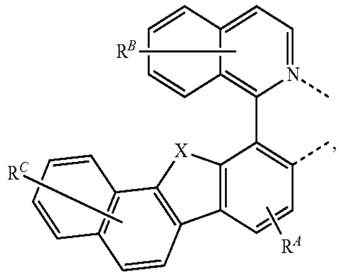

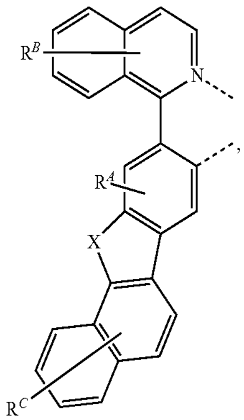

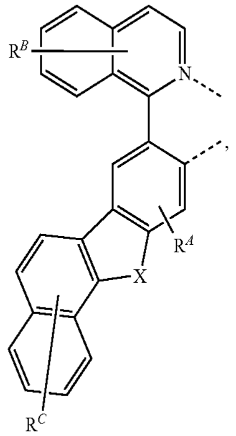

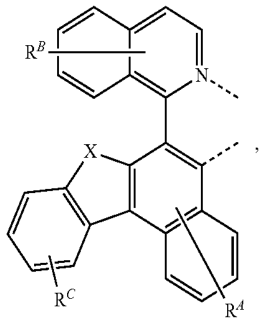

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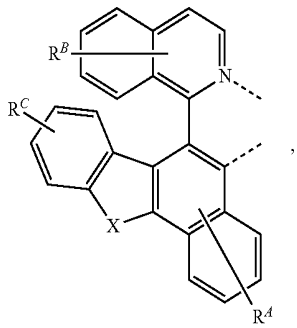

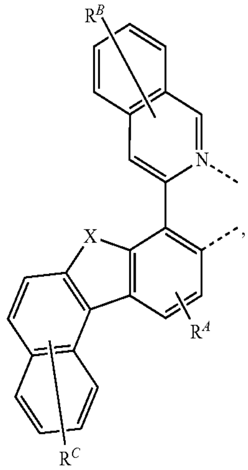

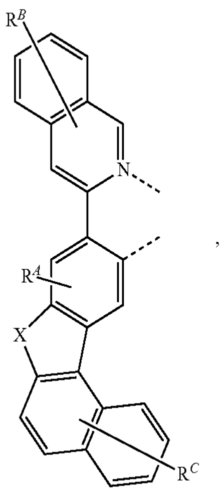

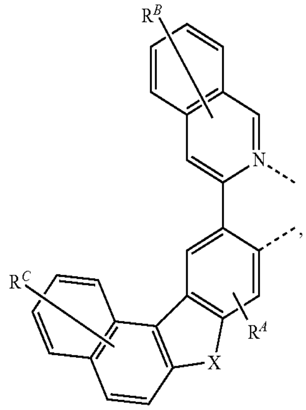

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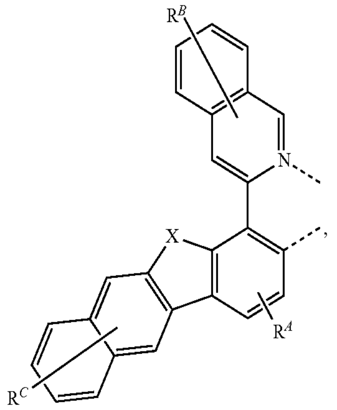

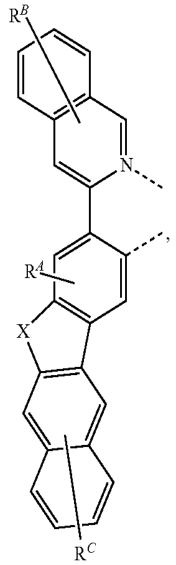

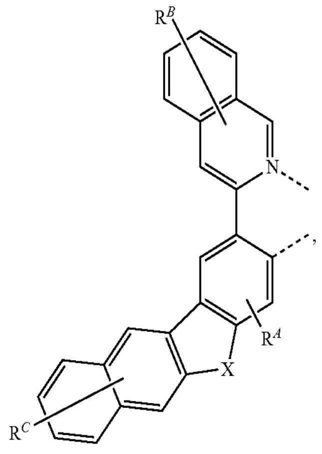

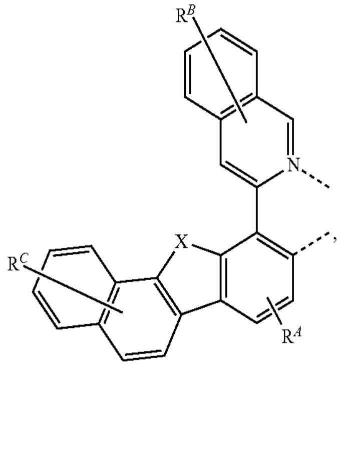

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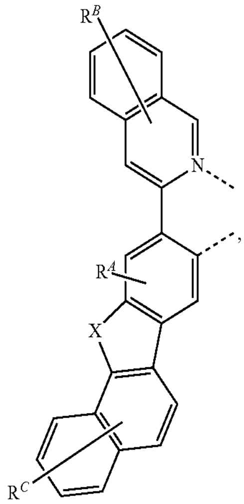

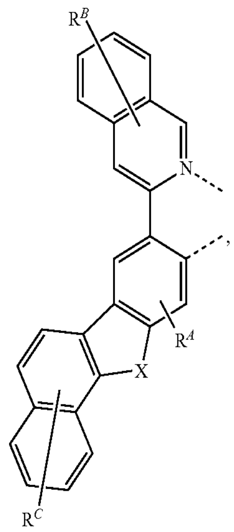

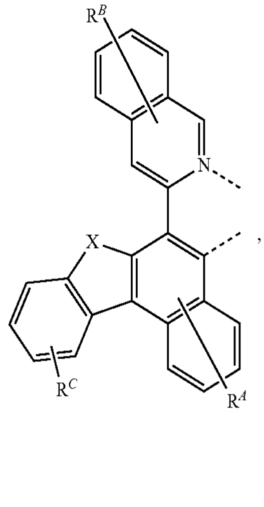

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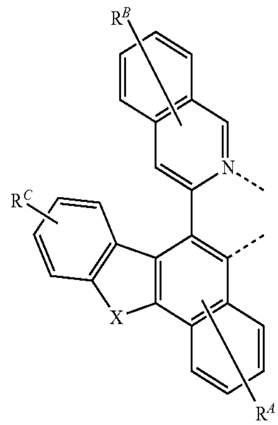

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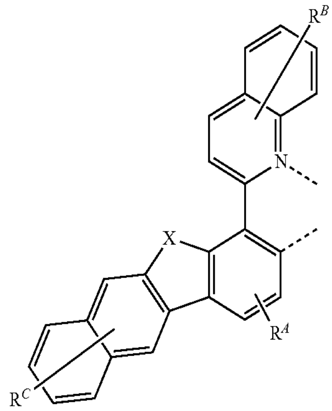

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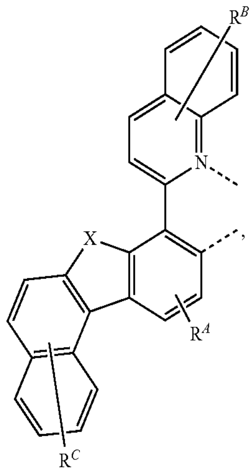

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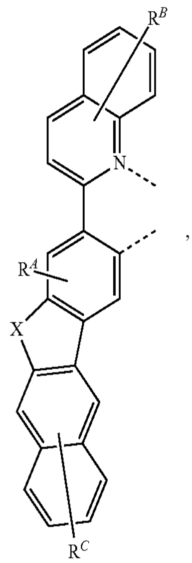

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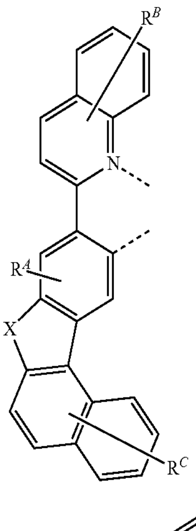

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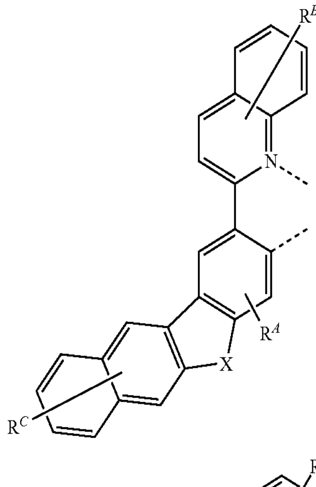

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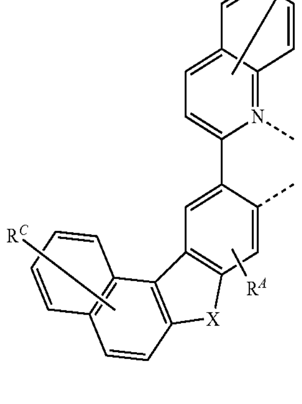

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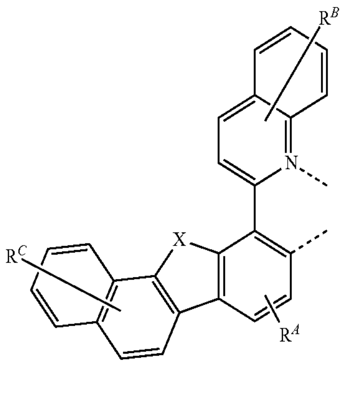

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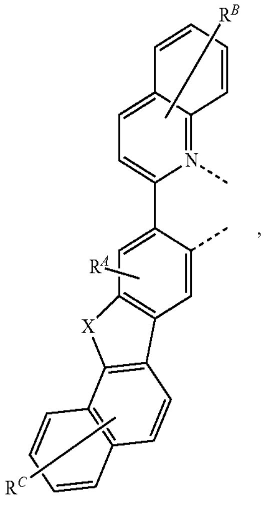

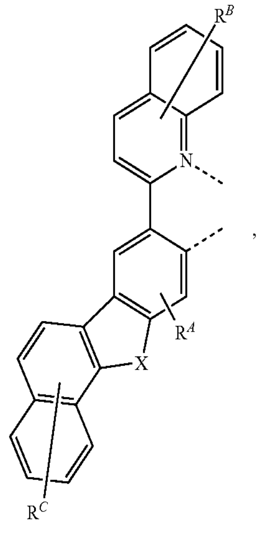

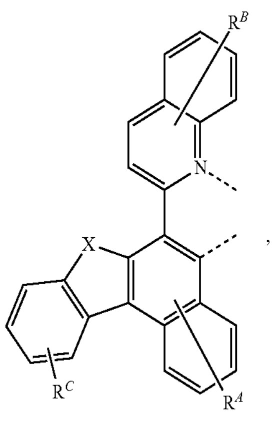

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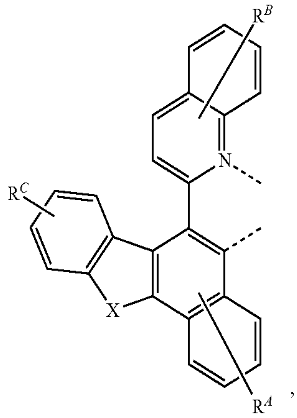

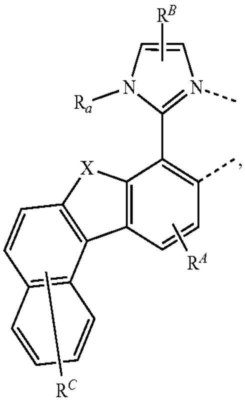

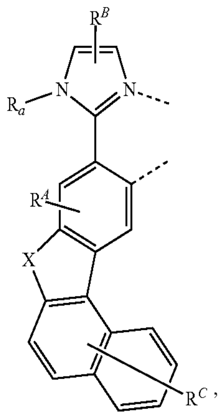

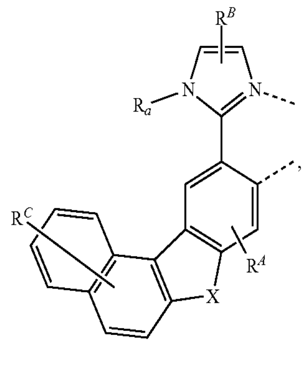

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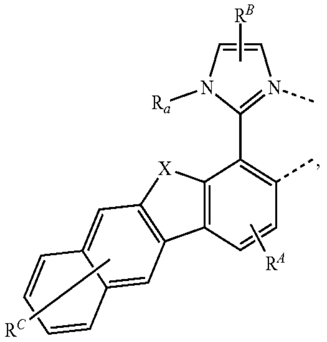

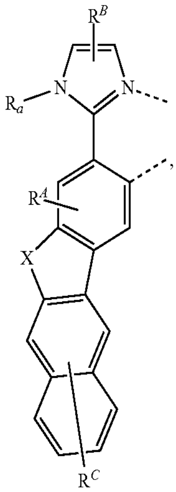

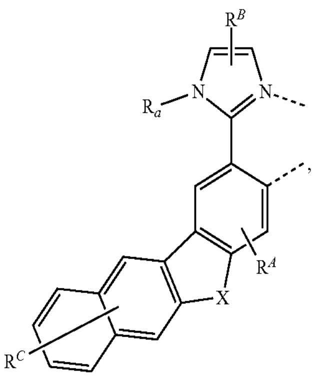

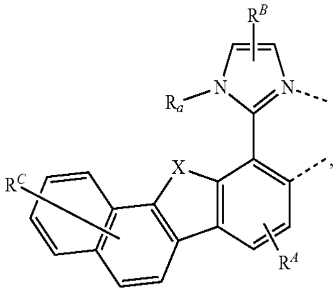

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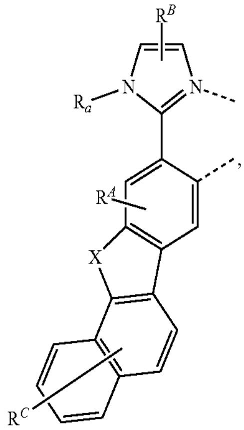

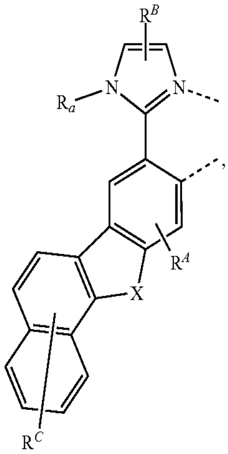

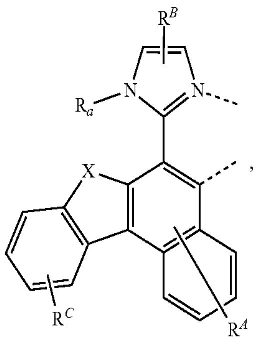

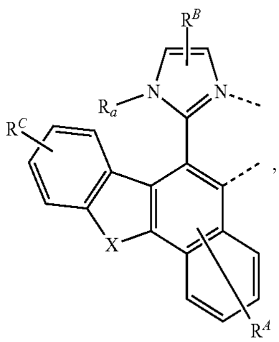

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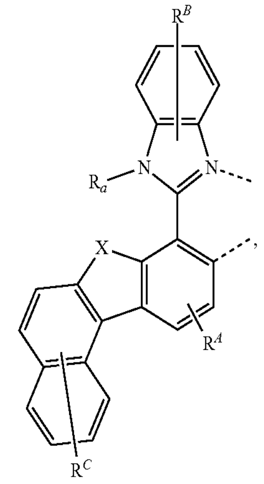

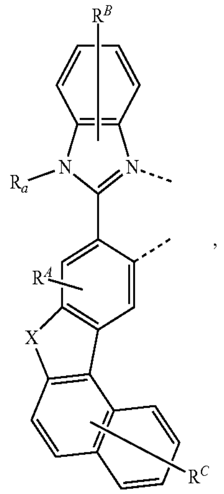

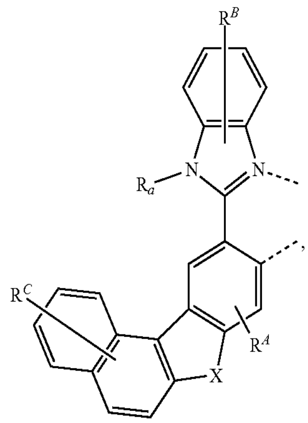

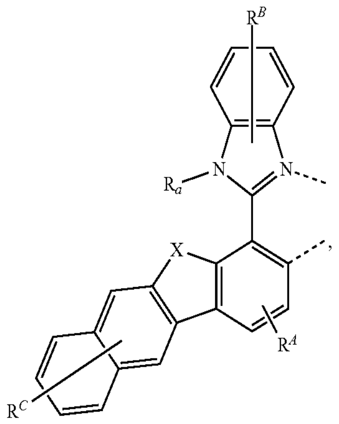

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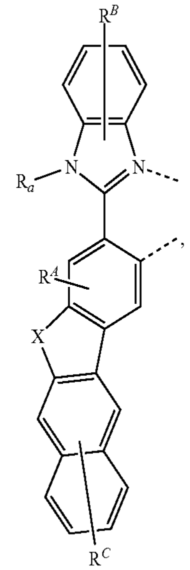

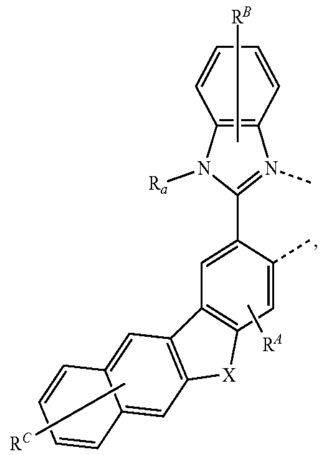

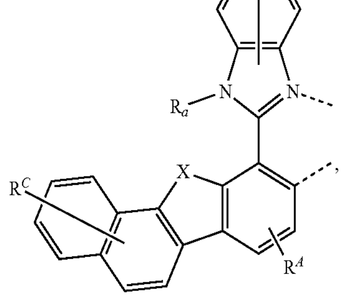

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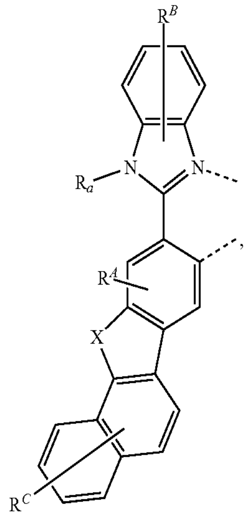

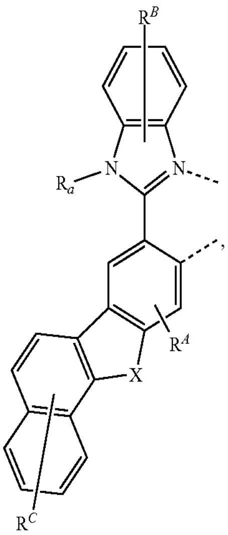

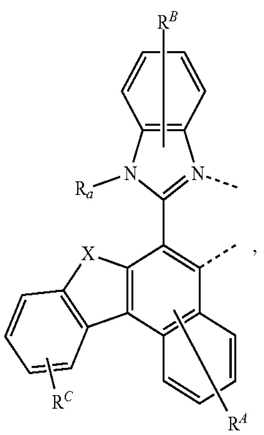

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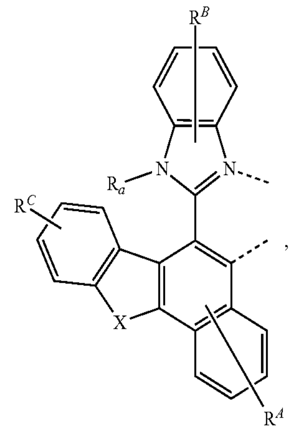

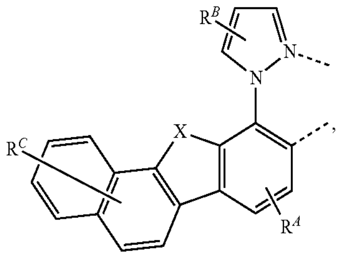

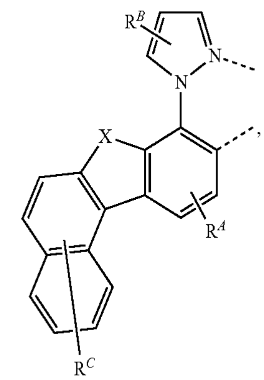

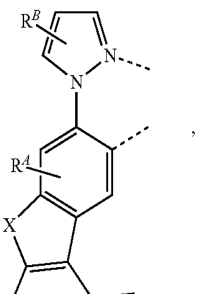

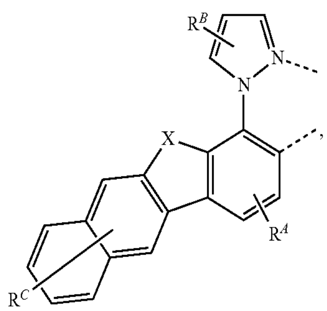

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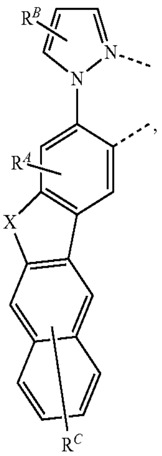

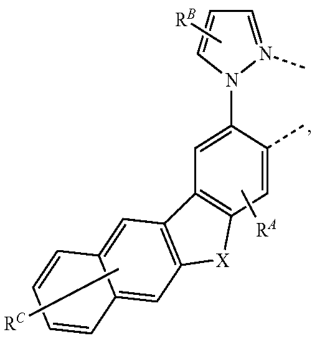

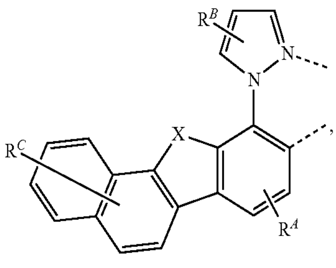

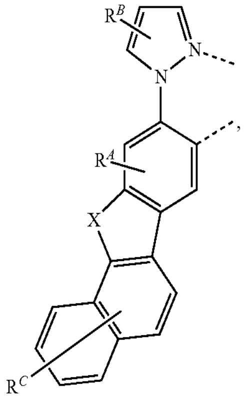

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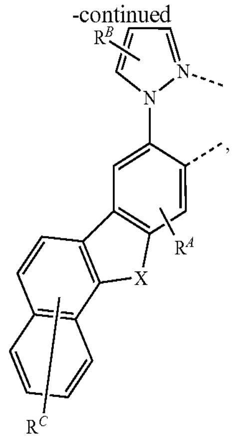

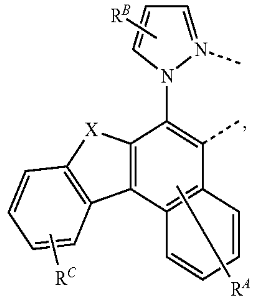

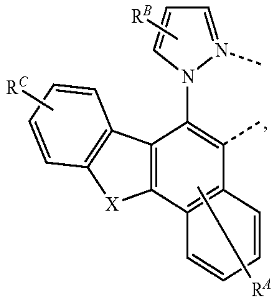

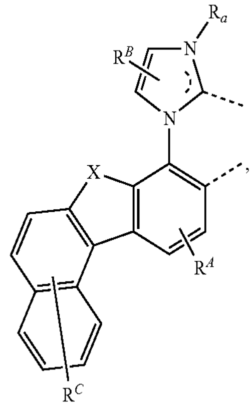

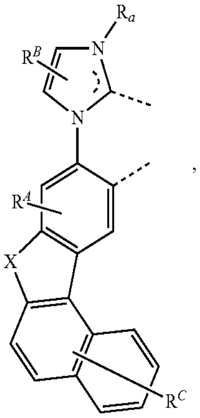

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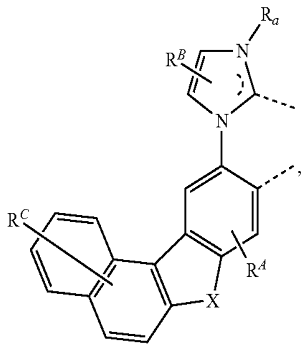

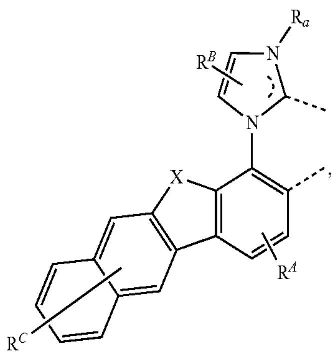

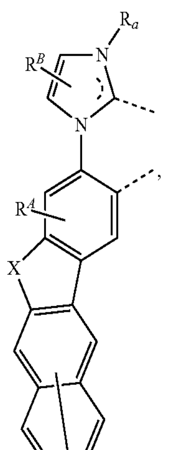

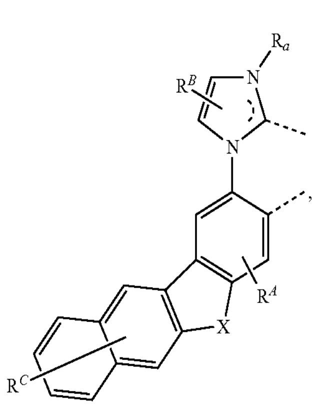

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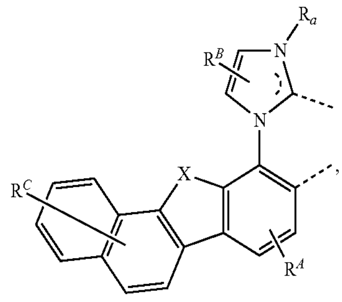

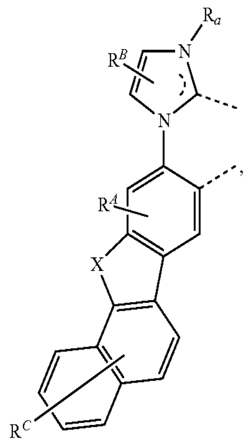

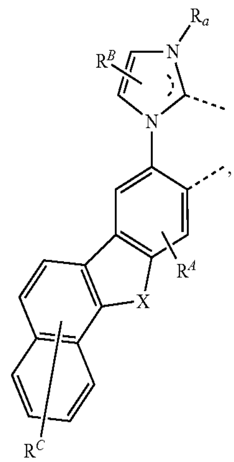

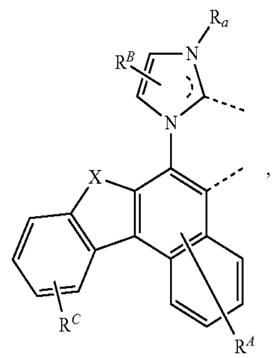

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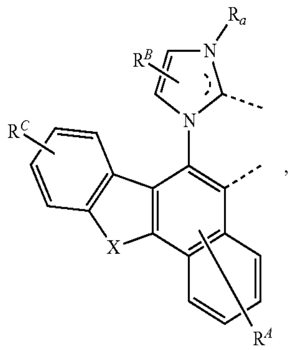

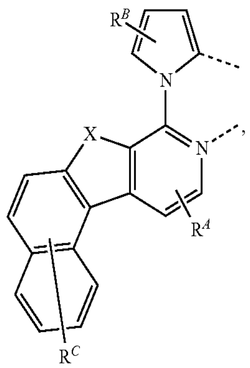

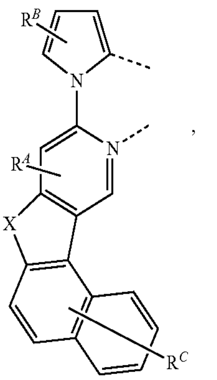

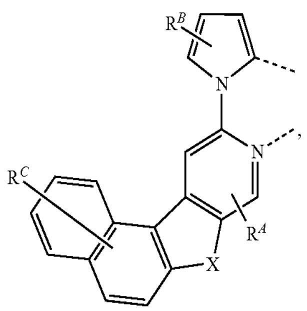

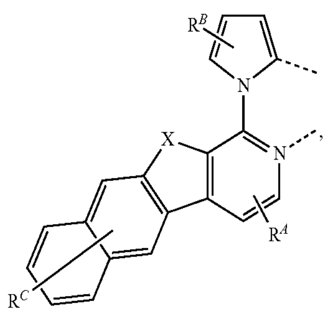

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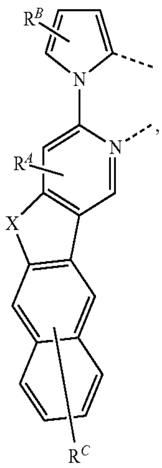

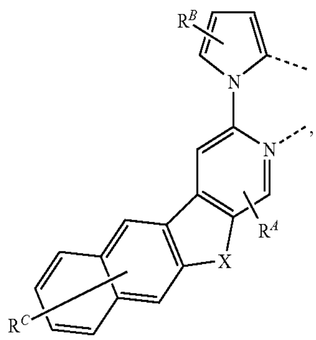

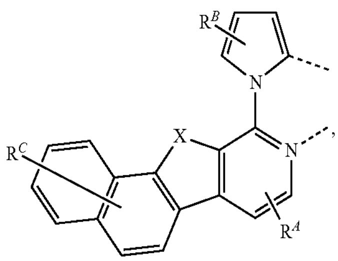

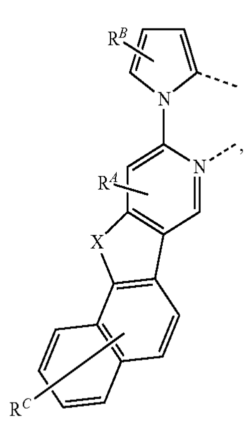

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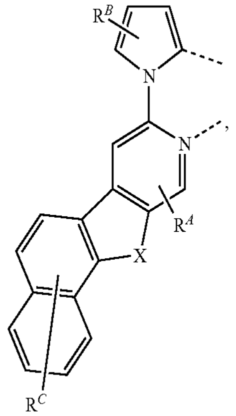

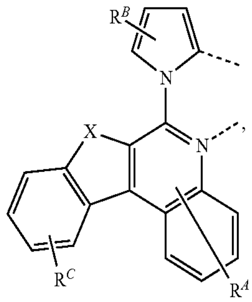

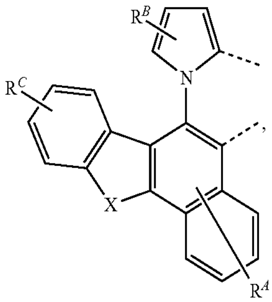

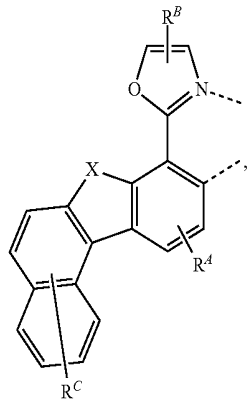

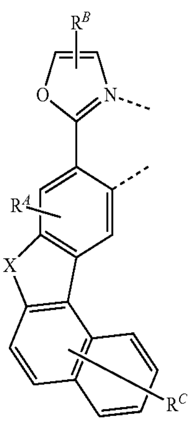

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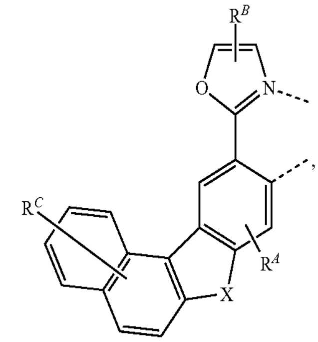

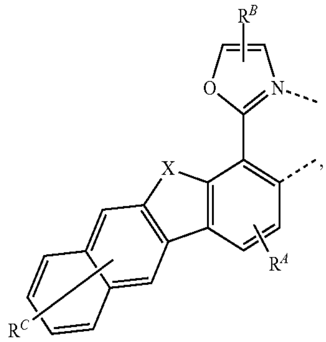

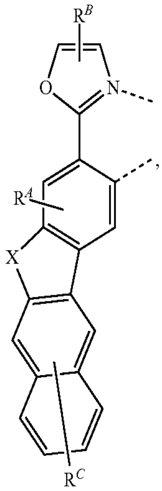

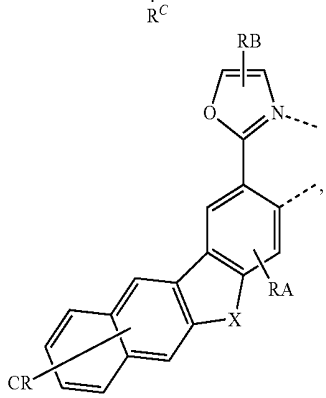

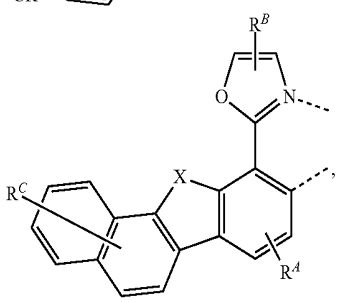

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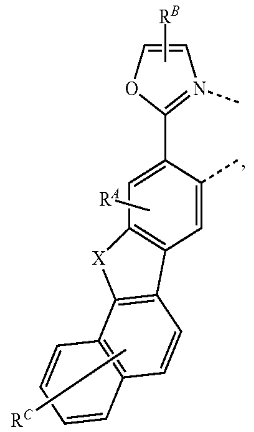

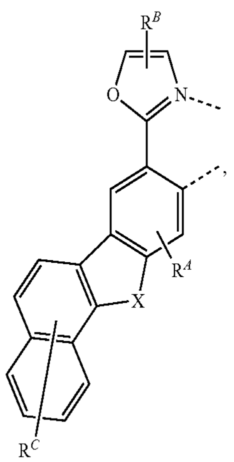

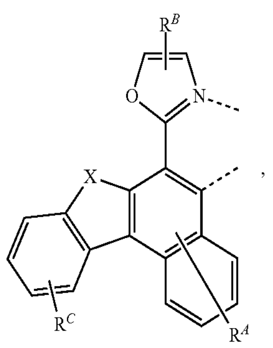

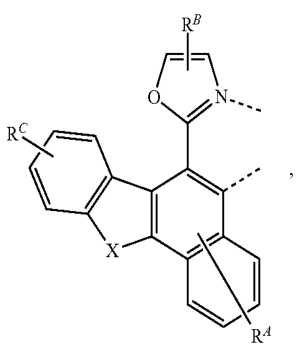

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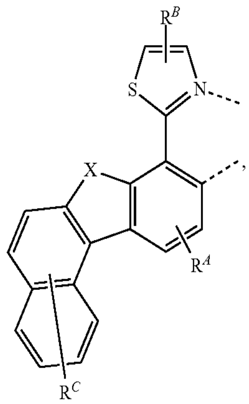

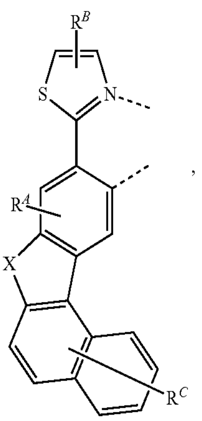

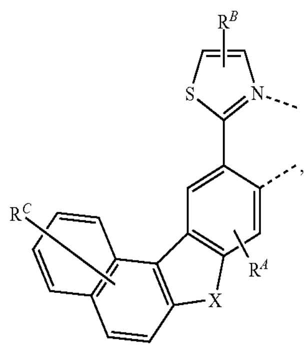

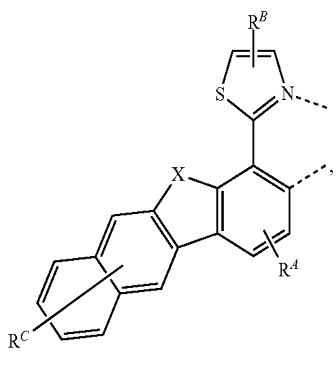

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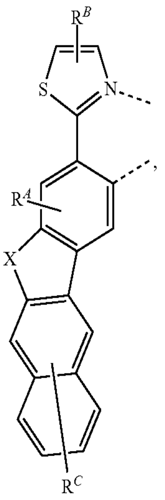

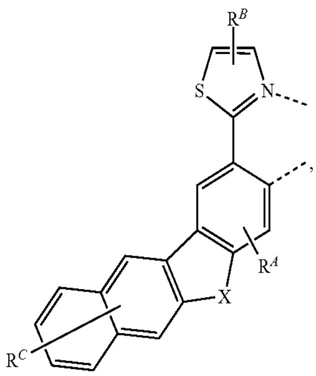

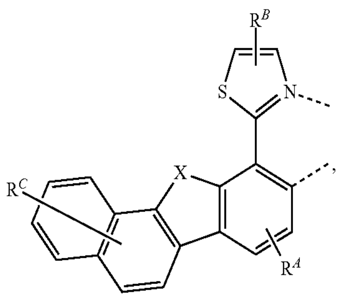

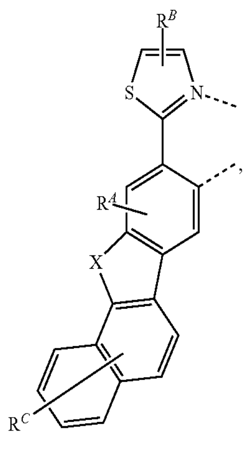

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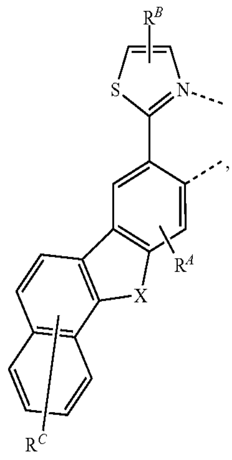

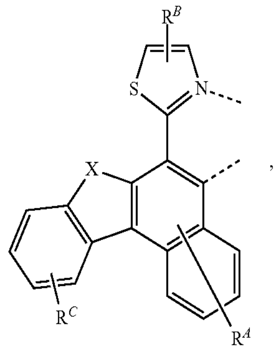

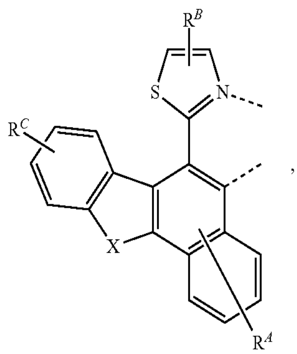

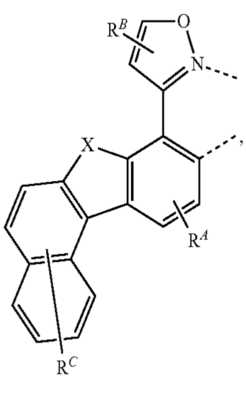

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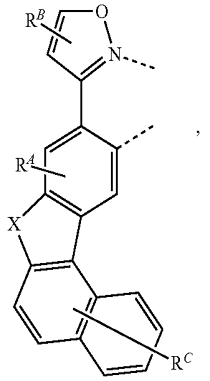

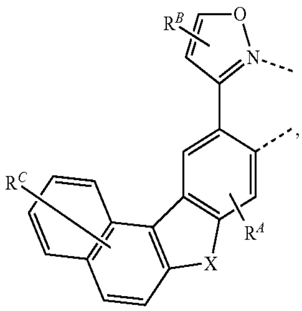

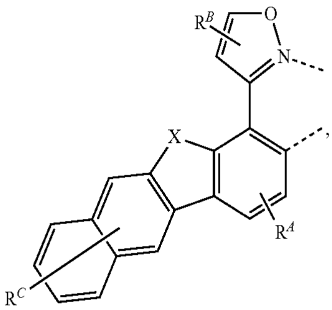

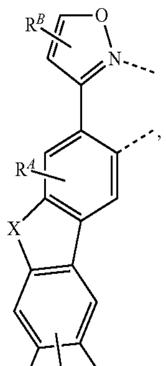

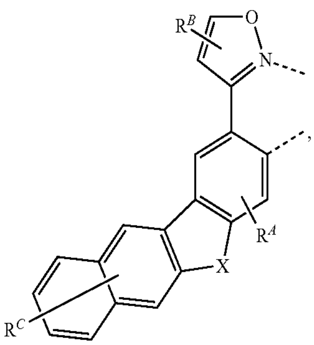

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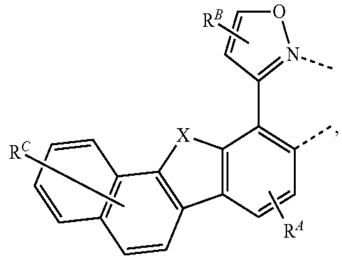

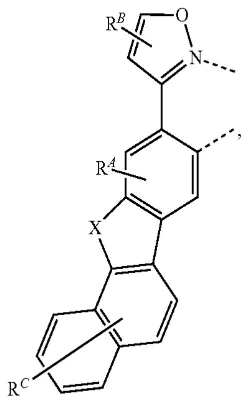

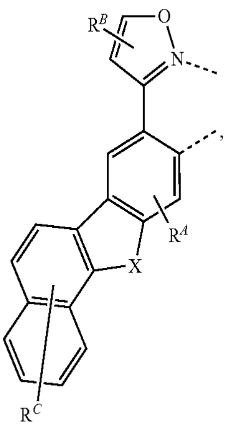

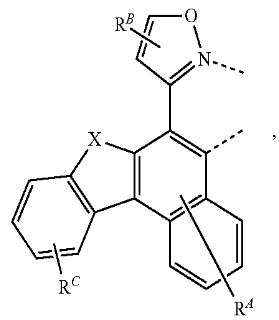

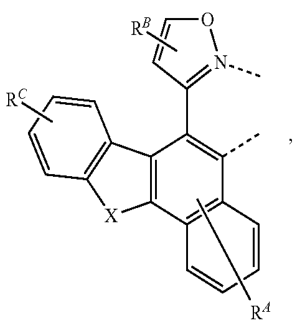

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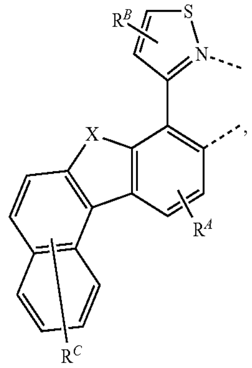
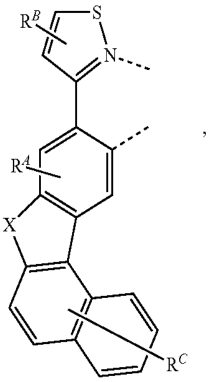
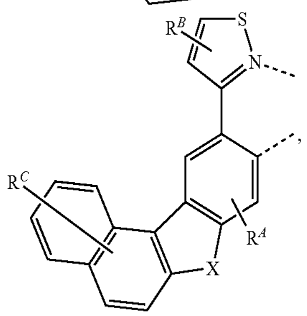
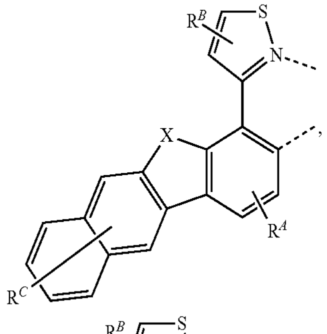
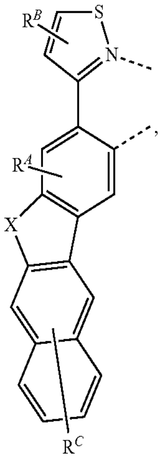

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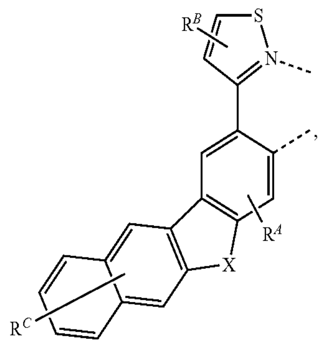
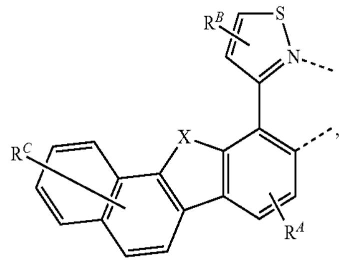
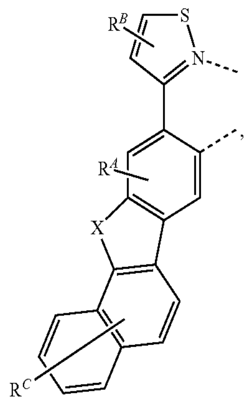
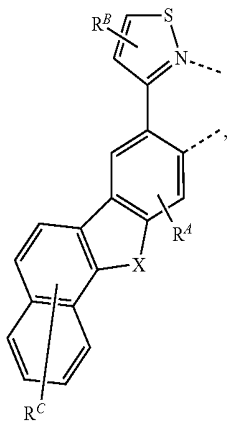
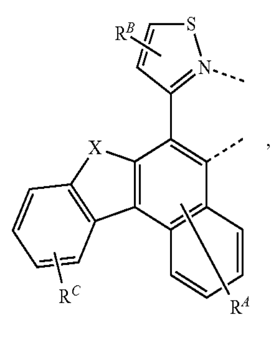

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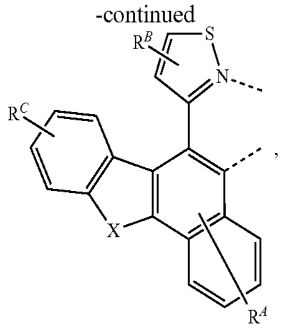

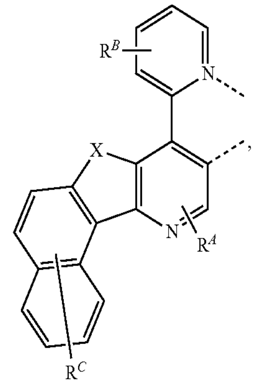

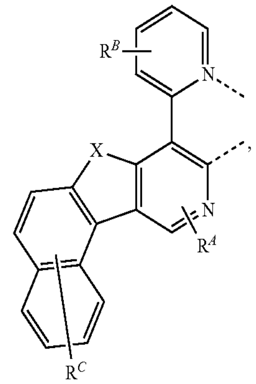

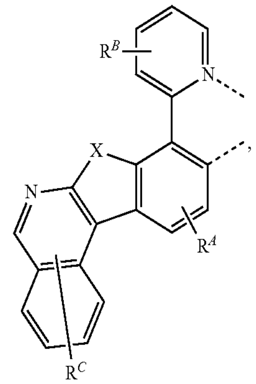

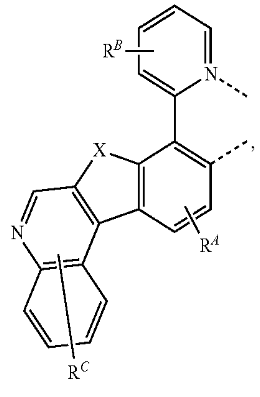

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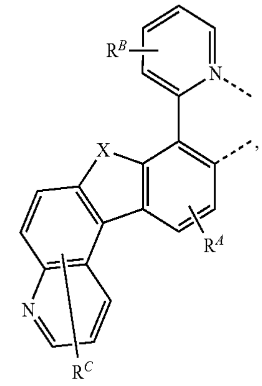

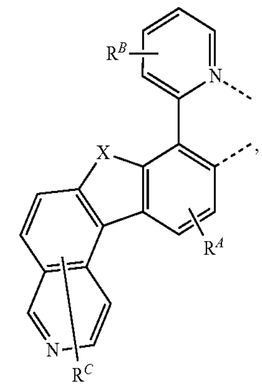

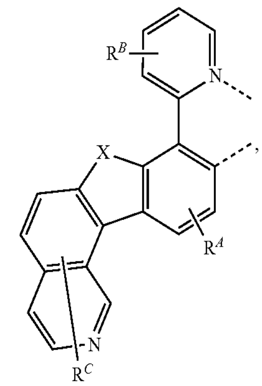

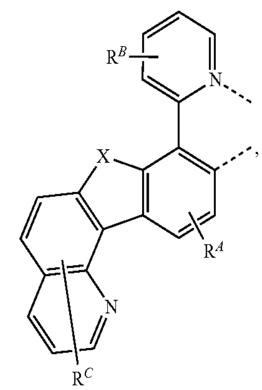

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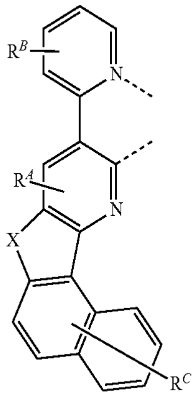
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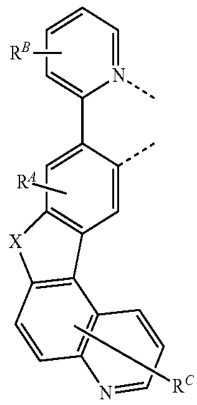
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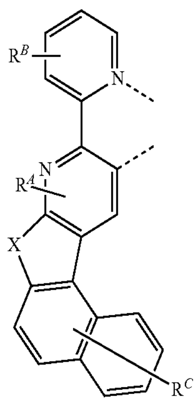
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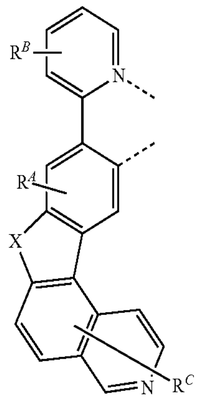
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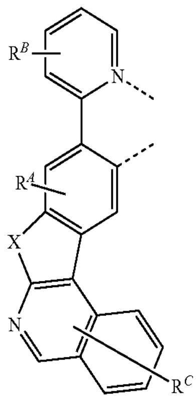
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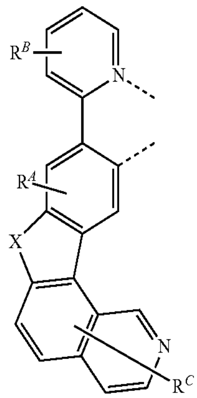
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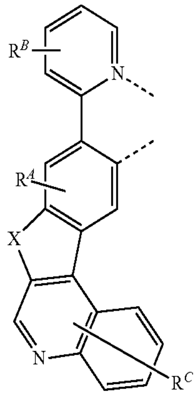
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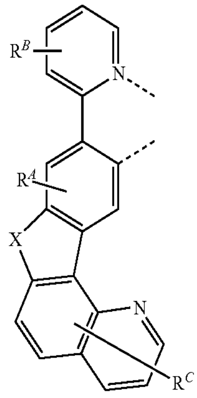
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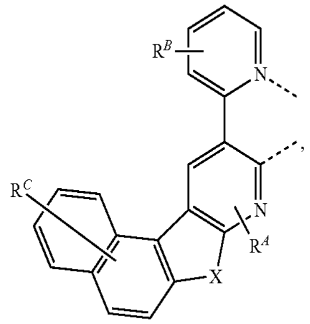

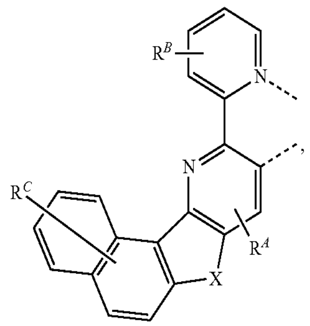

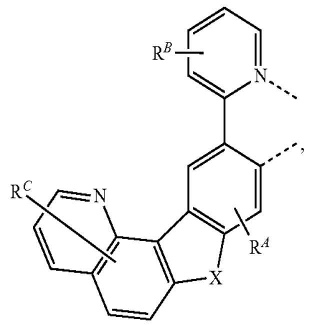

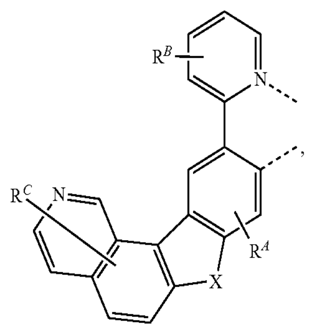

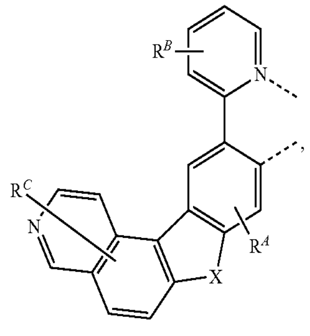

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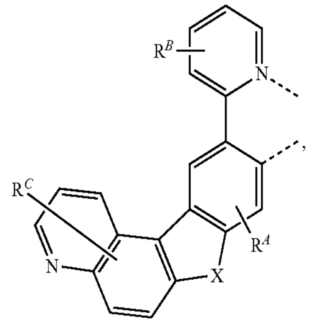

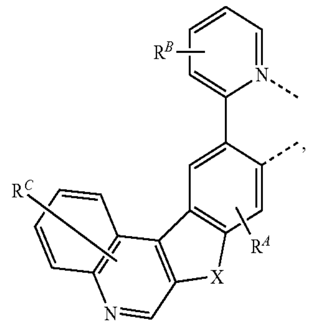

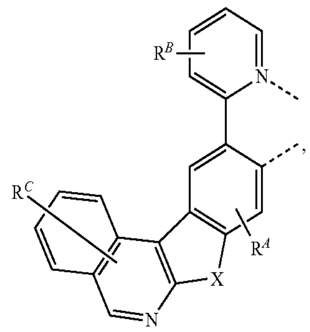

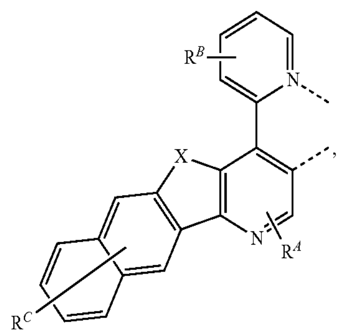

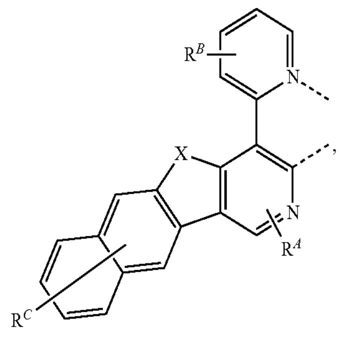

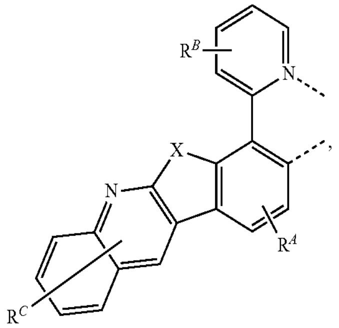

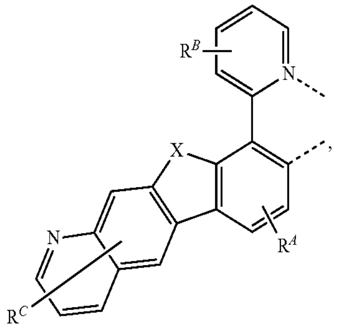

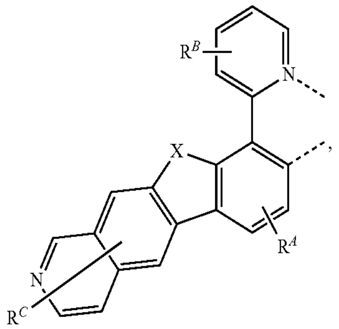

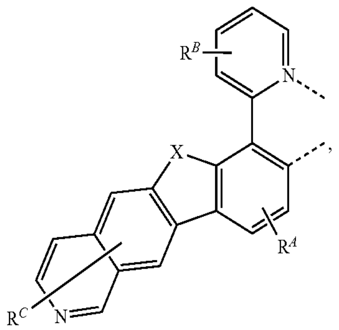

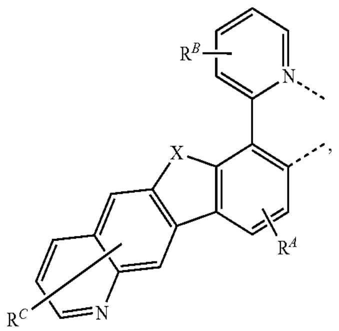

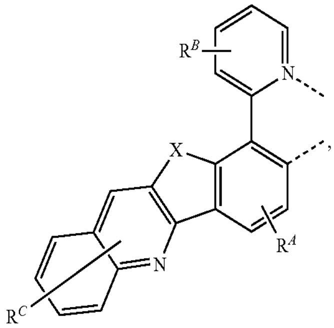

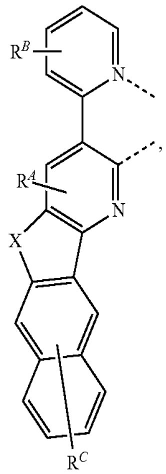

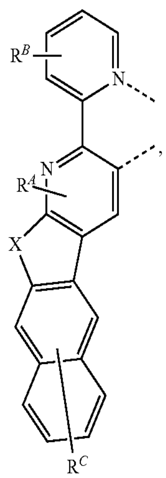

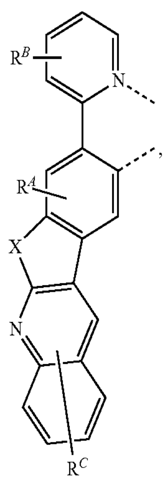

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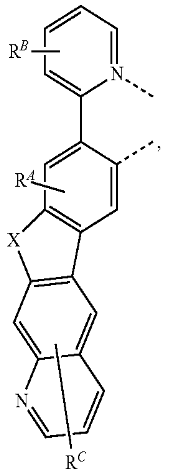

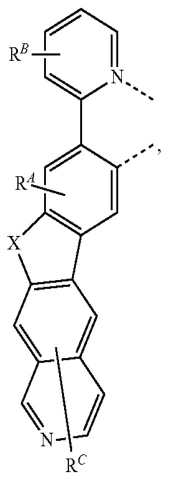

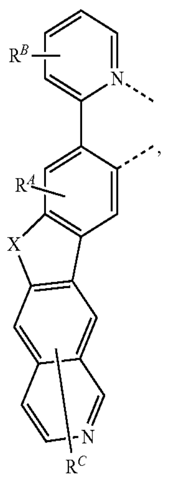

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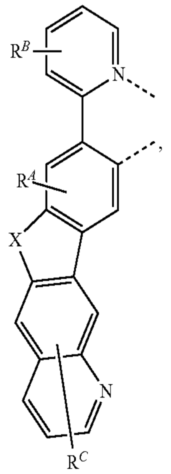

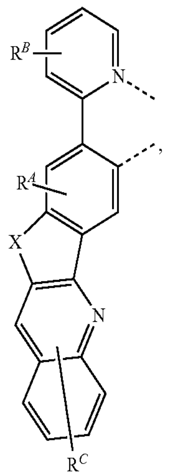

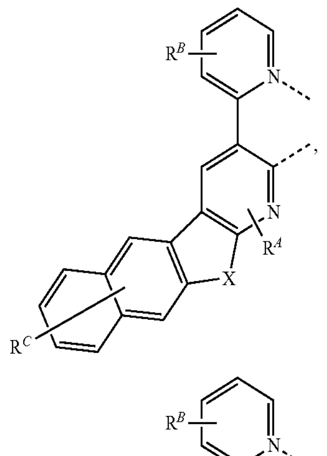

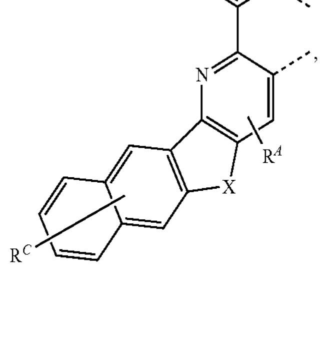

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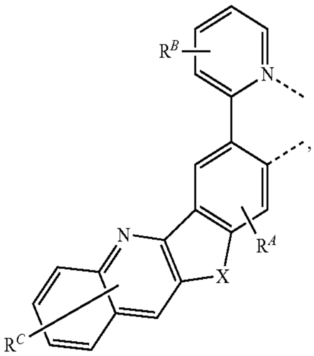

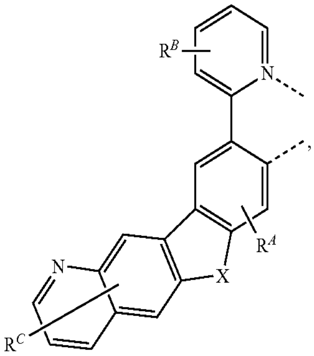

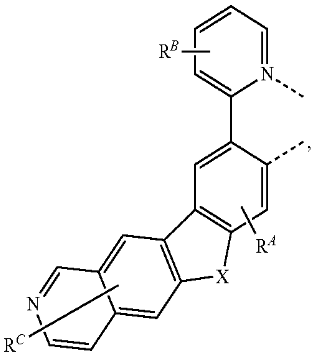

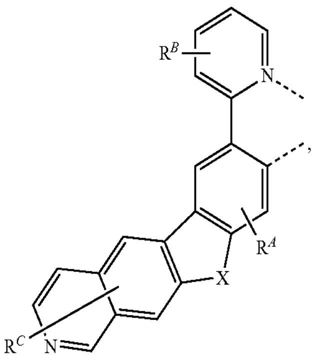

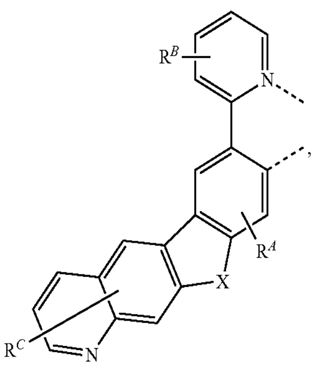

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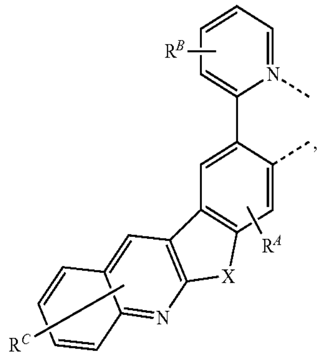

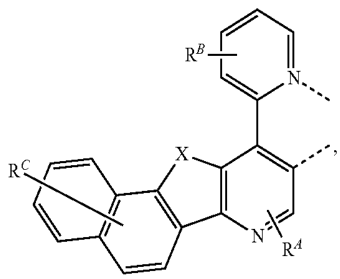

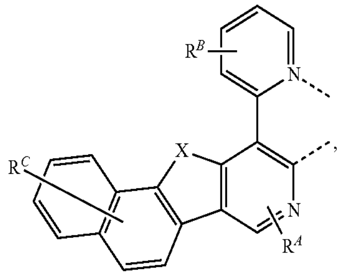

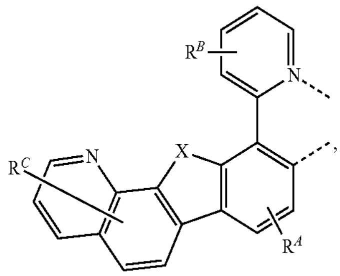

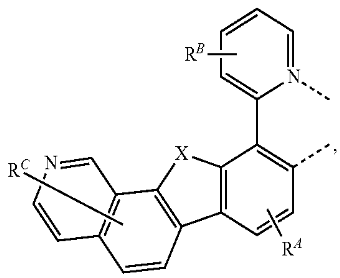

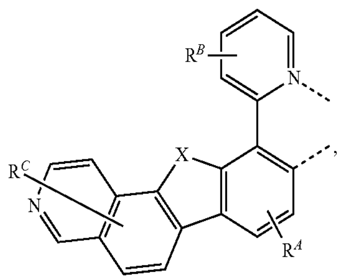

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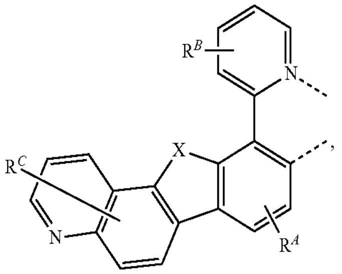

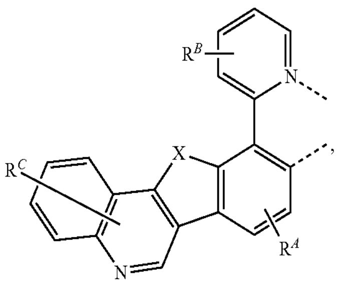

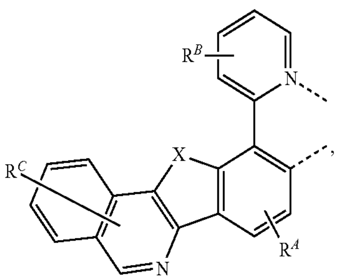

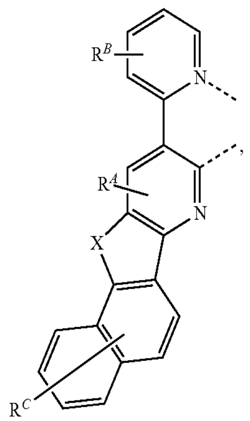

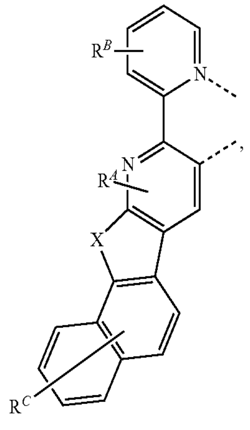

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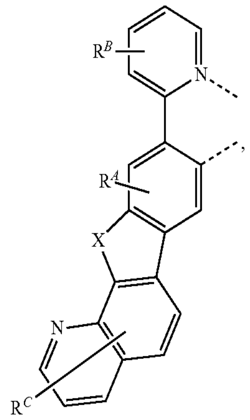

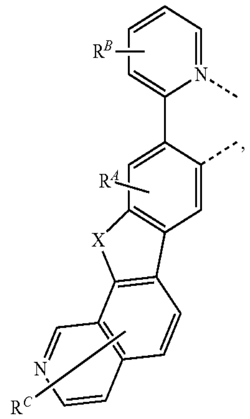

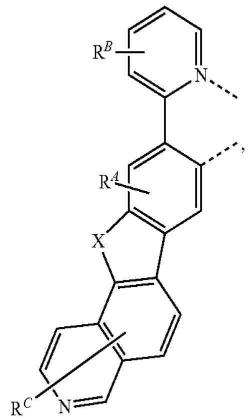

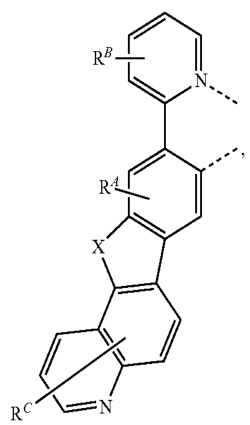

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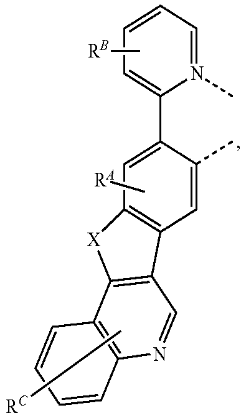

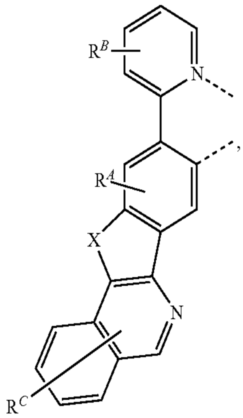

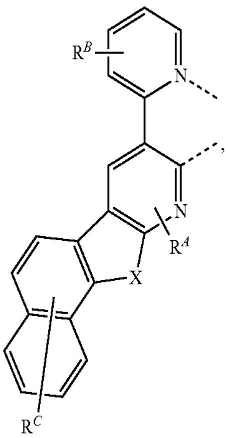

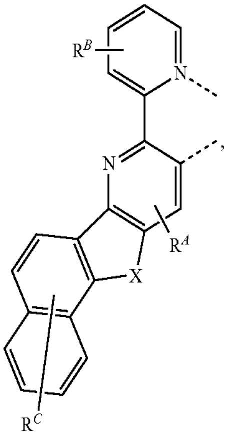

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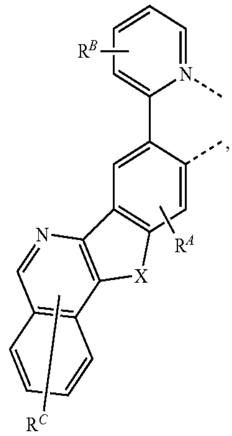

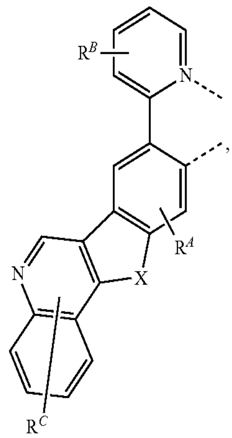

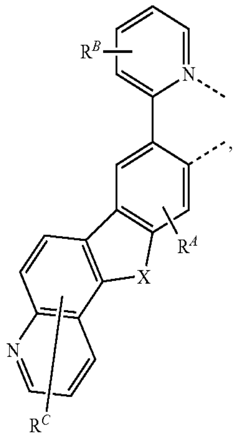

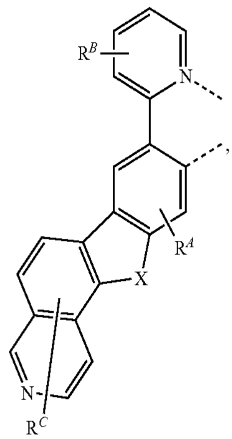

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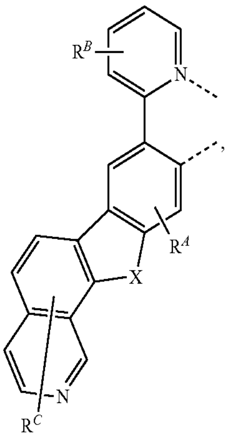

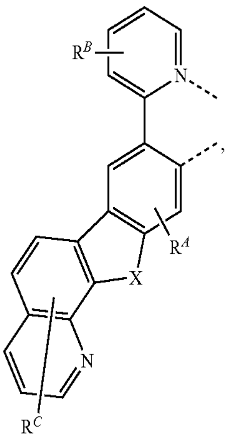

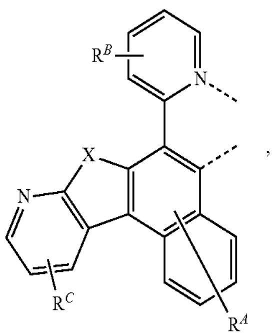

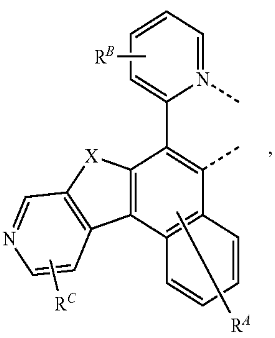

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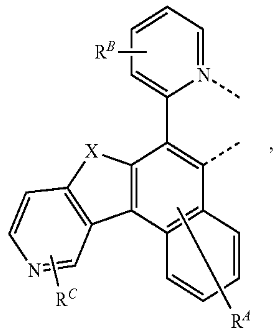

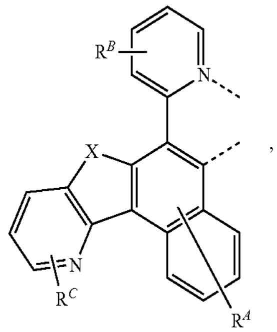

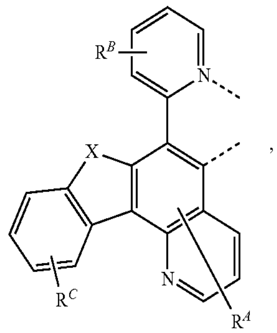

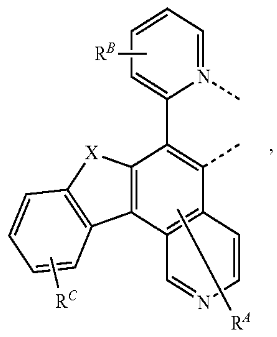

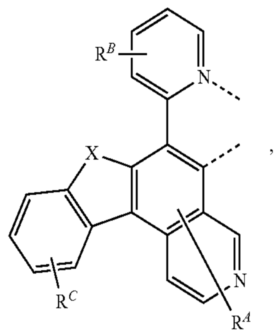

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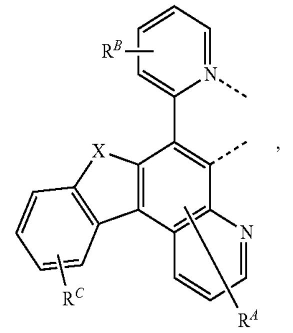

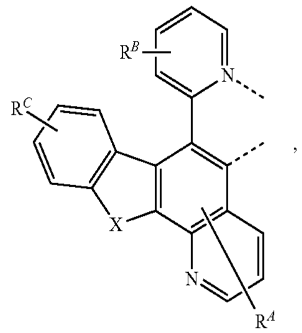

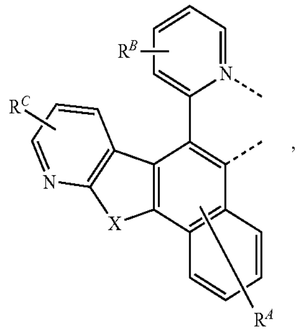

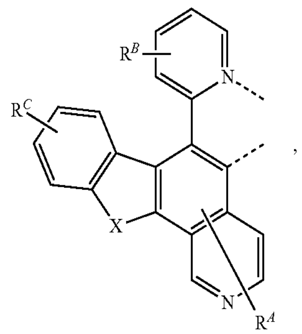

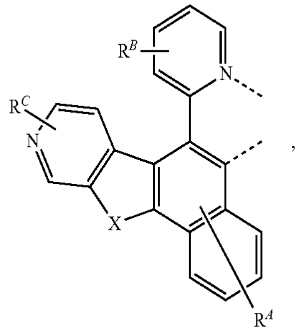

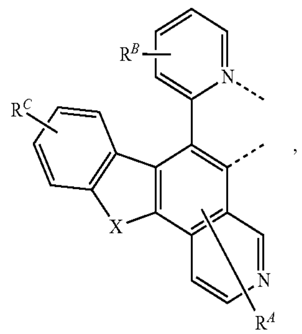

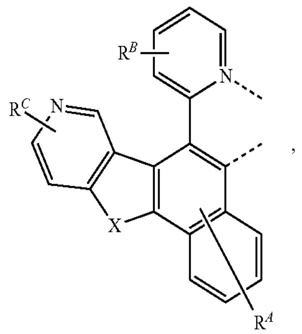

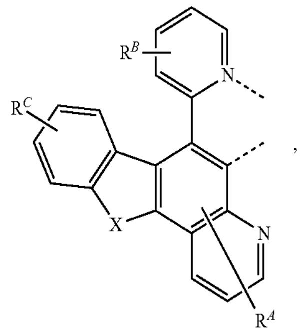

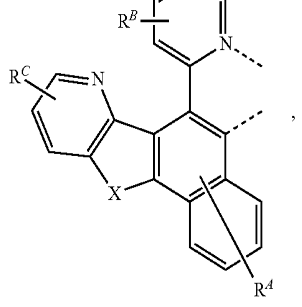

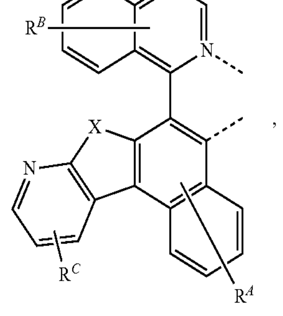

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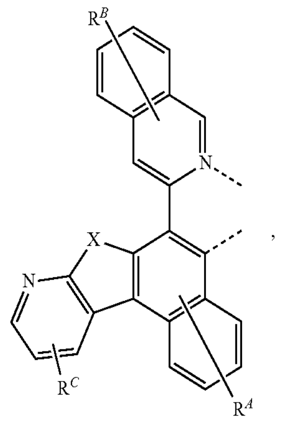

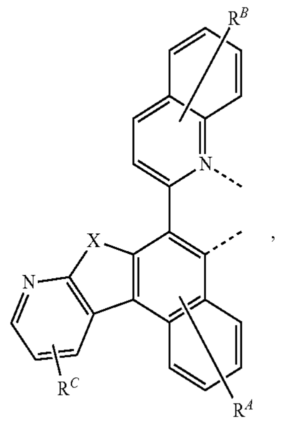

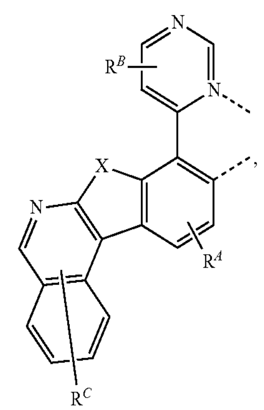

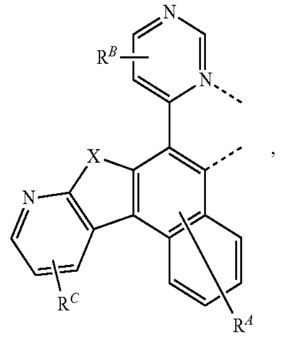

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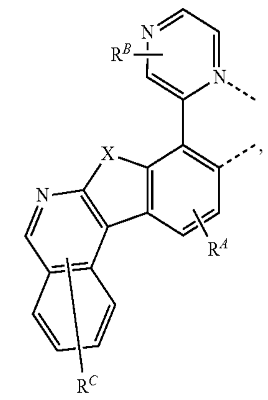

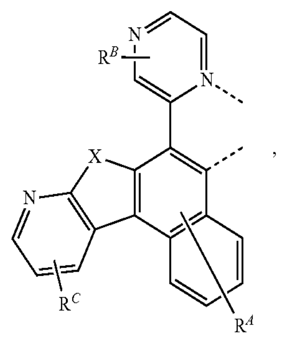

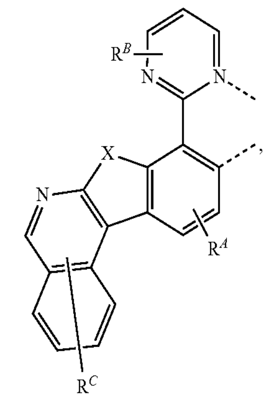

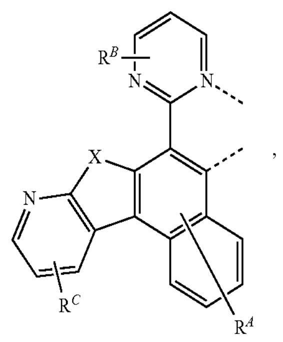

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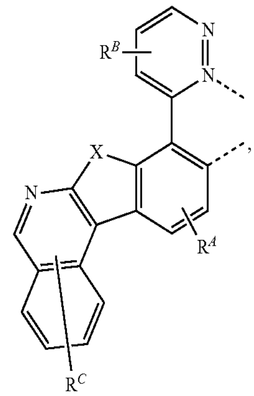

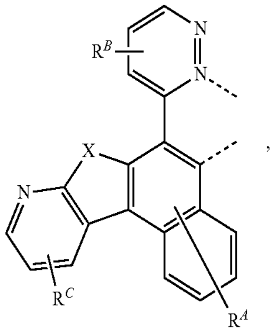

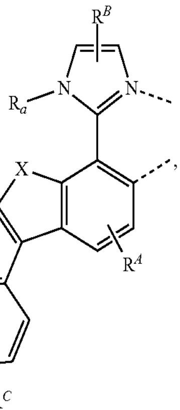

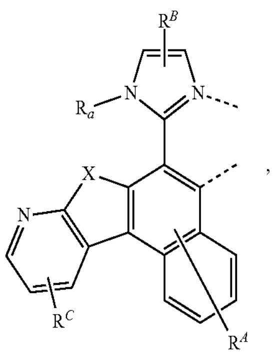

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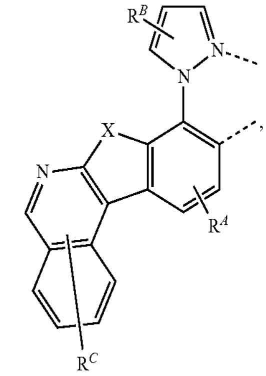

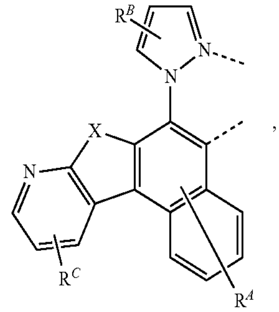

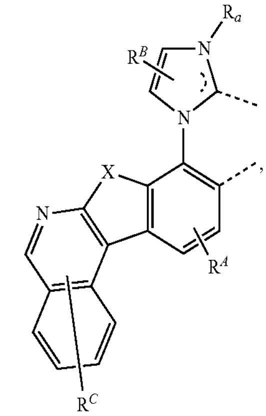

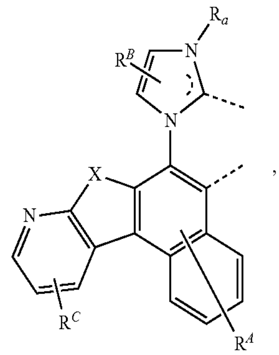

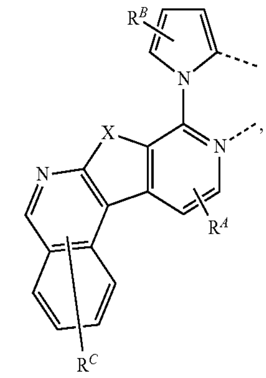

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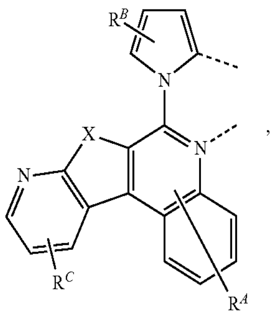

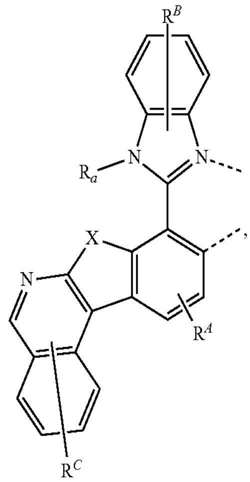

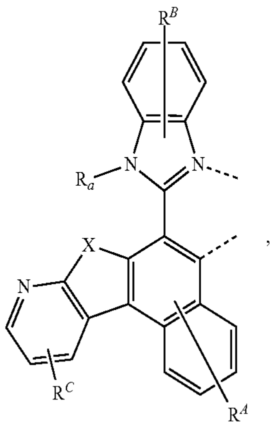

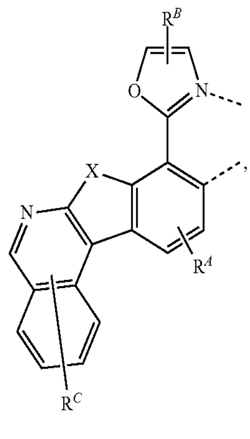

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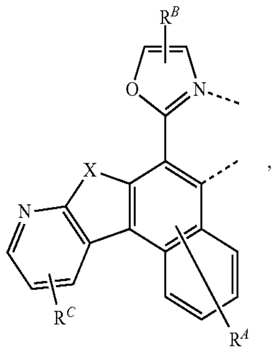

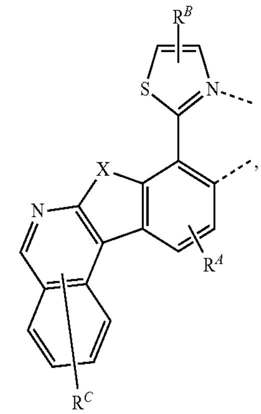

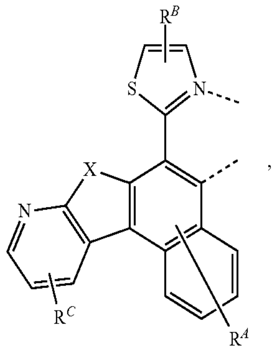

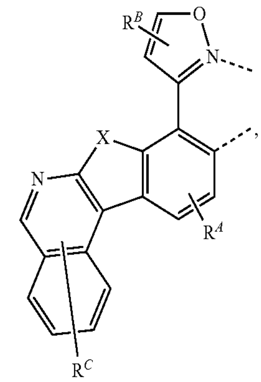

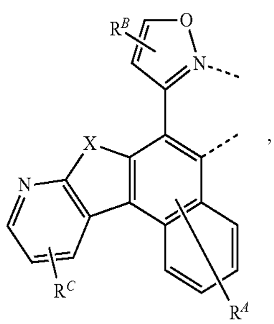

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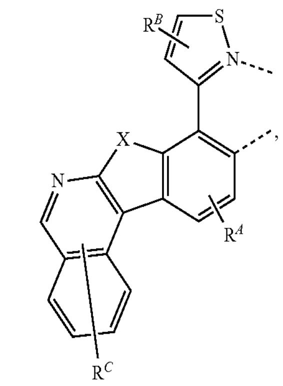

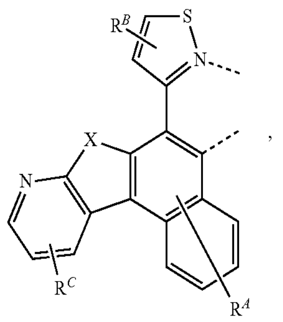

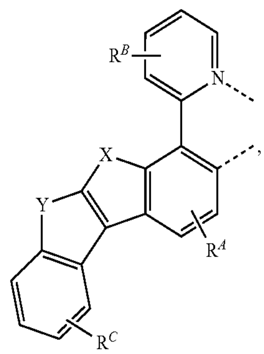

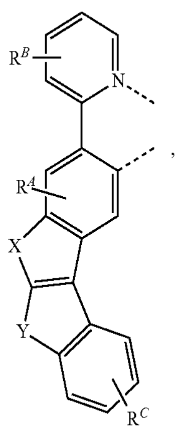

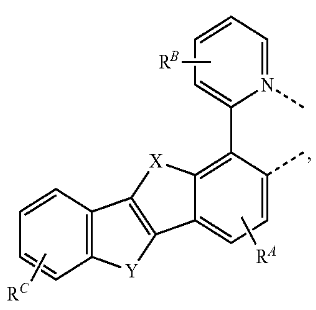

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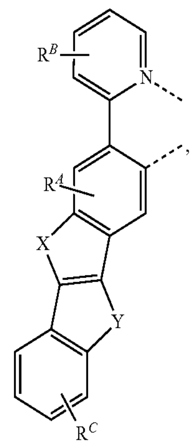

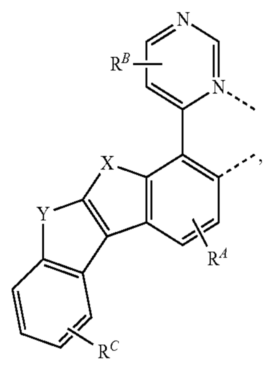

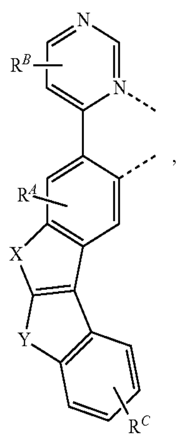

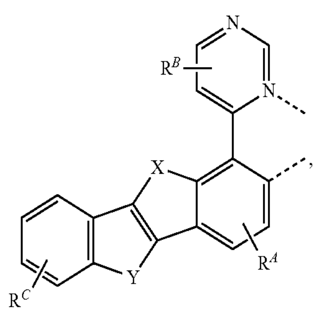

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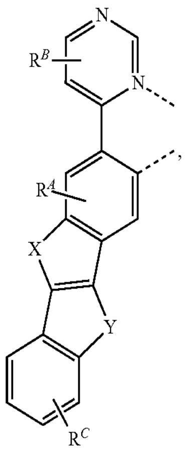

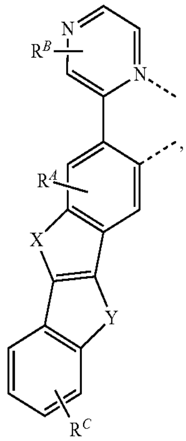

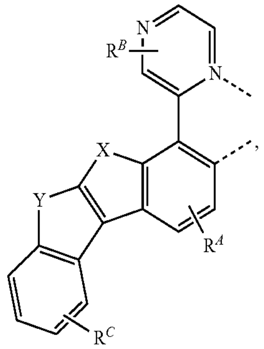

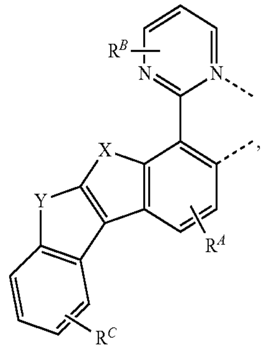

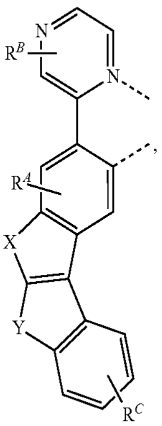

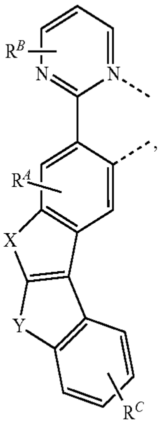

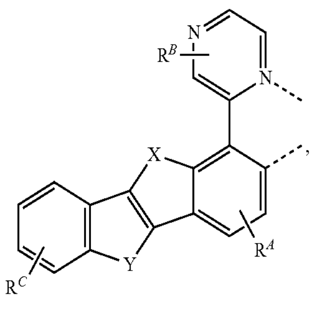

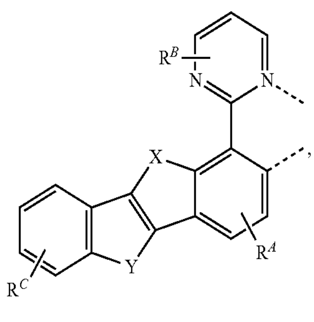

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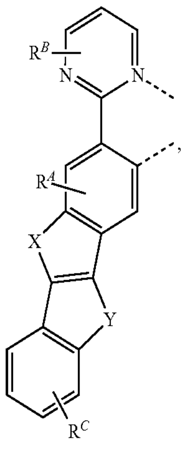

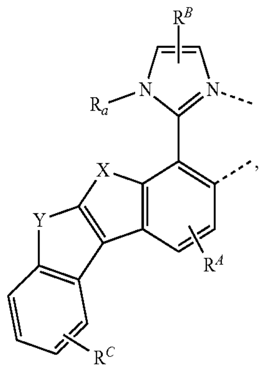

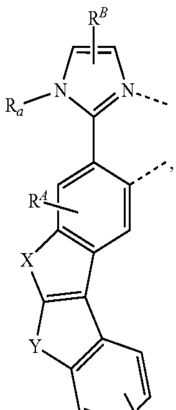

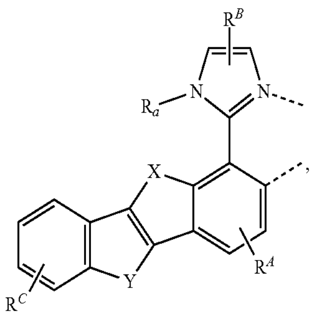

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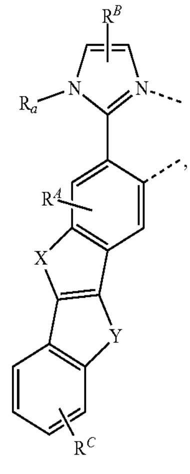

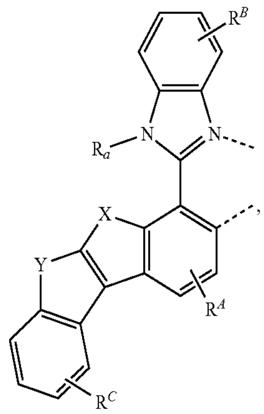

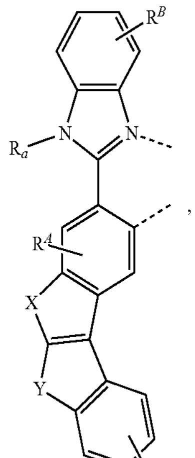

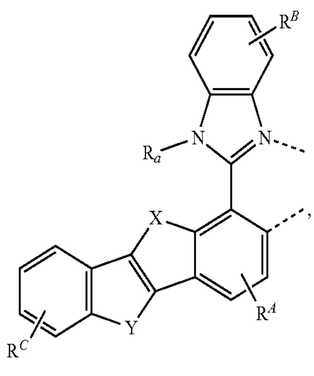

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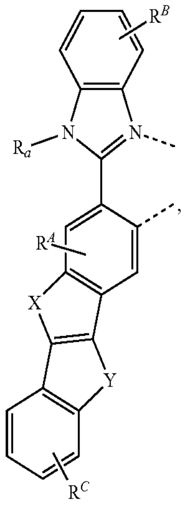

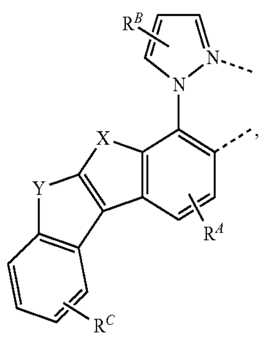

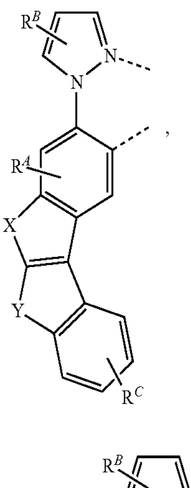

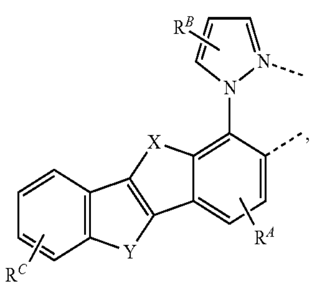

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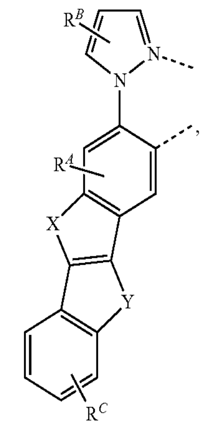

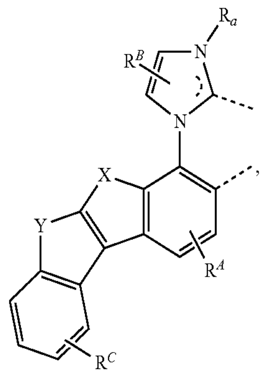

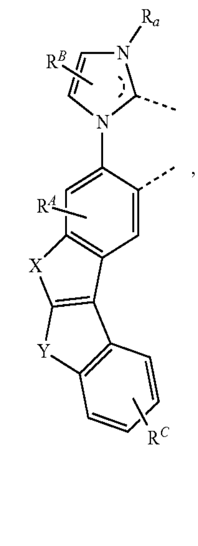

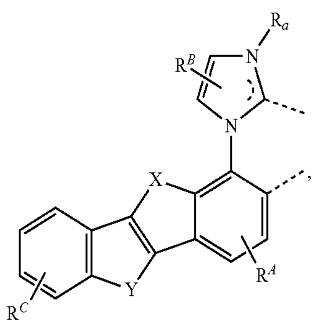

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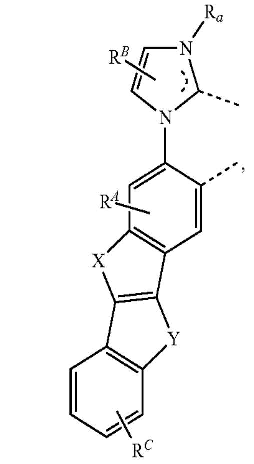

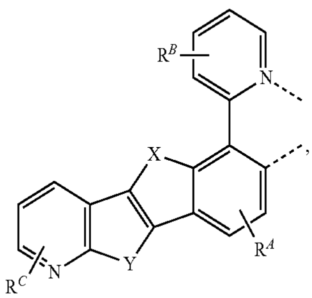

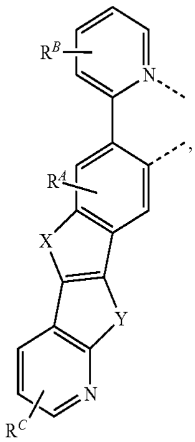

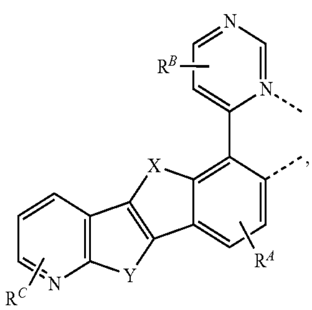

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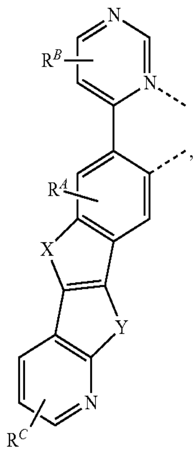

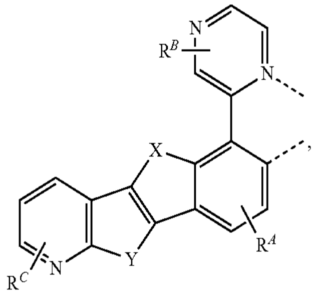

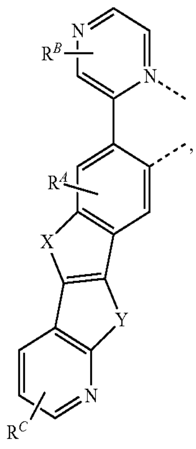

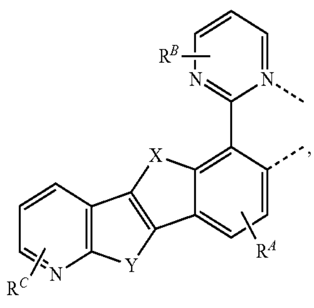

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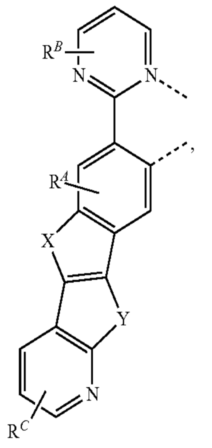

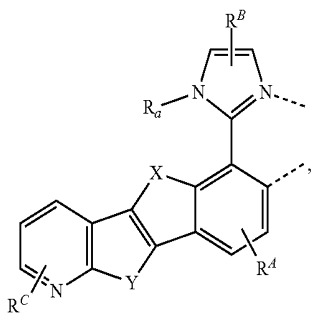

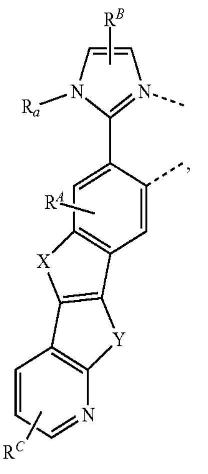

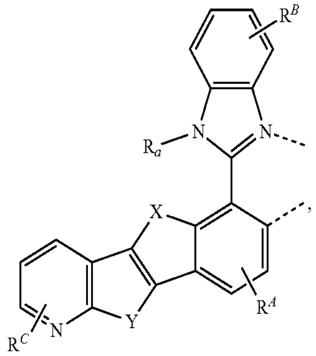

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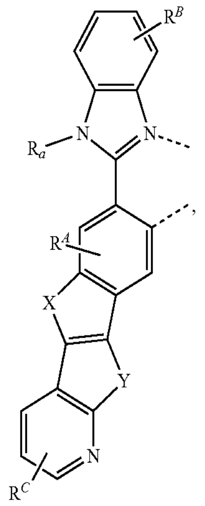

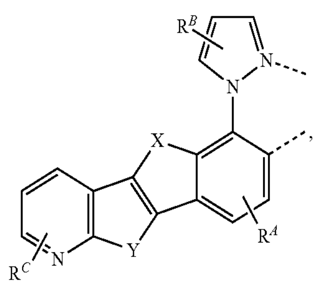

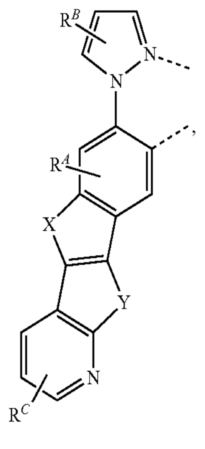

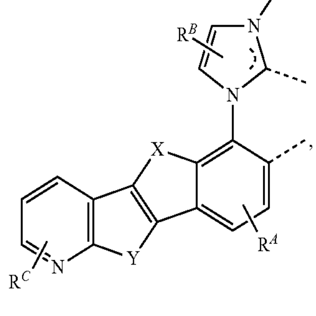

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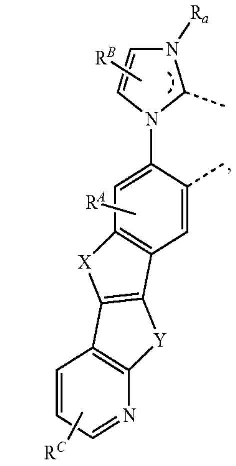

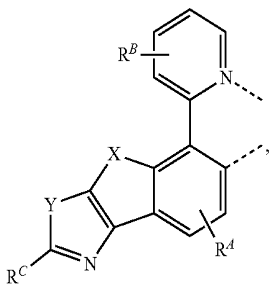

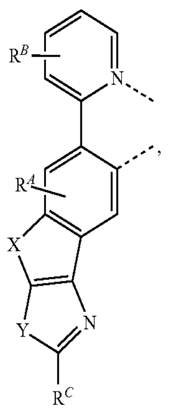

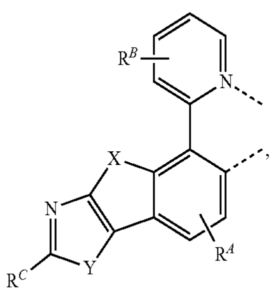

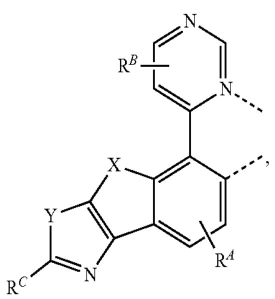

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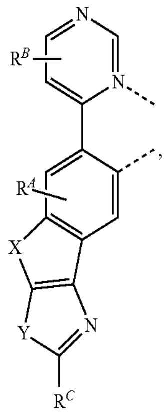

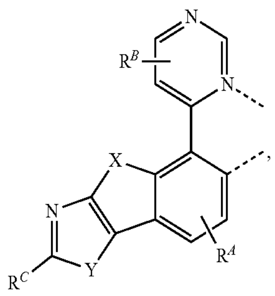

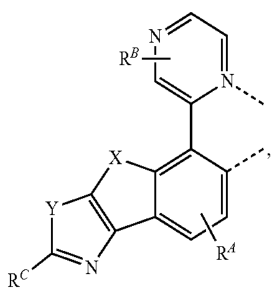

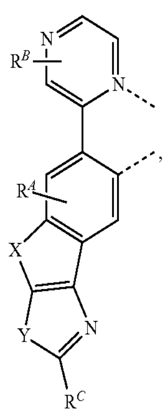

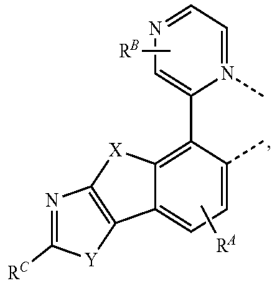

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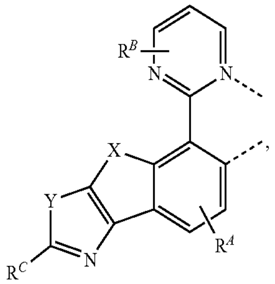

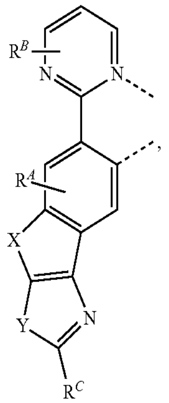

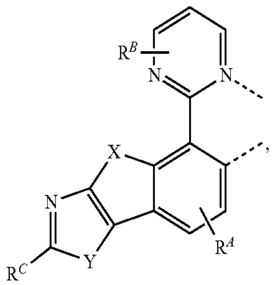

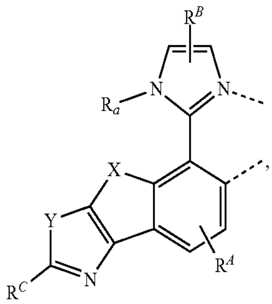

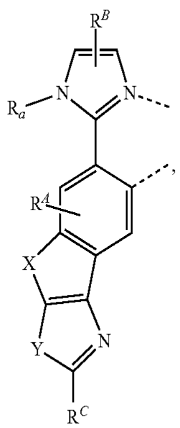

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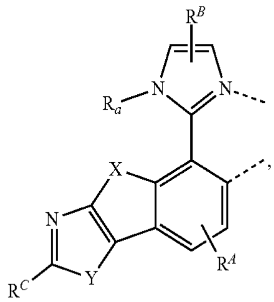

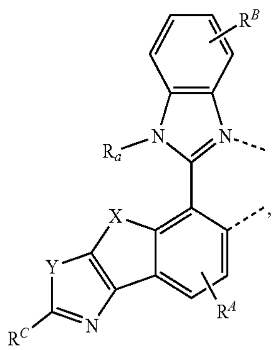

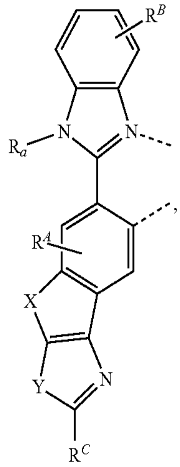

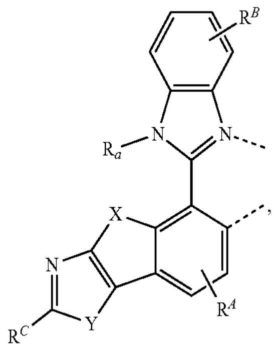

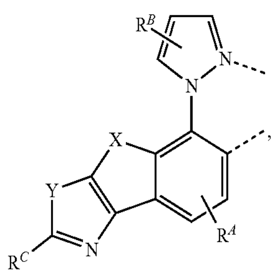

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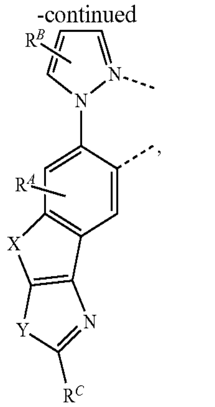
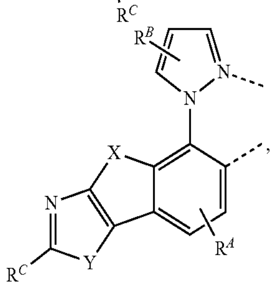
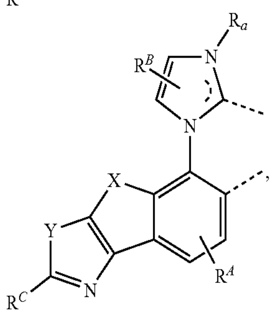
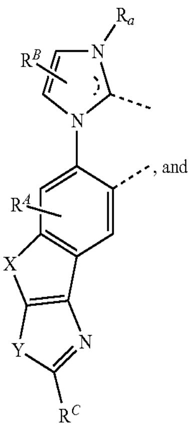
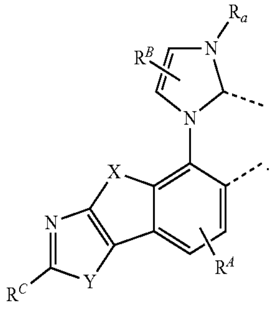






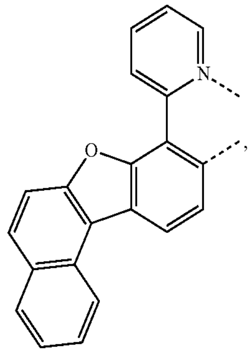




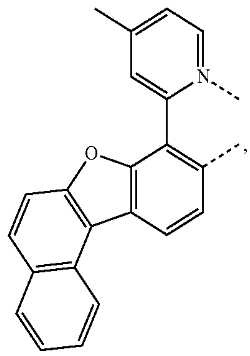
wherein Y is selected from the group consisting of O, S, Se, and NR'; and

wherein R^A and R^C have the same definition as R^B.

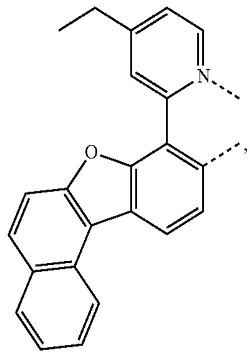
In one embodiment, the ligand LA is selected from the group consisting of:



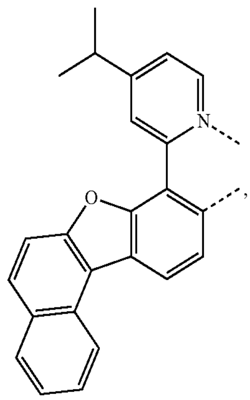
L_{A1}



L_{A2}

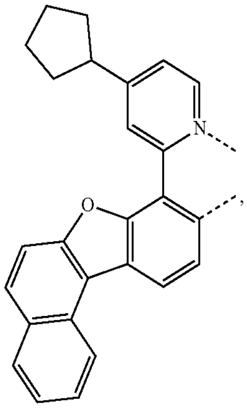


L_{A3}

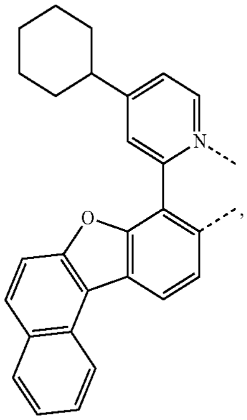


L_{A4}

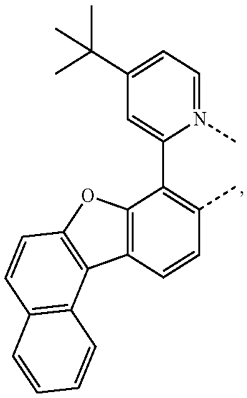
L_{A5}



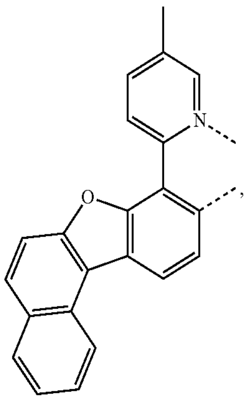
L_{A6}



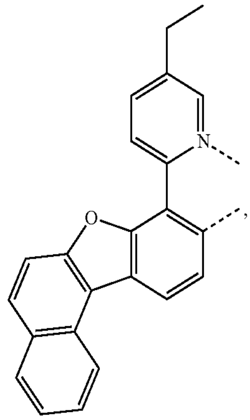
L_{A7}



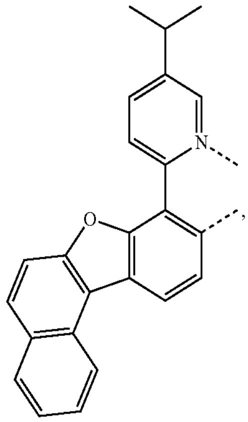
L_{A8}



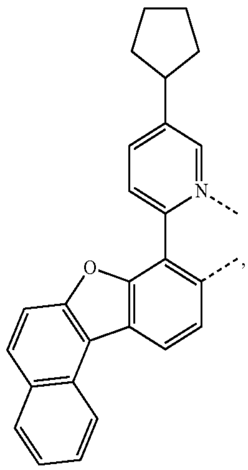
L_{A9}



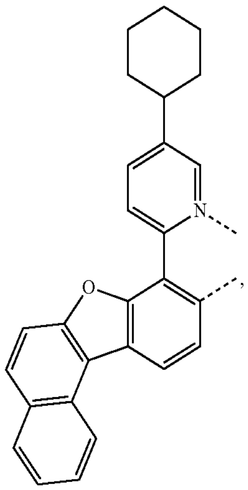
L_{A10}



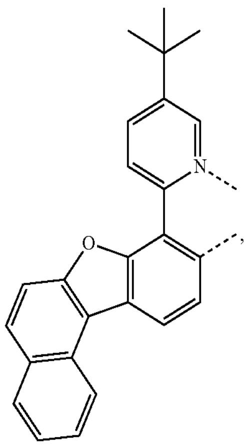
L_{A11}



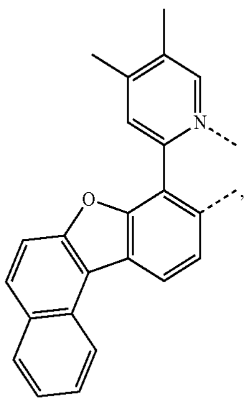
L_{A12}



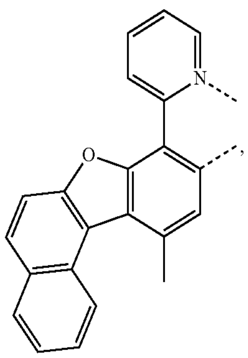
L_{A13}



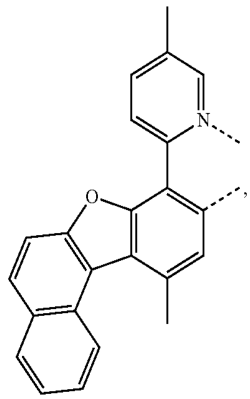
L_{A14}



L_{A15}



L_{A16}



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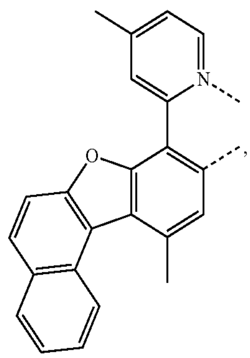

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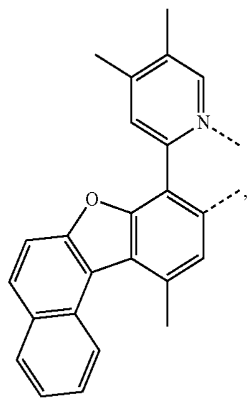

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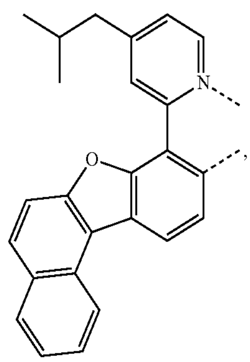

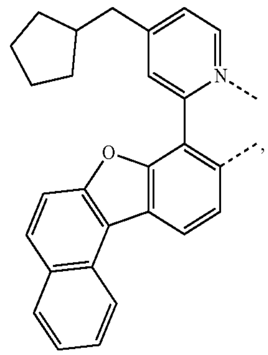
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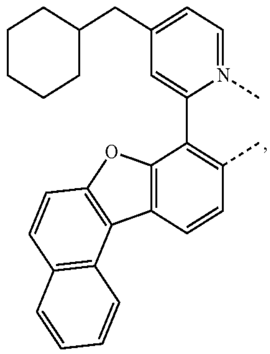
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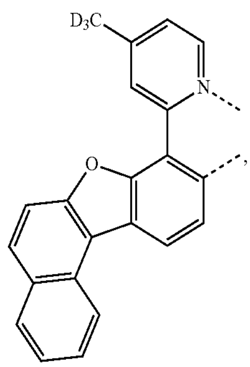
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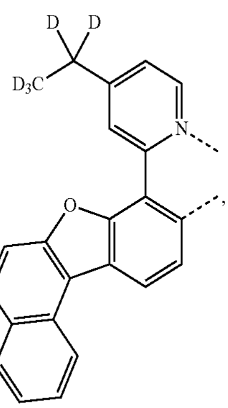
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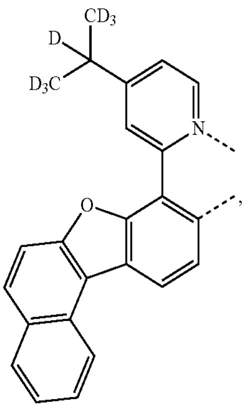
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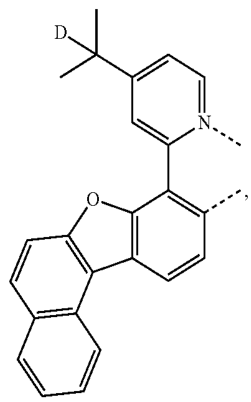
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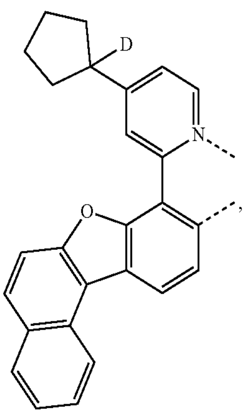
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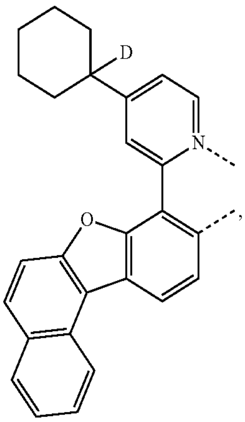
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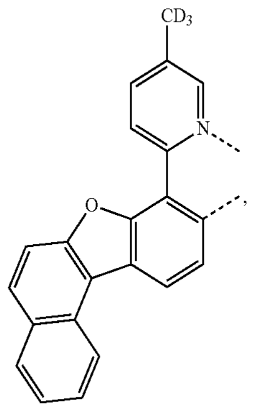

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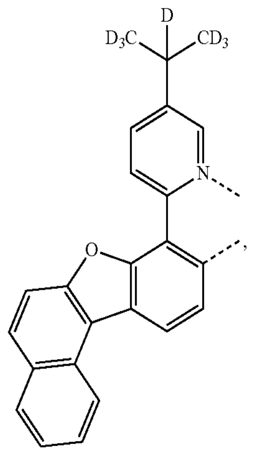

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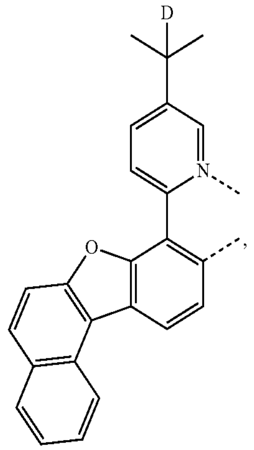

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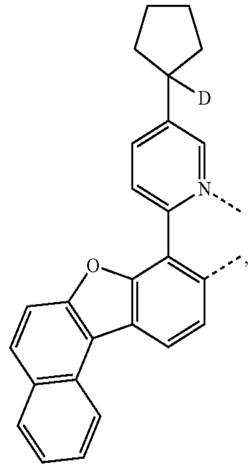

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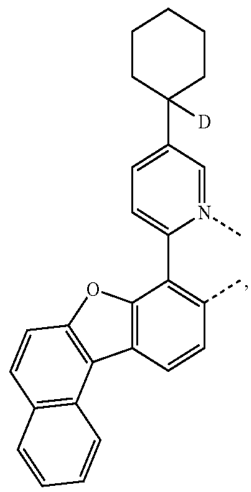

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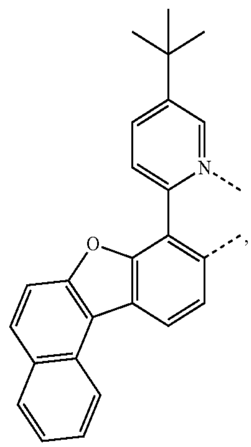

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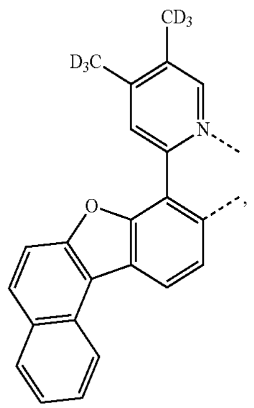

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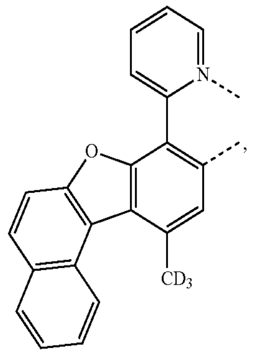

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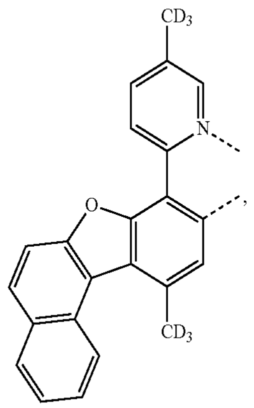

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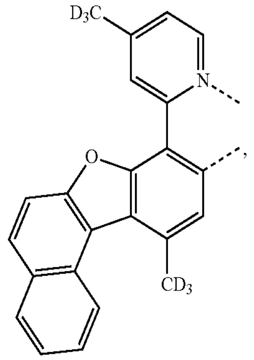

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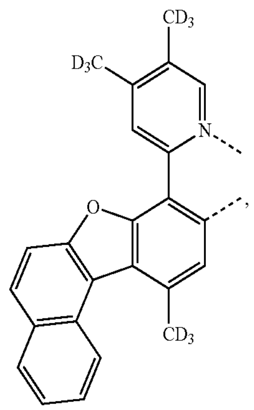

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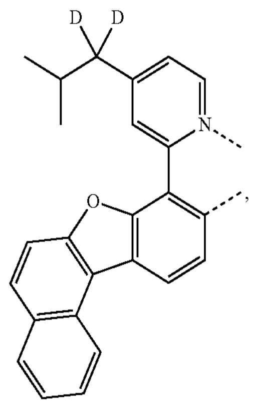

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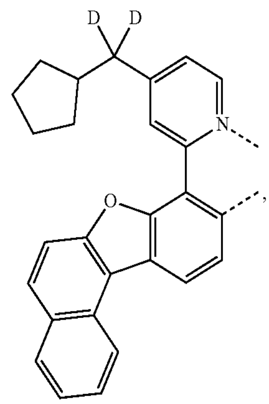

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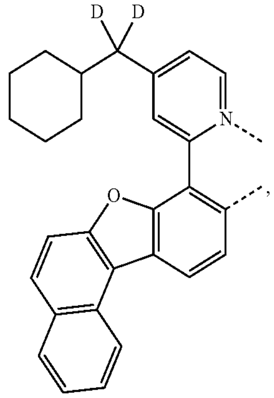

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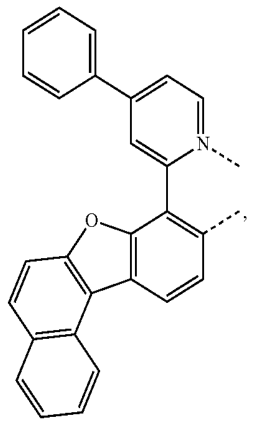

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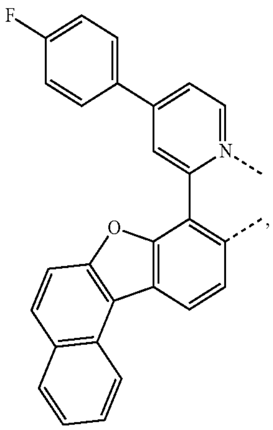

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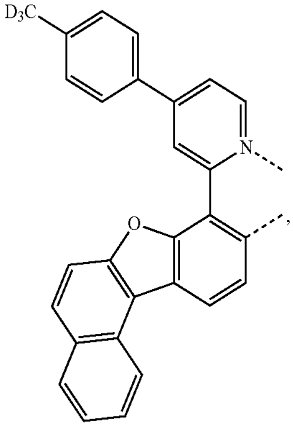

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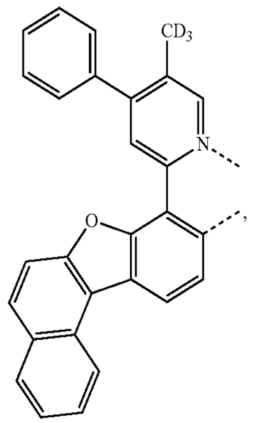

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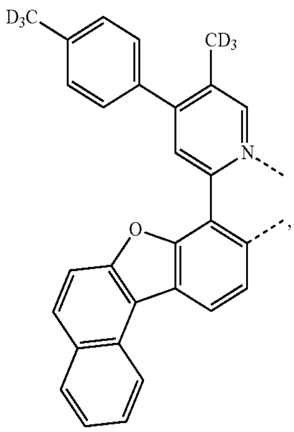

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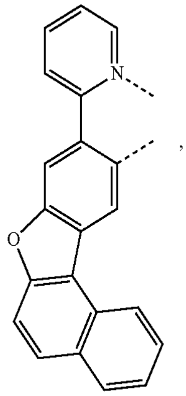

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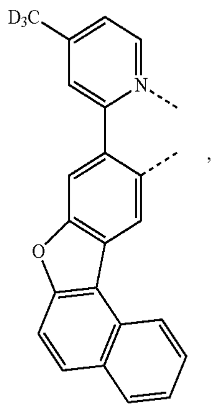

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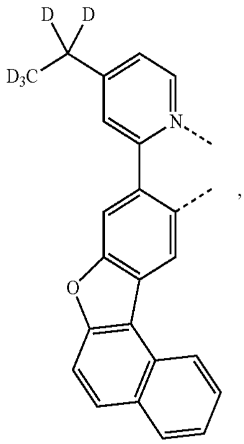

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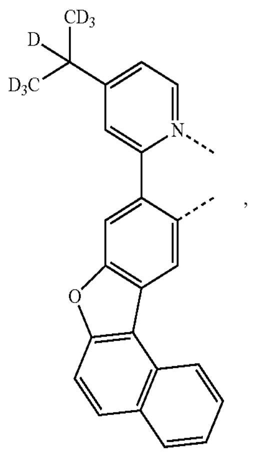

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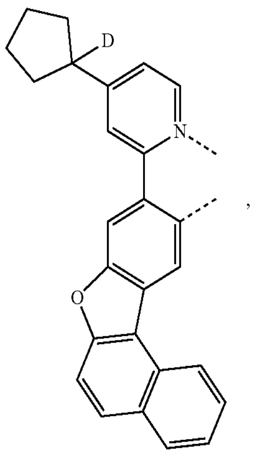

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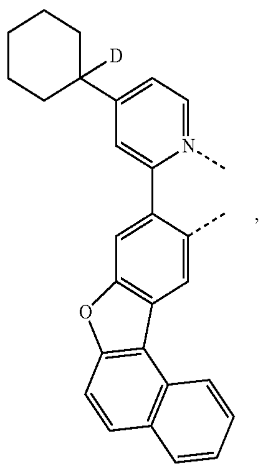

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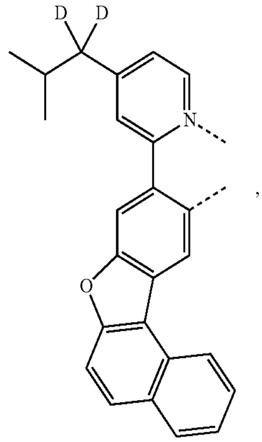

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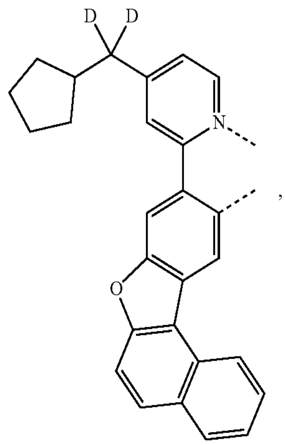

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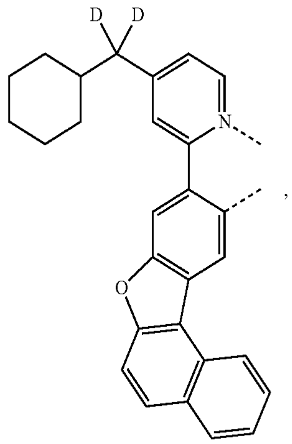

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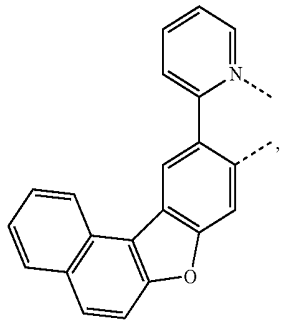

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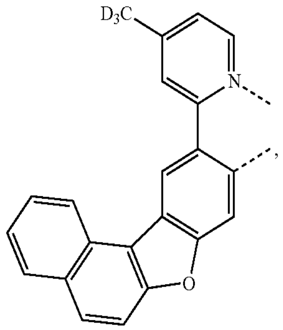

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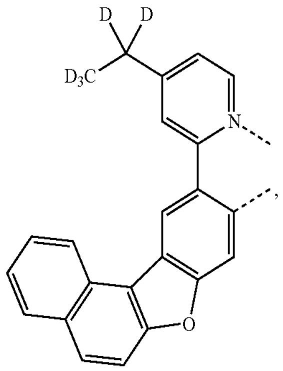

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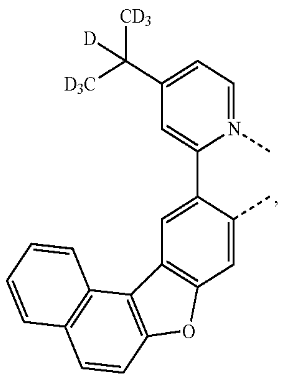

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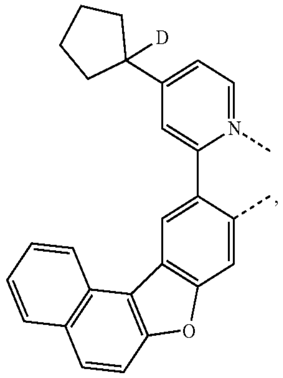

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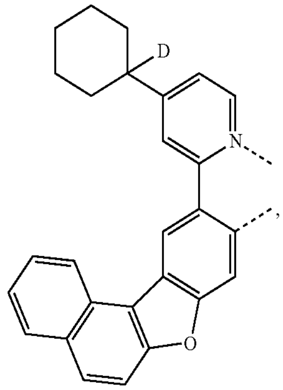

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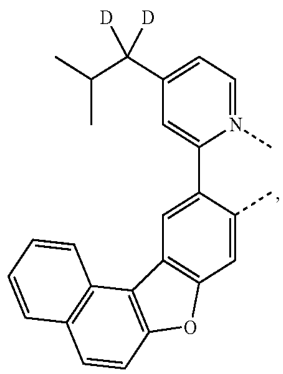

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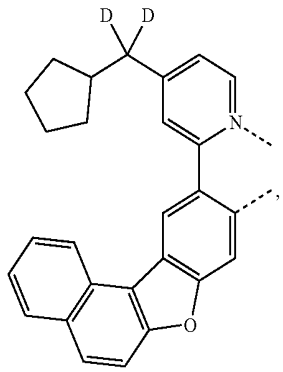

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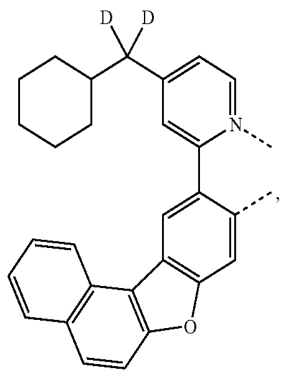

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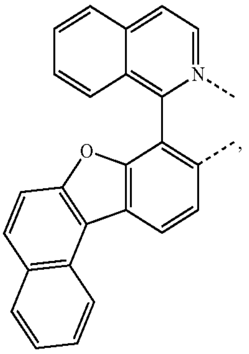

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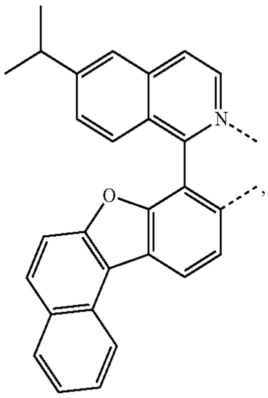

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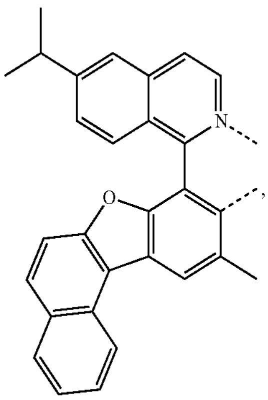

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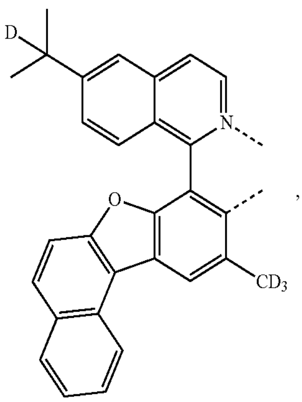

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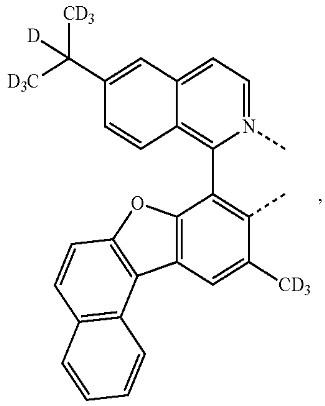

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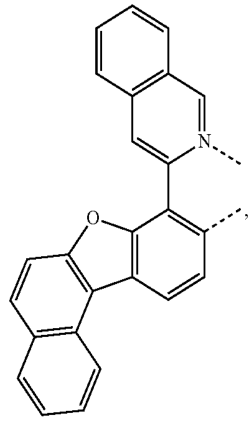

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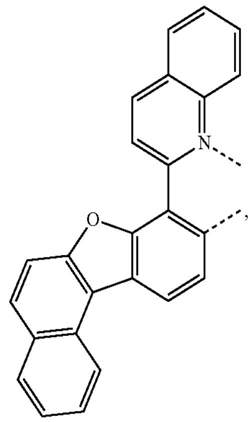

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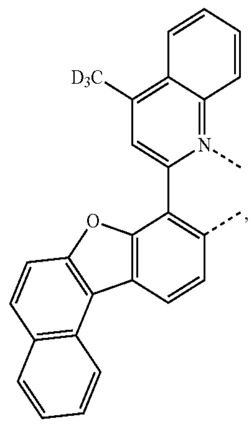

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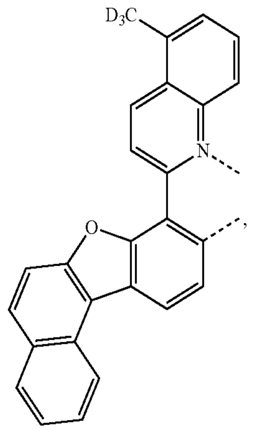

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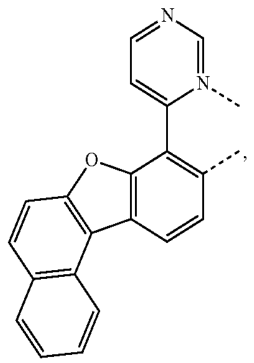

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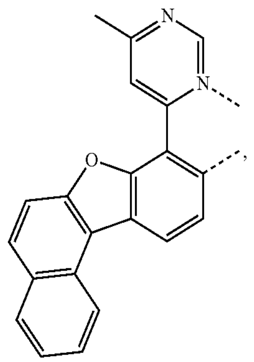

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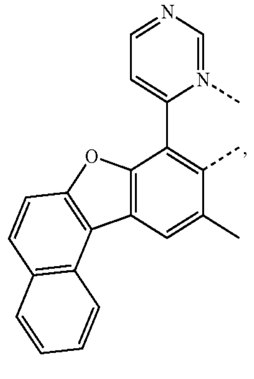

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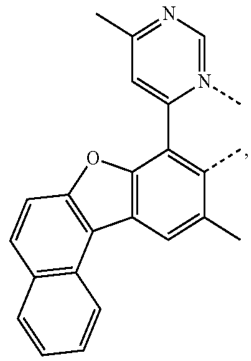

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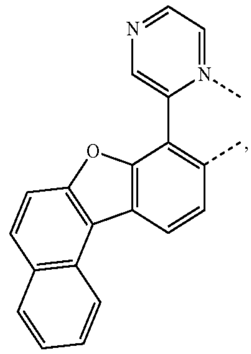

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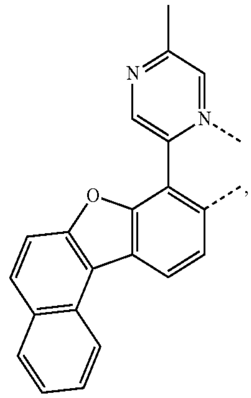

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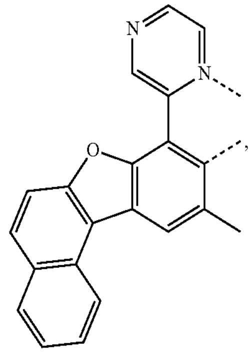

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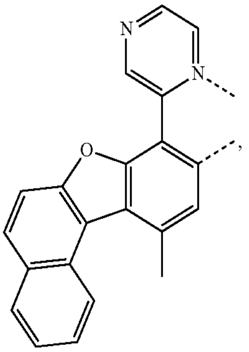
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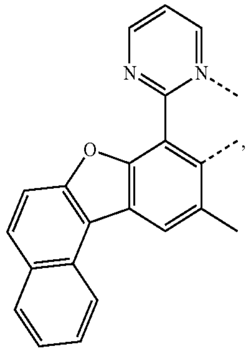
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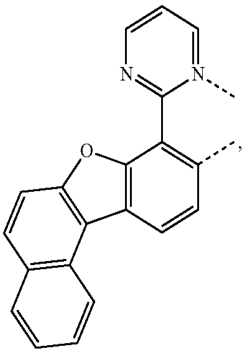
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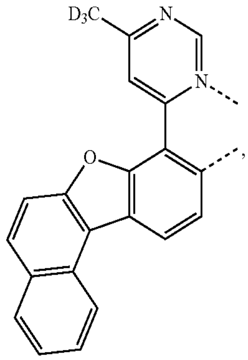

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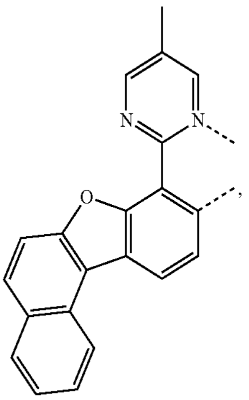
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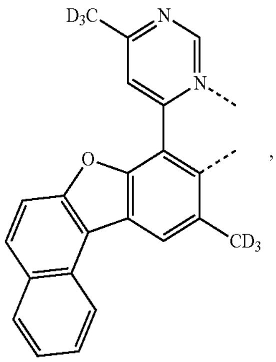

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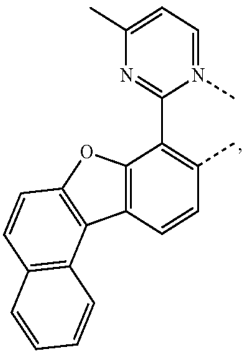
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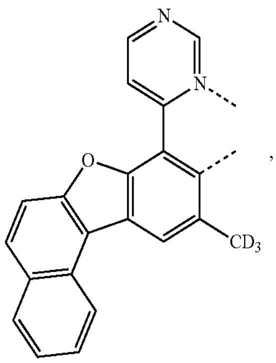

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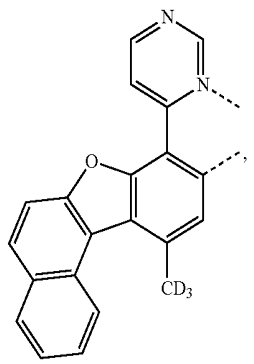

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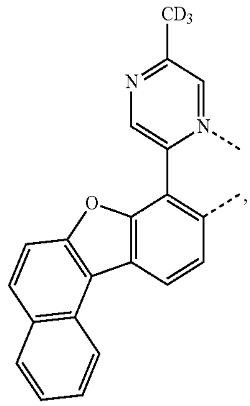

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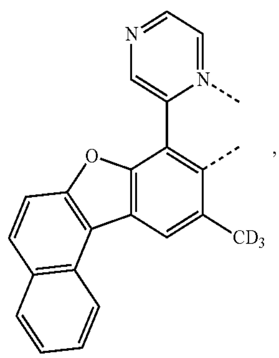

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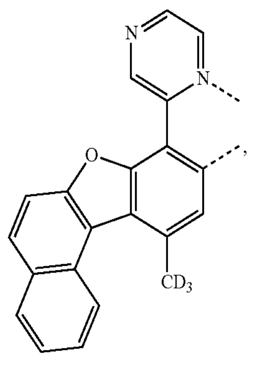

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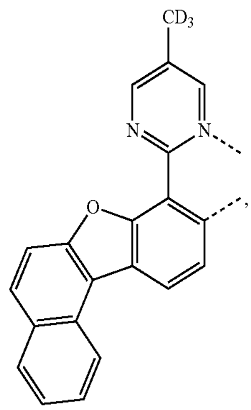

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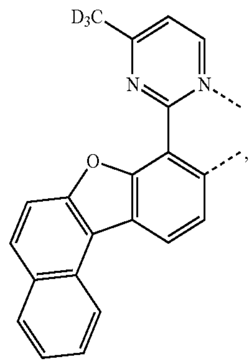

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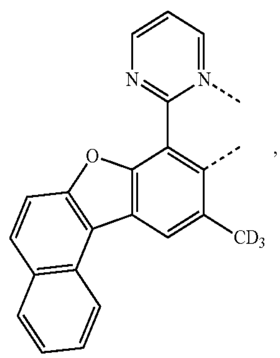

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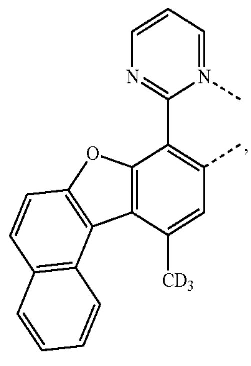

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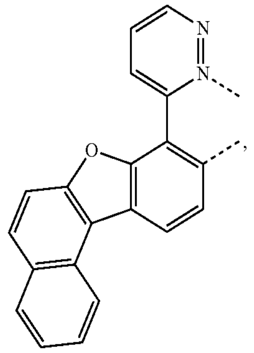

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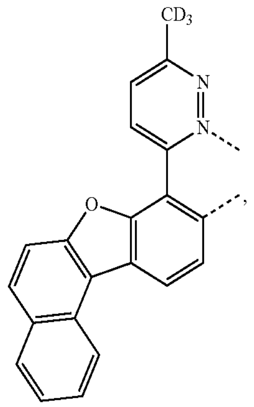

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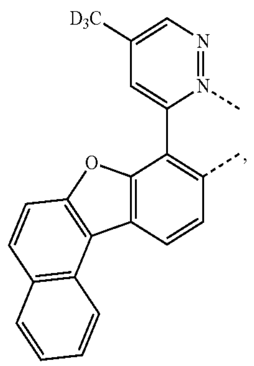

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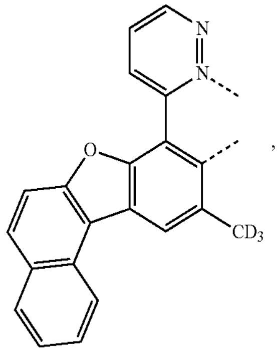

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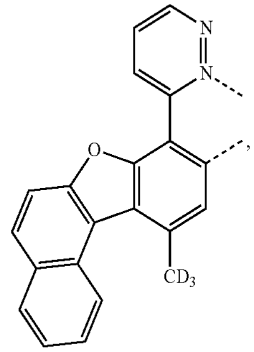

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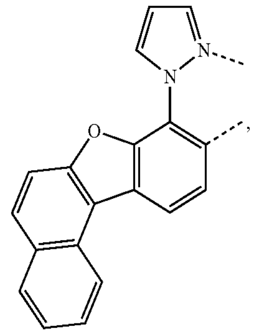

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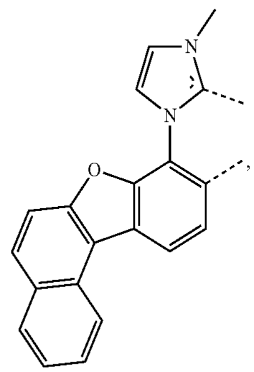

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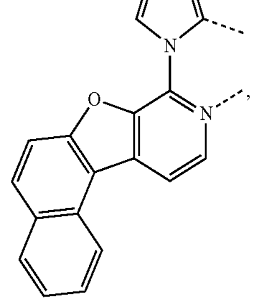

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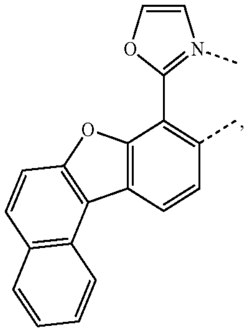

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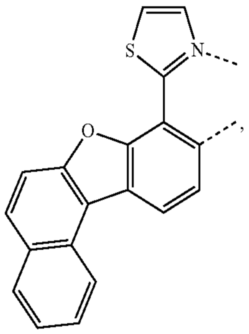

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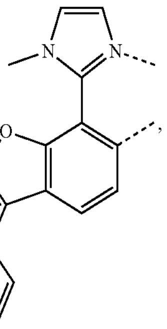

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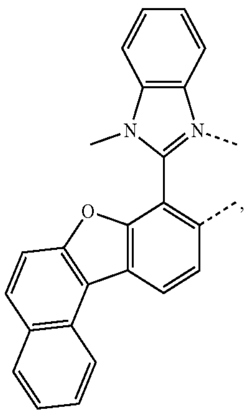

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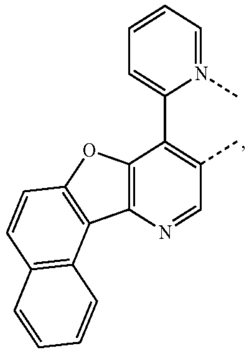

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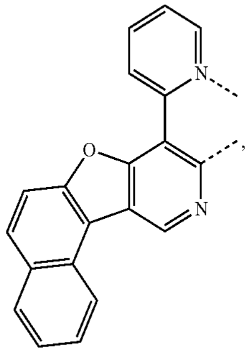

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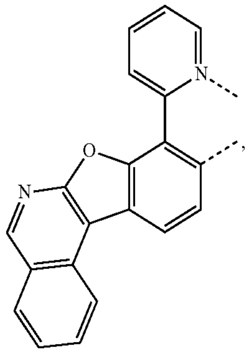

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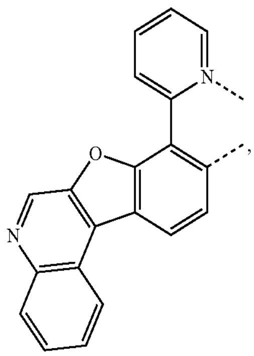

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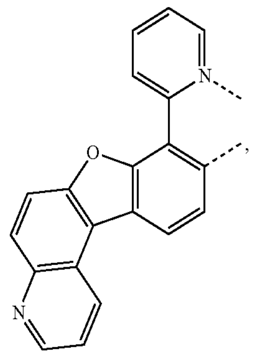

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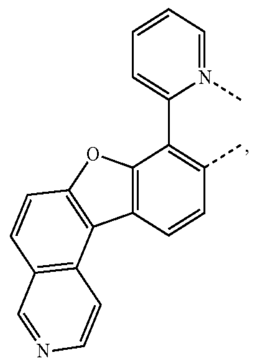

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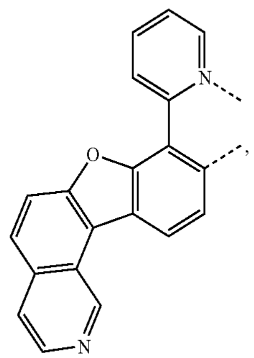

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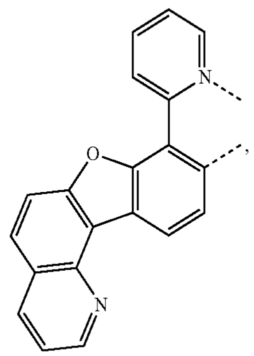

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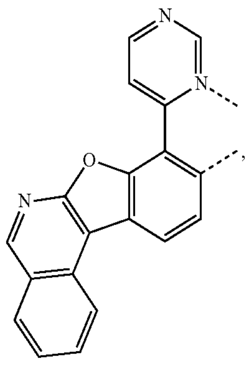

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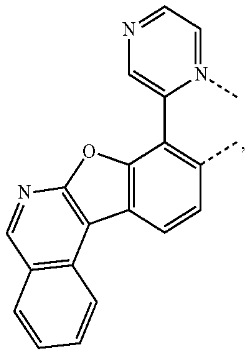

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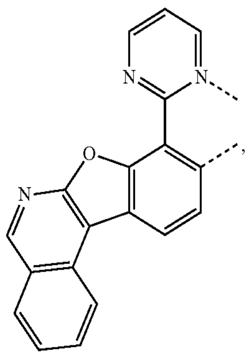

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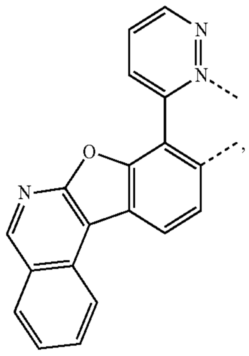

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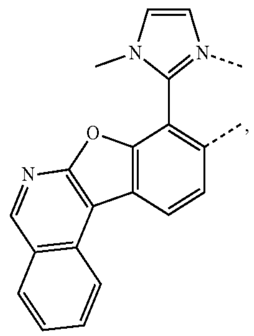

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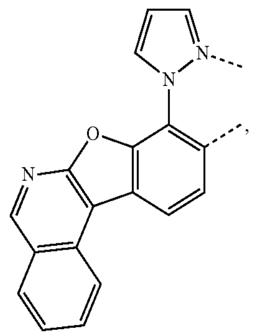

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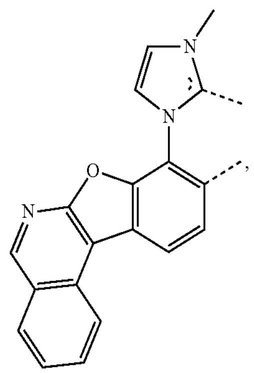

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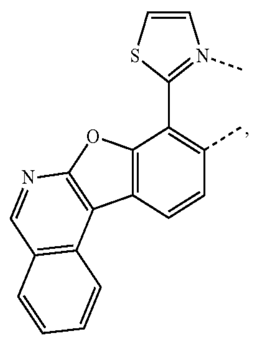

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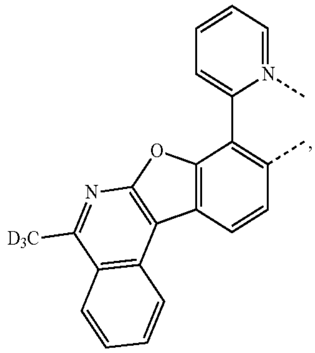

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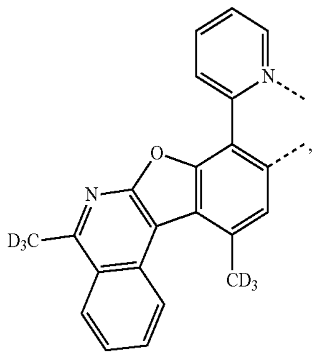

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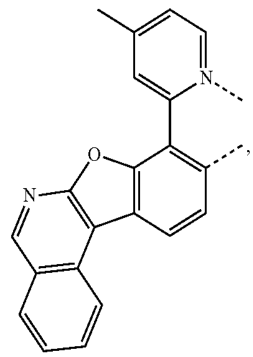

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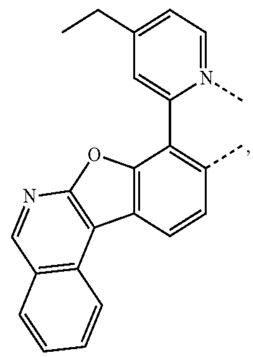

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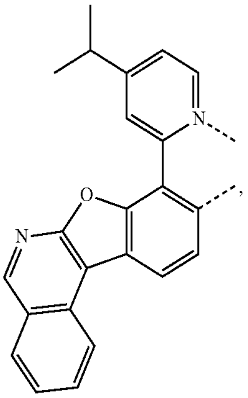

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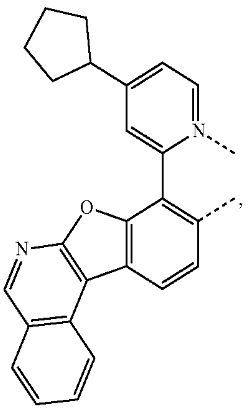

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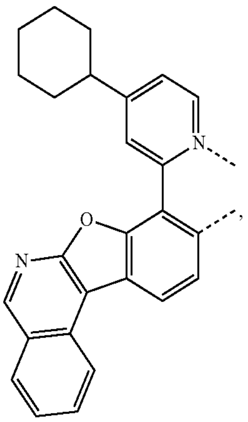

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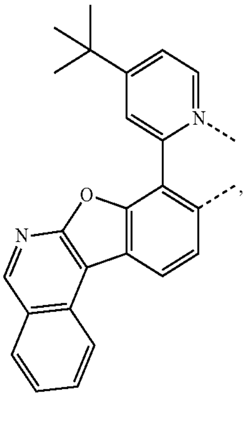

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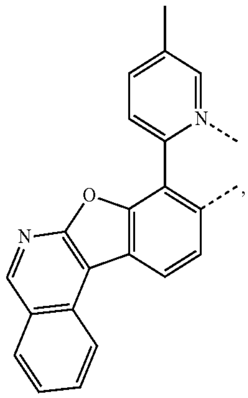

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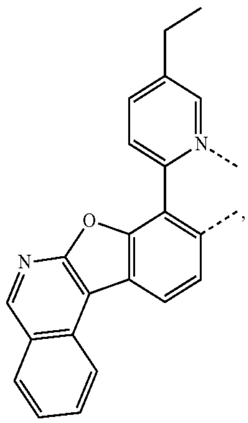

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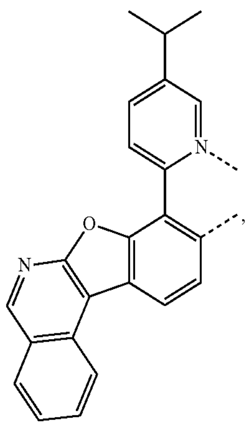

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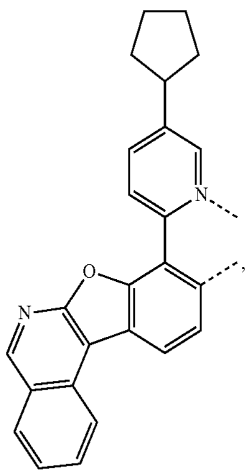

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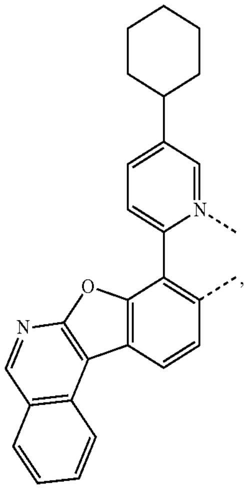

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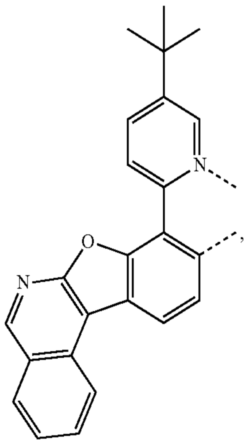

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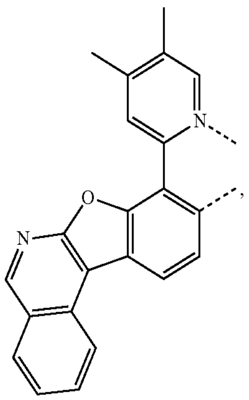

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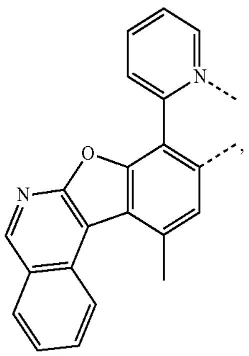

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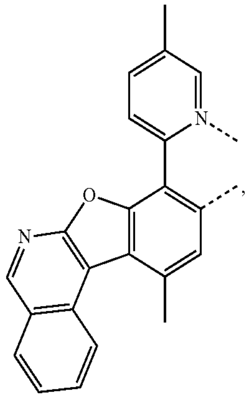

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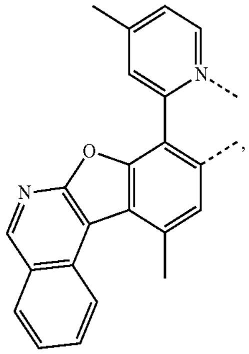

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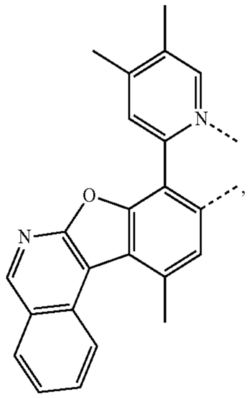

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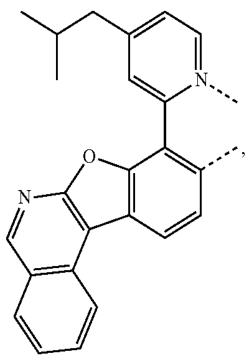

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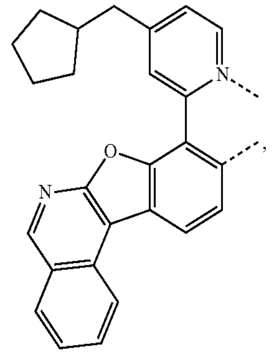

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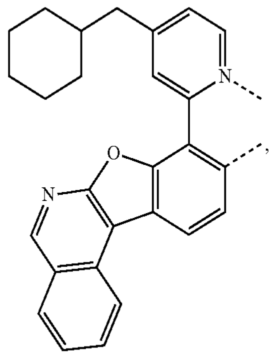

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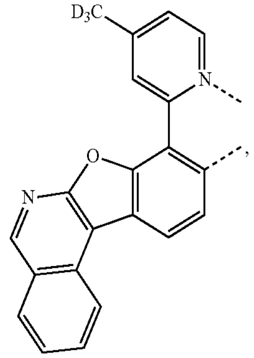

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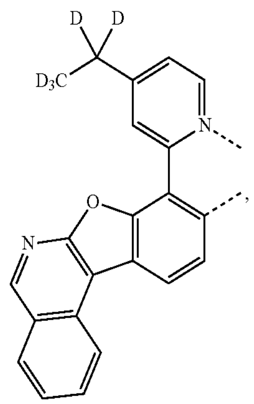

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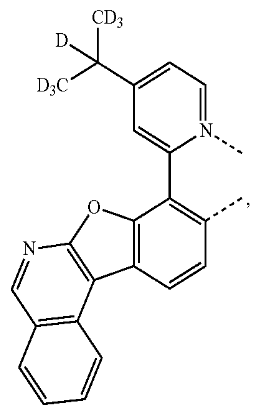

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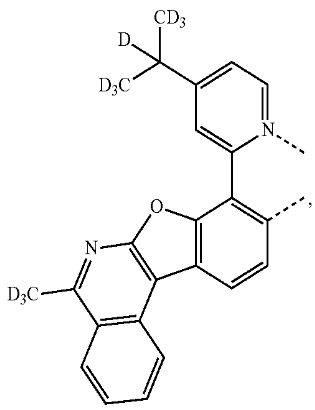

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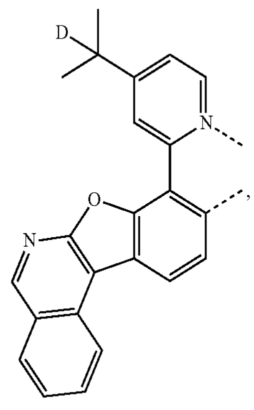

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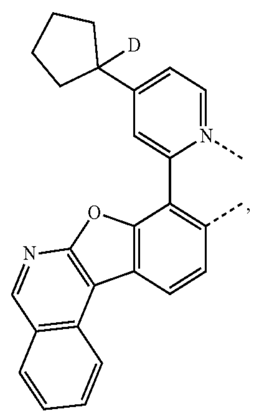

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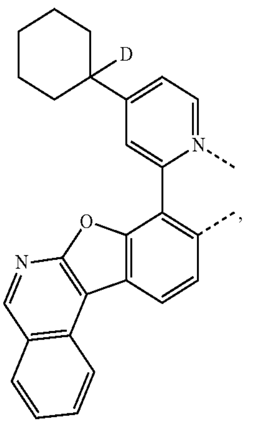

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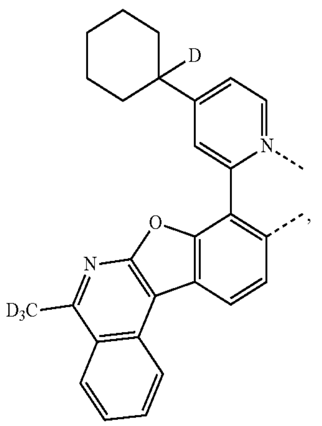

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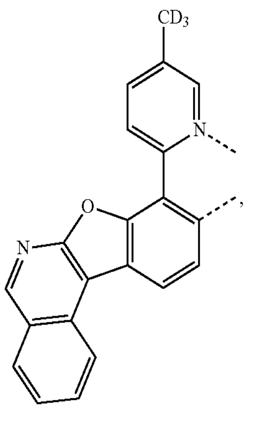

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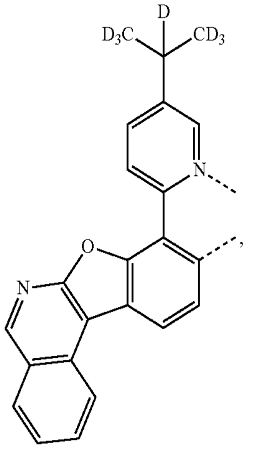

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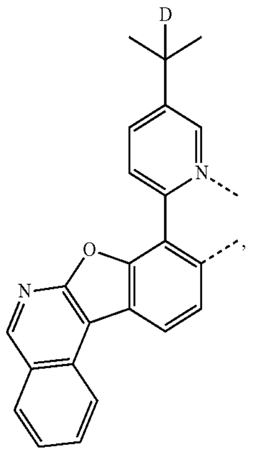

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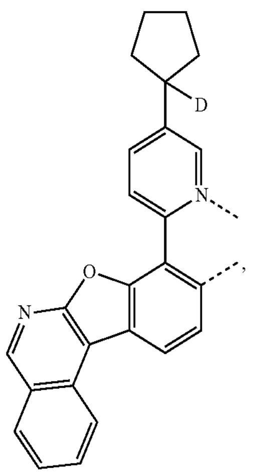

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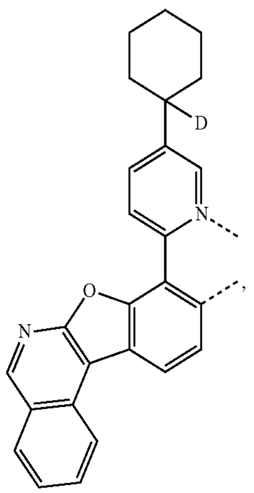

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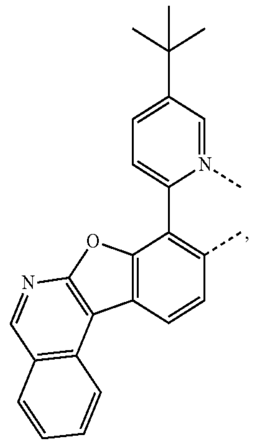

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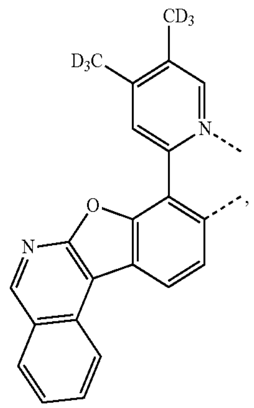

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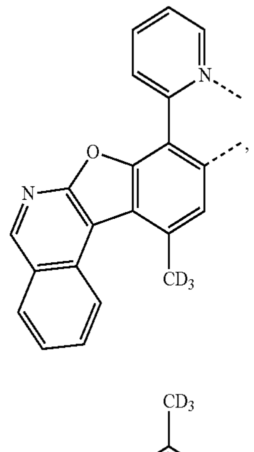

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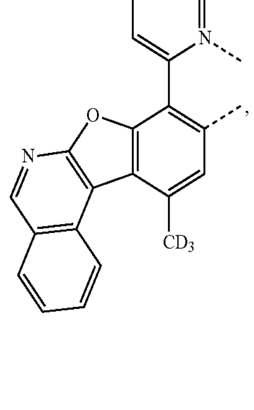

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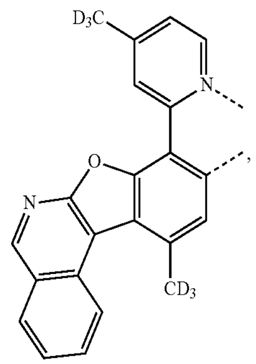

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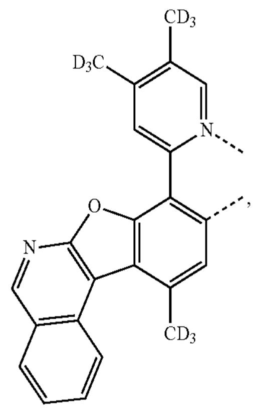

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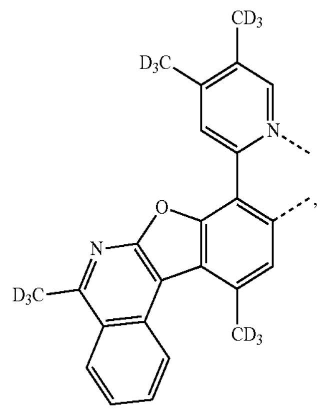

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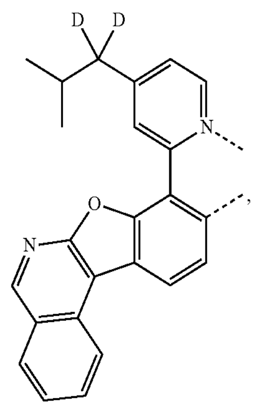

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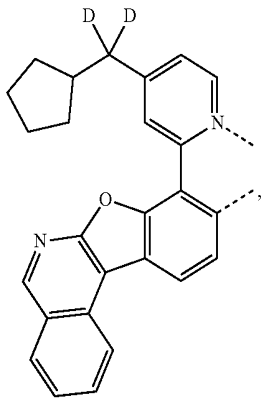

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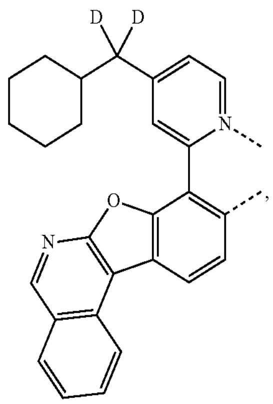

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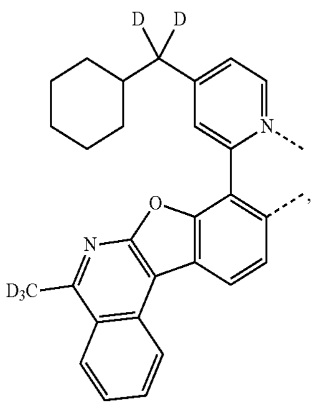

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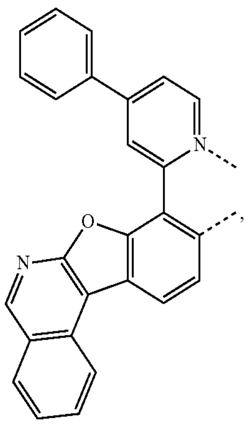

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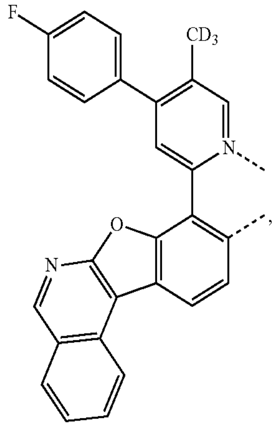

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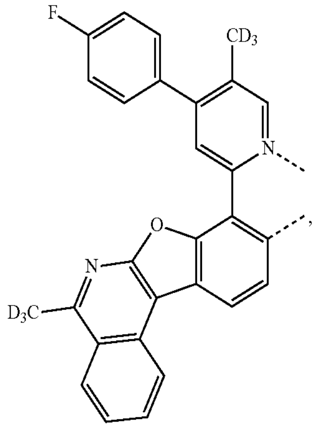

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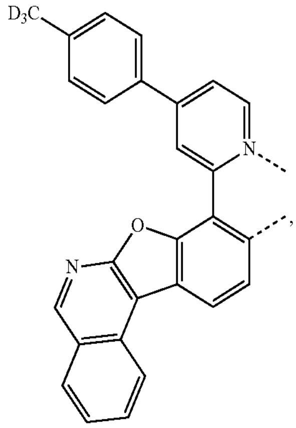

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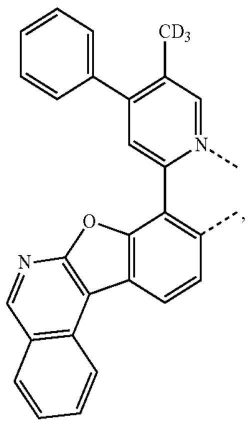

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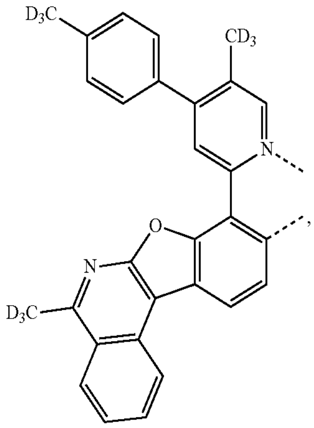

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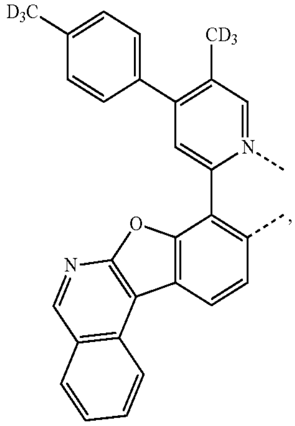

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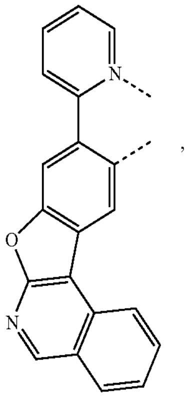

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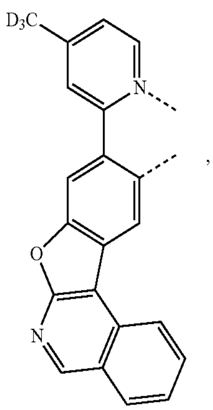

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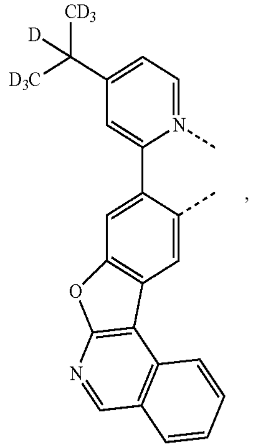

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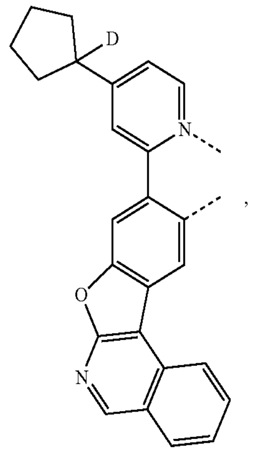

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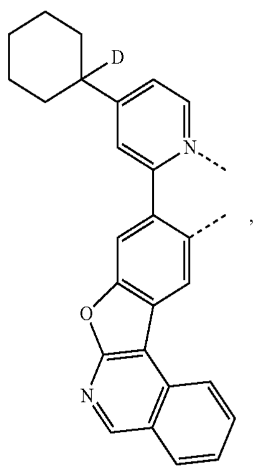

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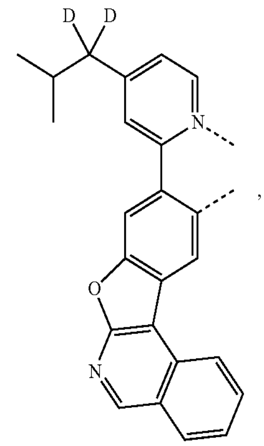

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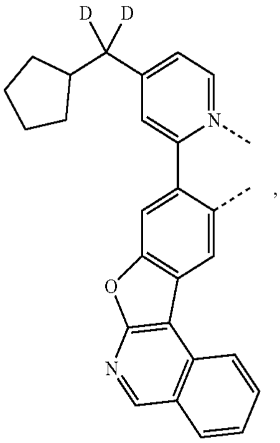

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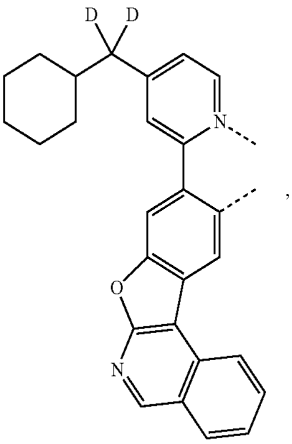

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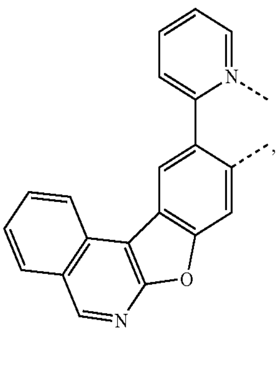

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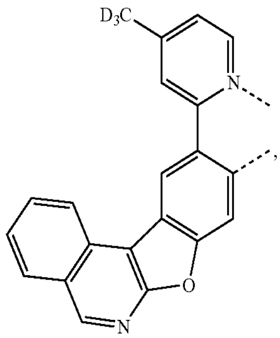

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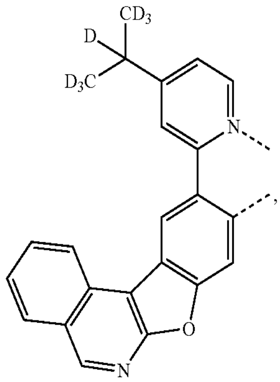

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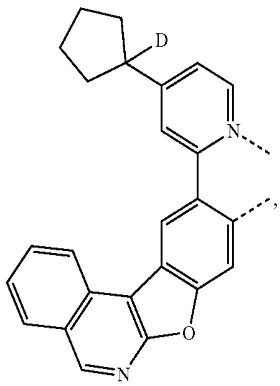

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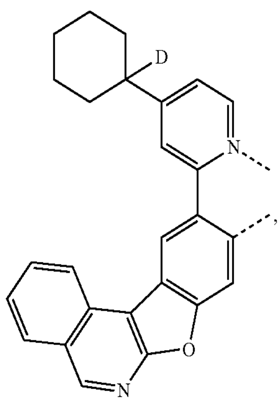

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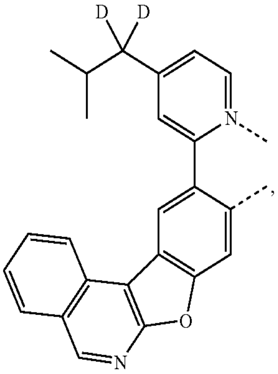

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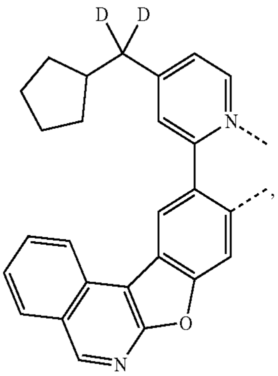

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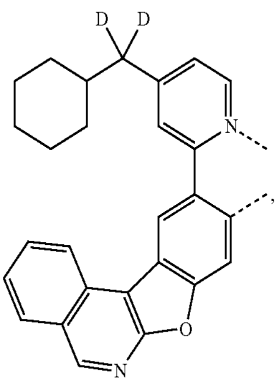

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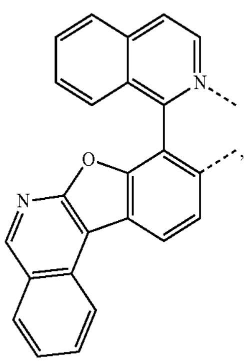

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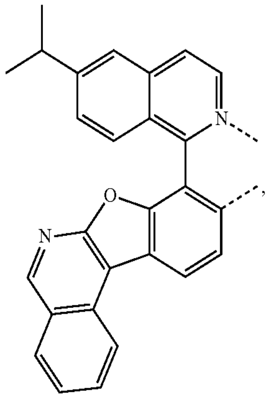

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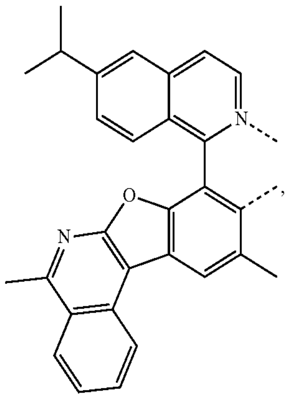

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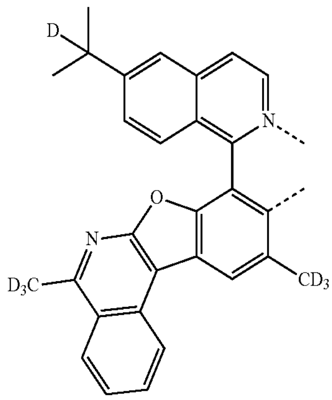

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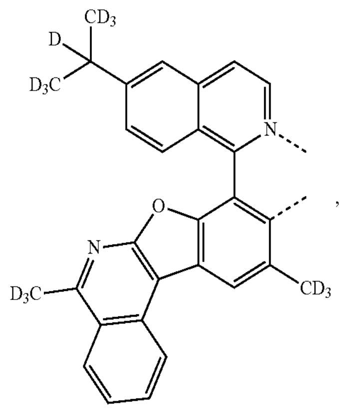

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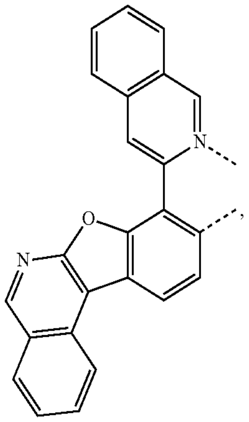

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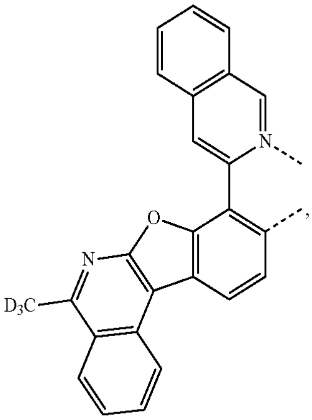

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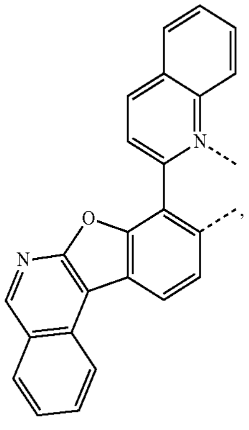

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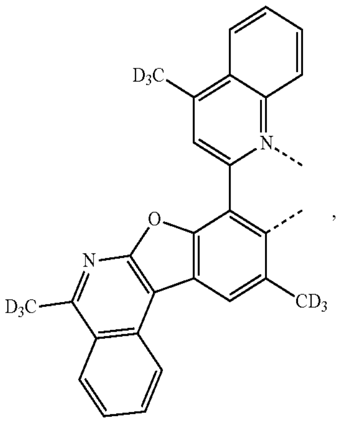

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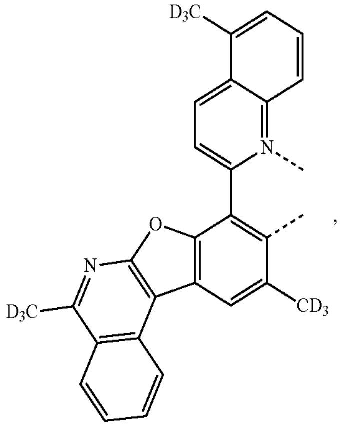

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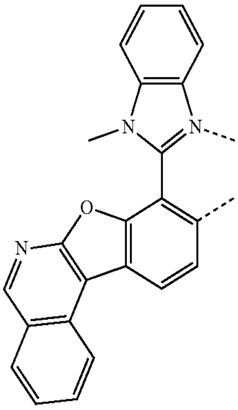

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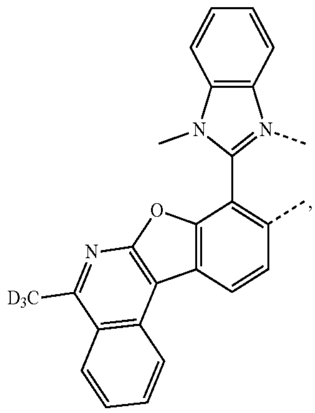

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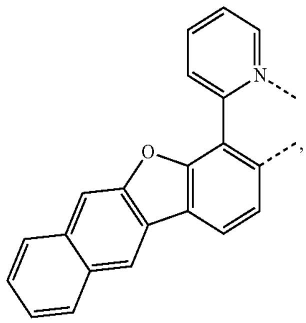

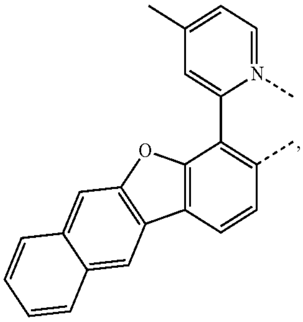

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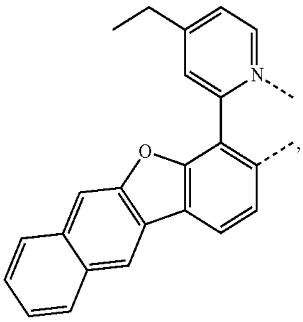

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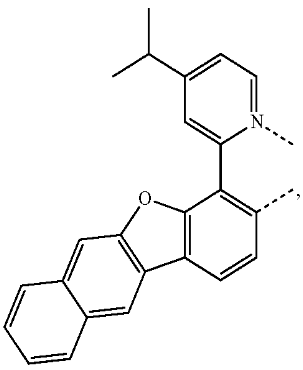

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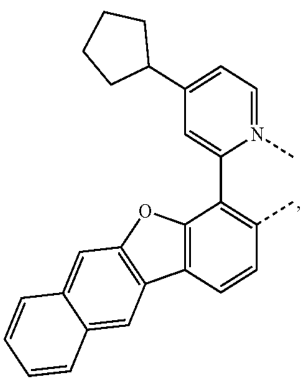

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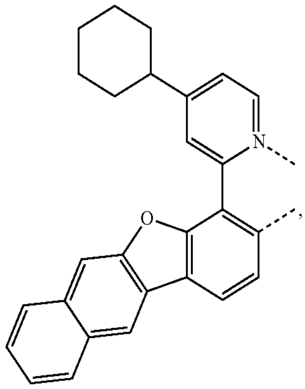

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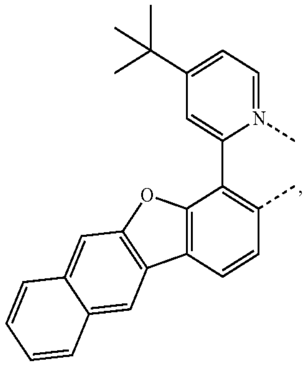

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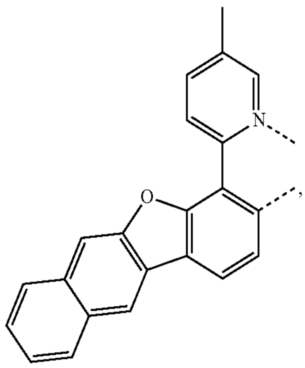

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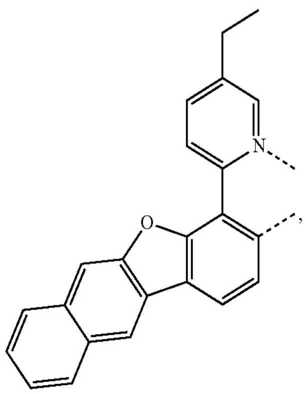

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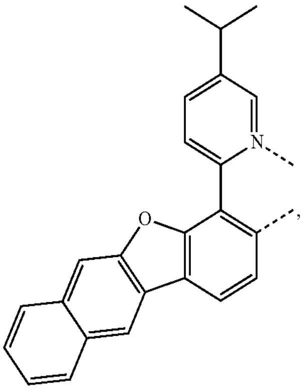

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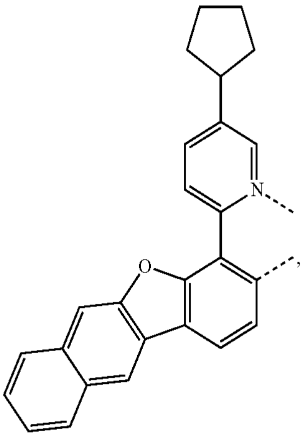

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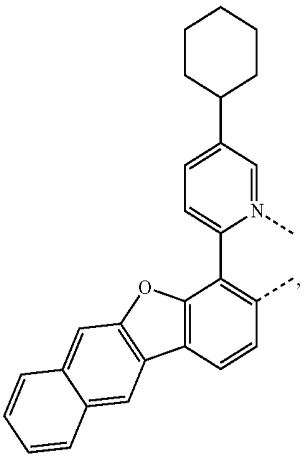

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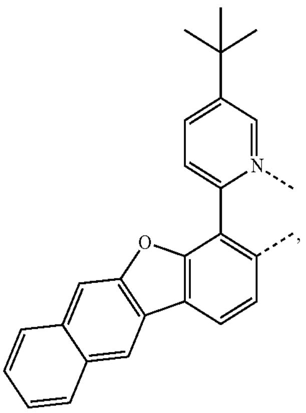

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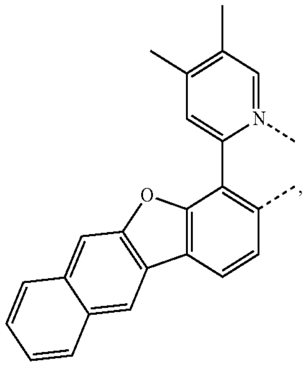

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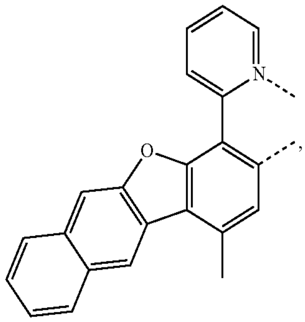

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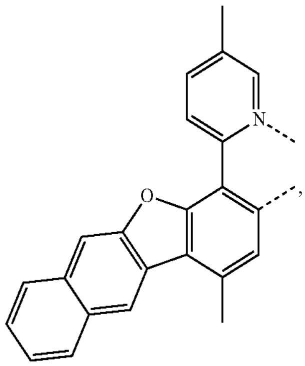

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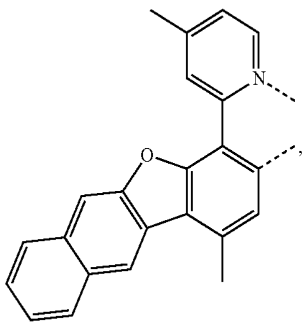

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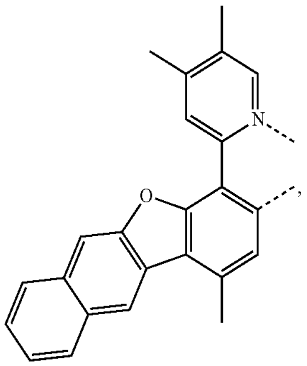

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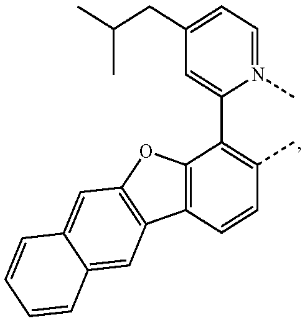

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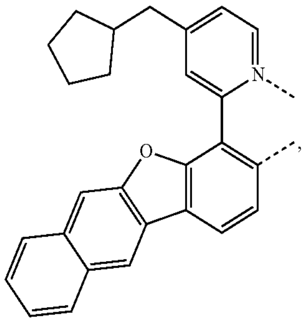

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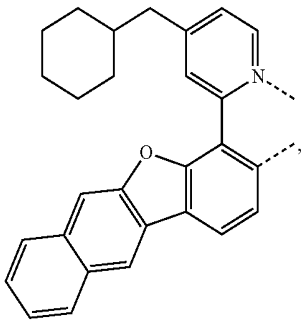

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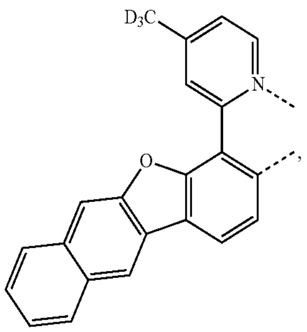

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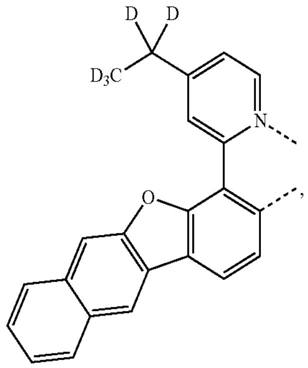

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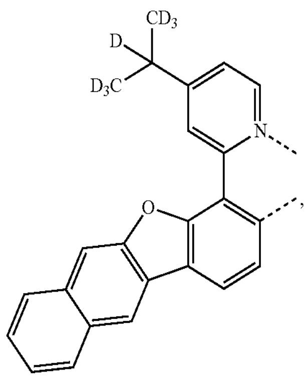

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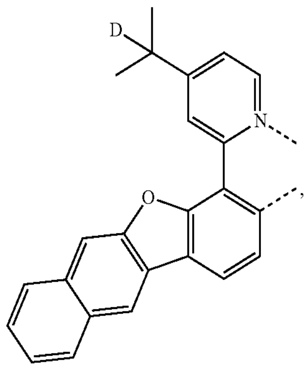

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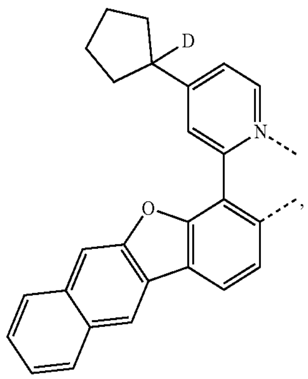

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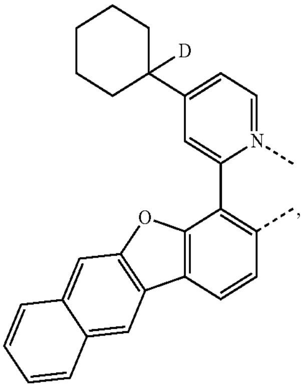

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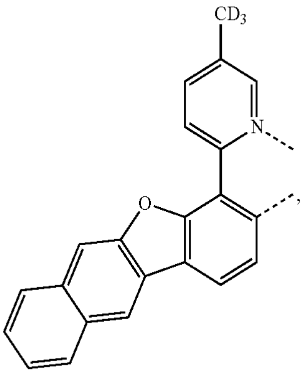

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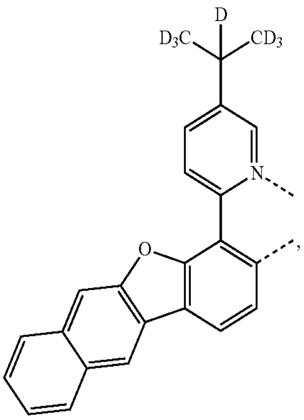

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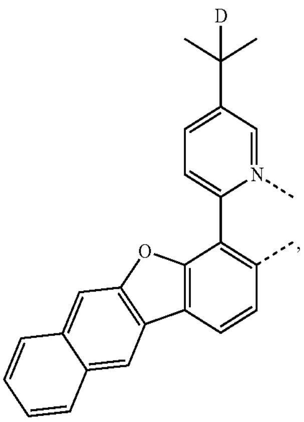

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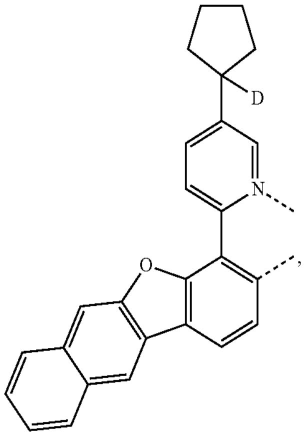

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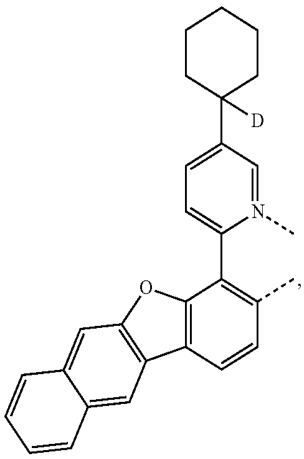

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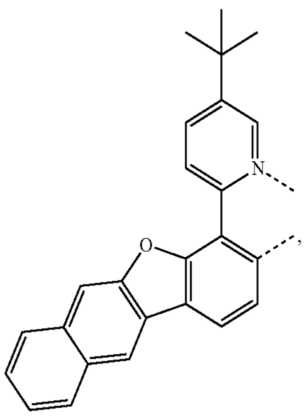

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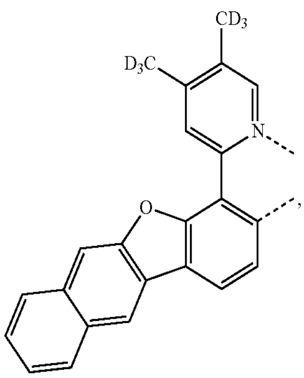

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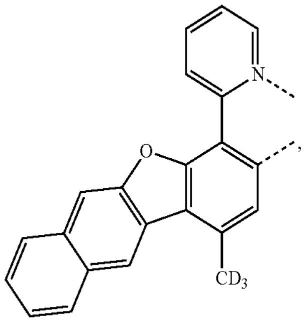

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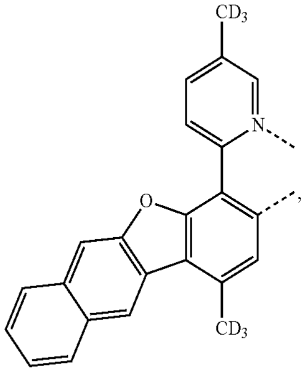

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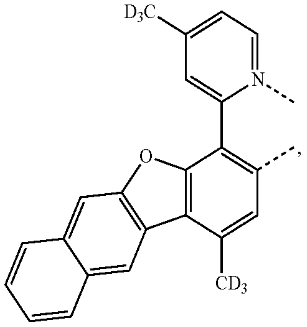

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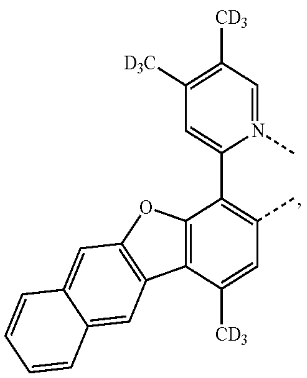

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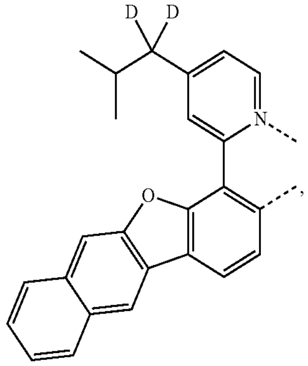

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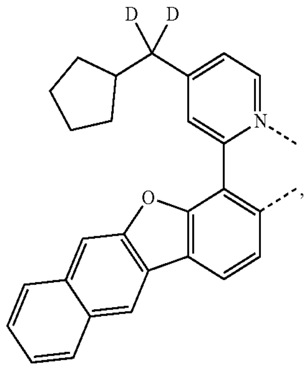

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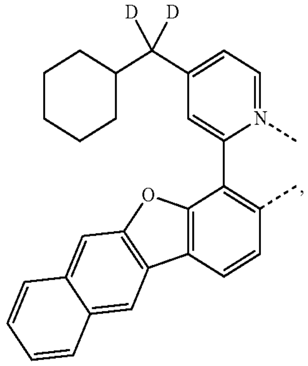

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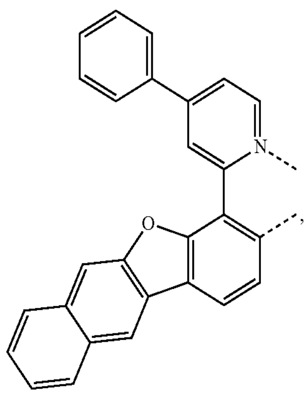

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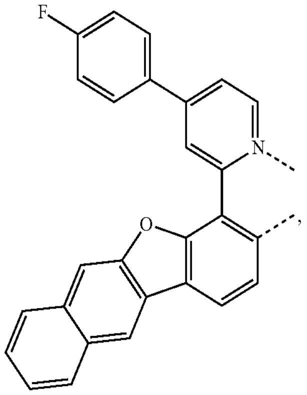

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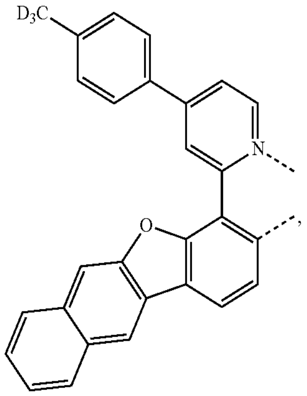

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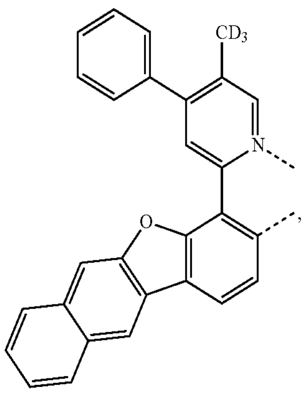

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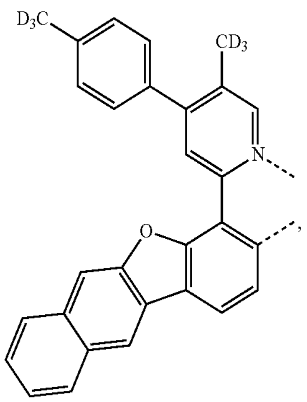

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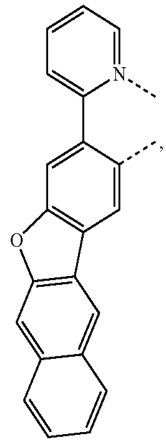

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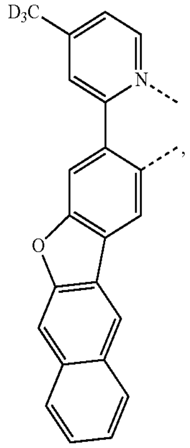

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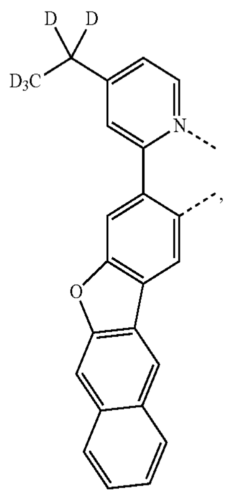

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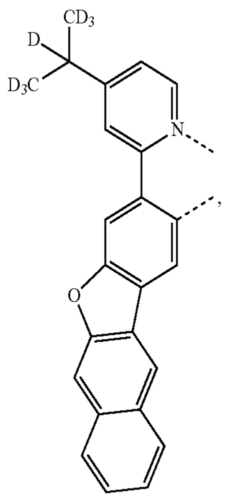

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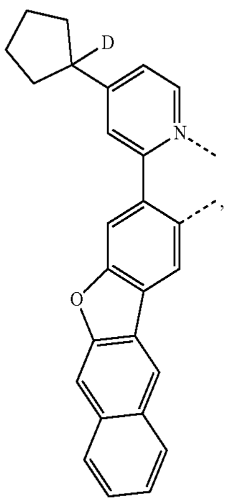

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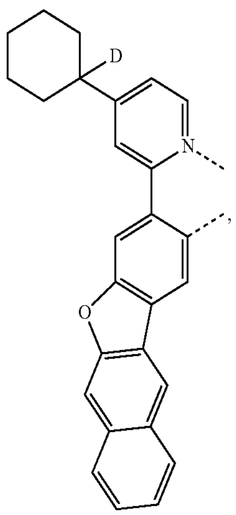

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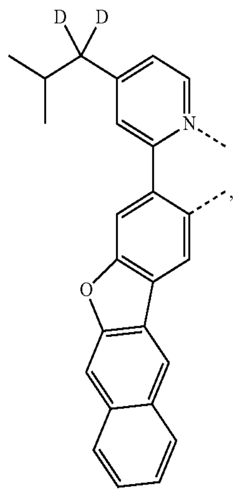

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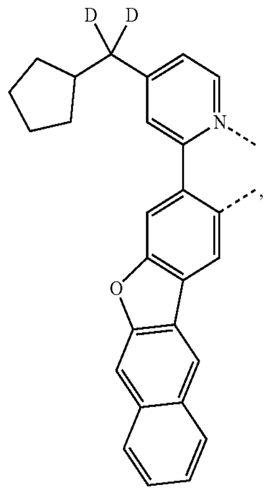

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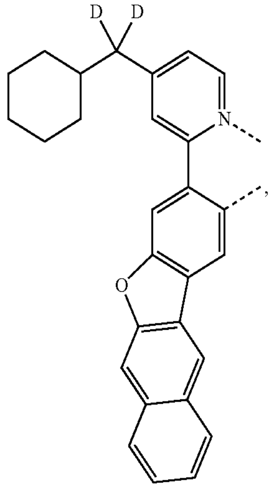

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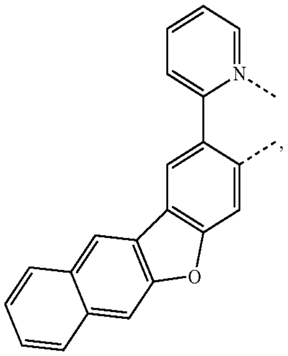

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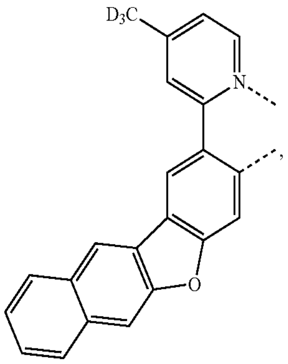

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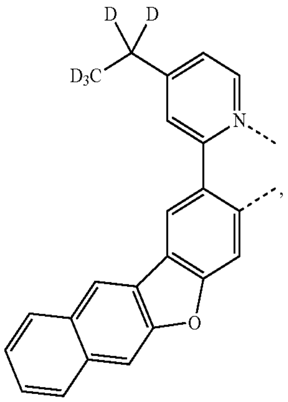

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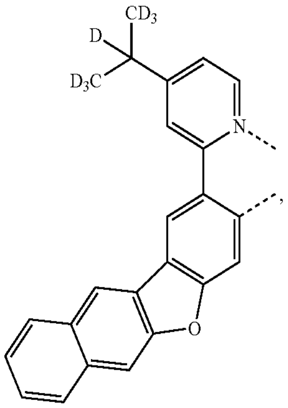

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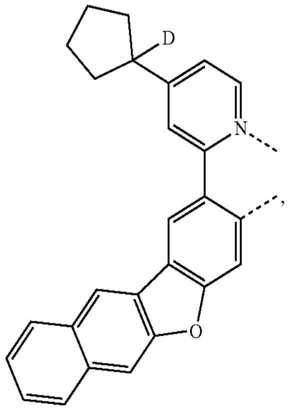

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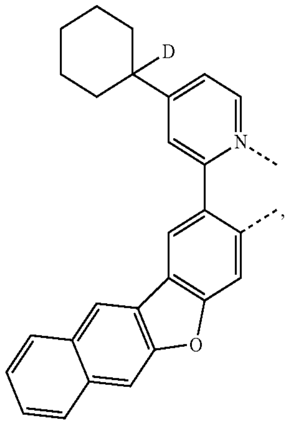

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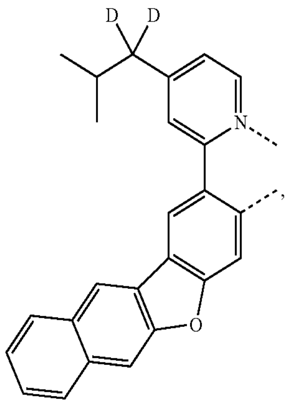

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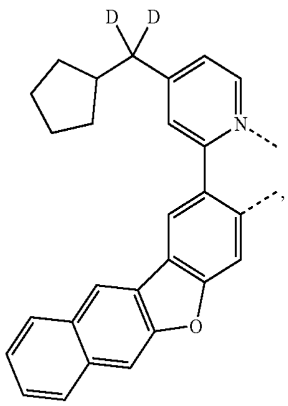

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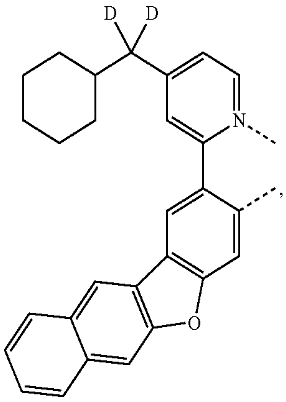

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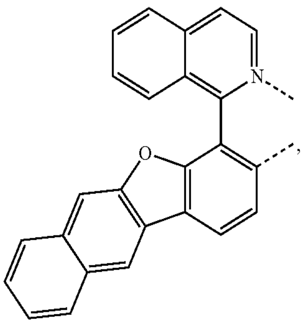

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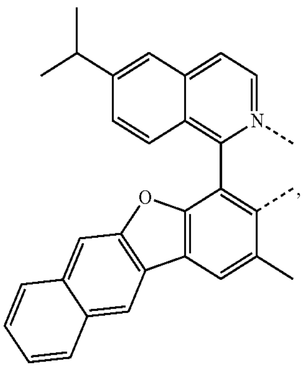

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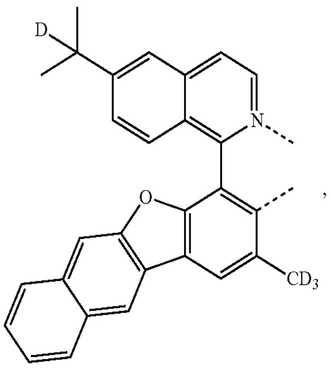

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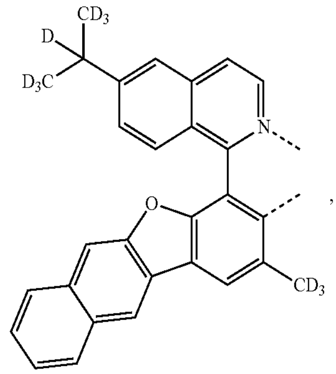

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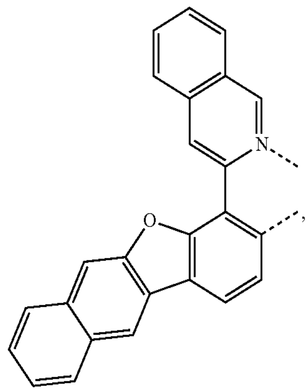

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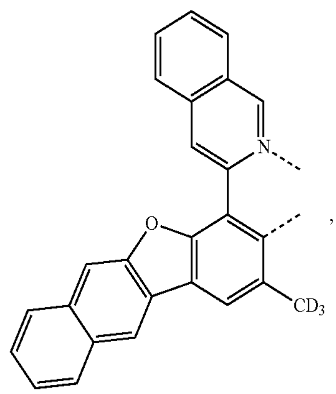

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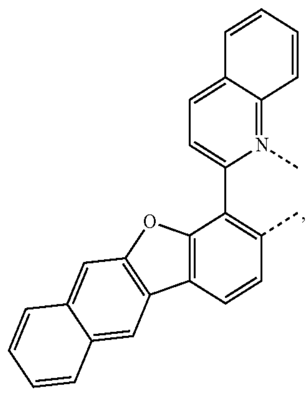

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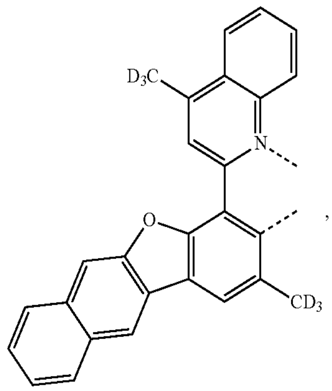

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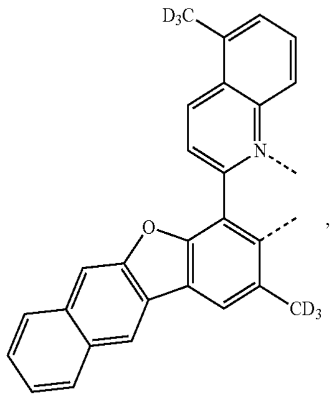

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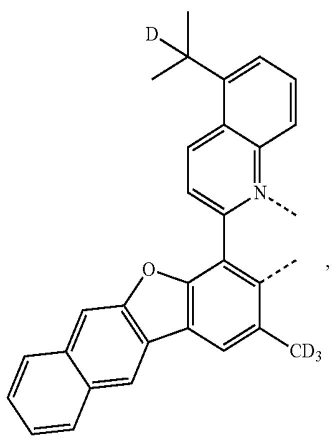

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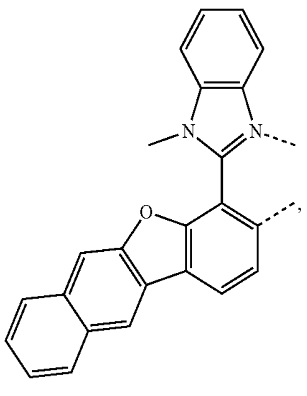

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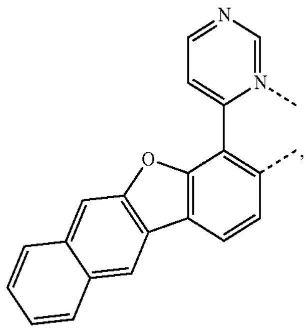

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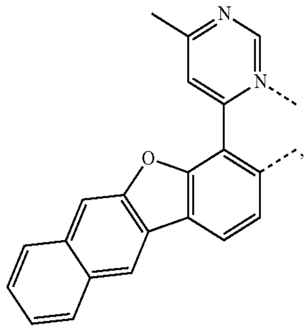

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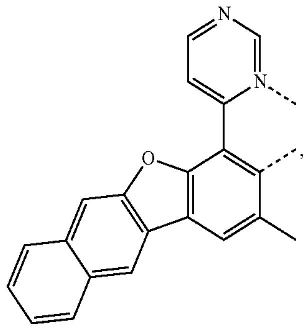

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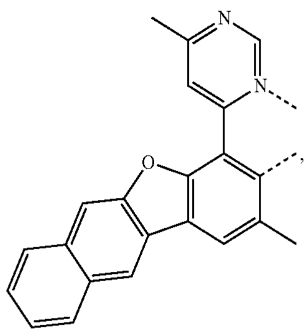

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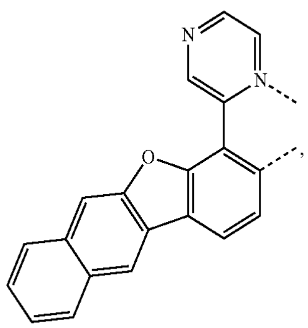

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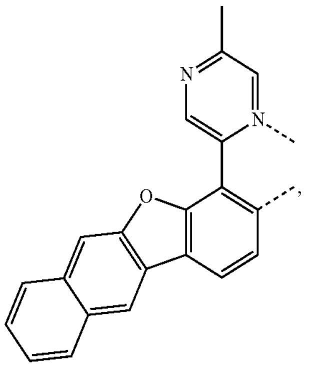

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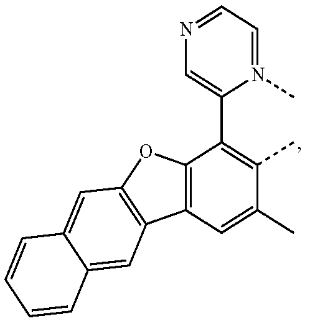

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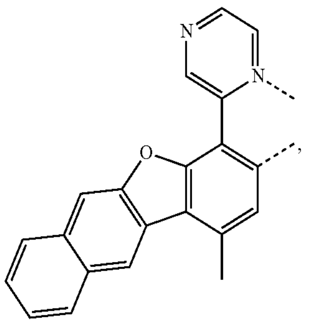

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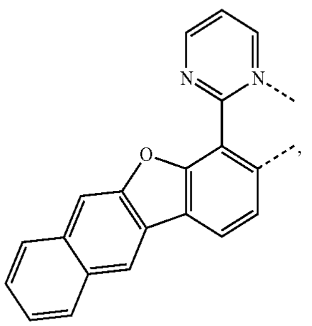

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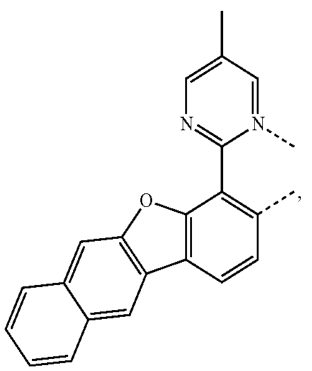

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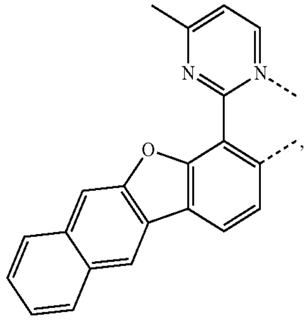

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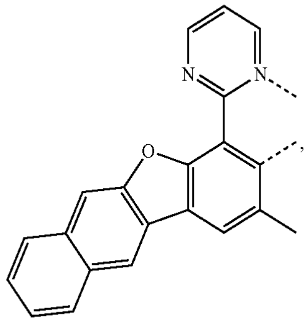

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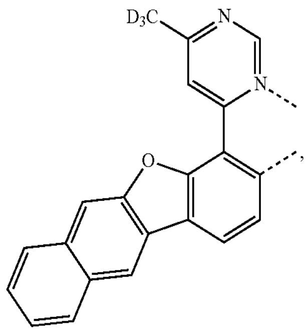

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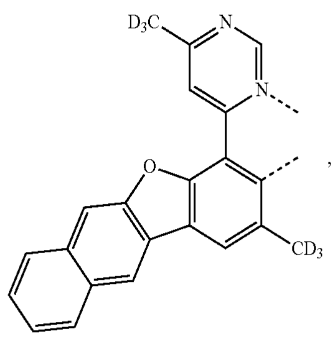

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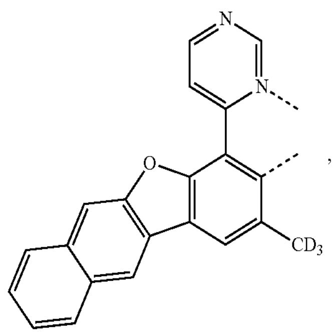

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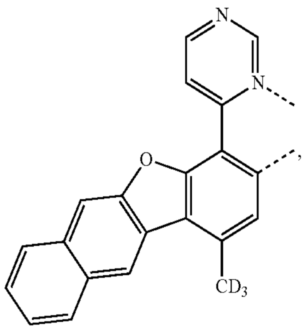

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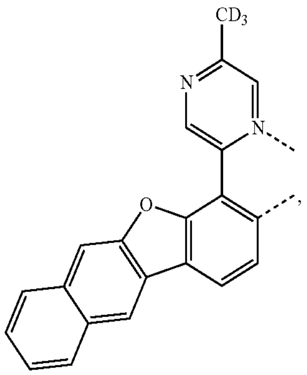

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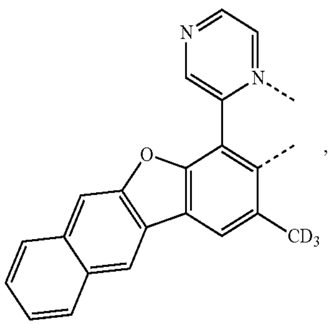

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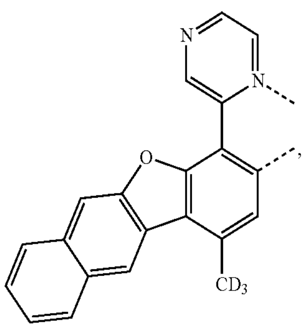

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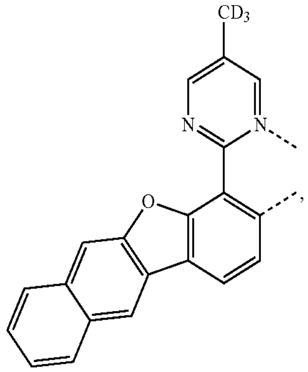

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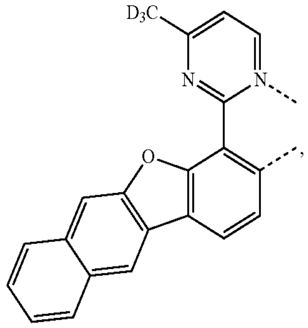

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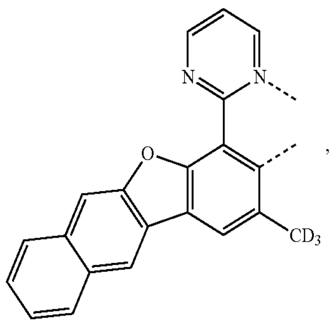

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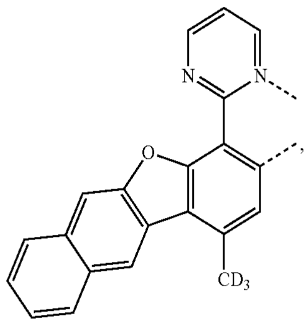

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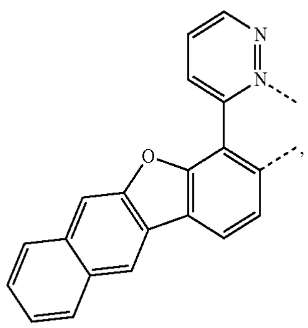

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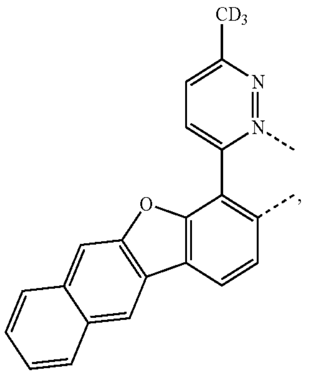

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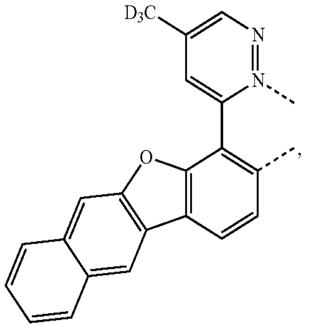

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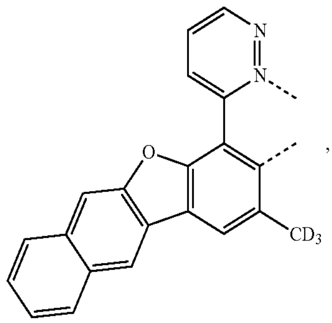

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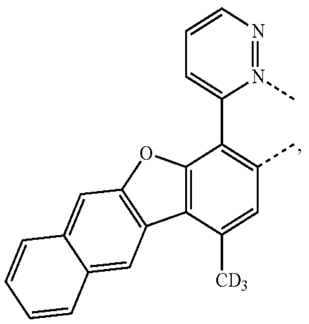

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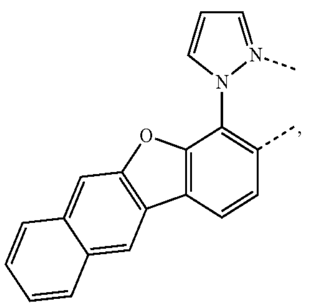

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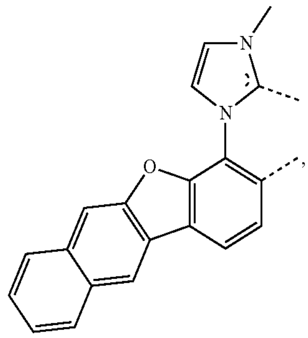

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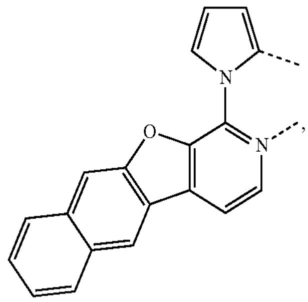

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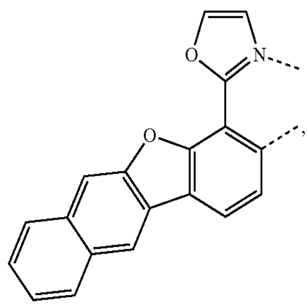

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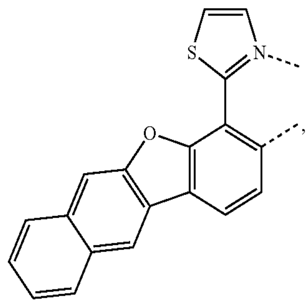

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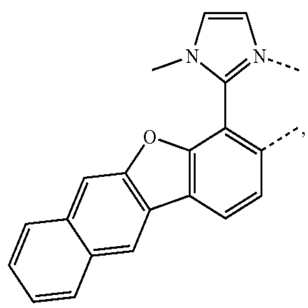

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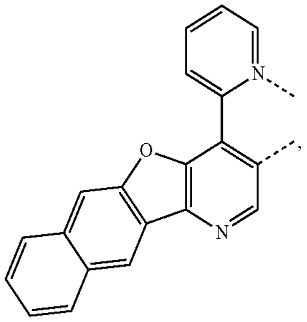

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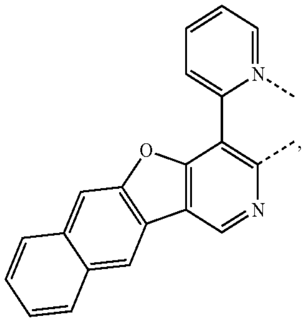

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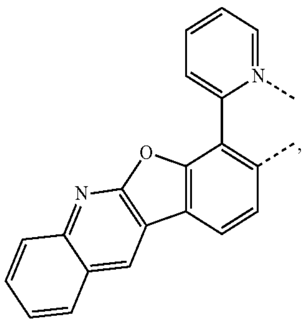

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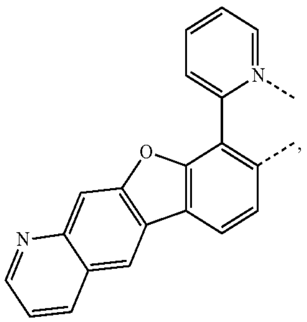

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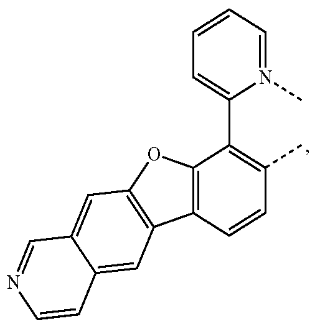

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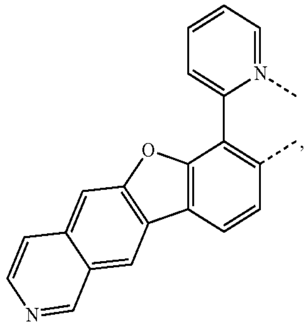

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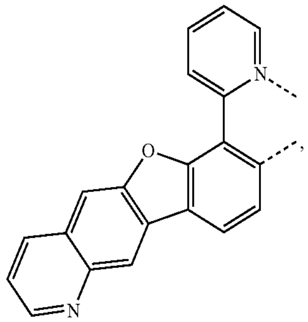

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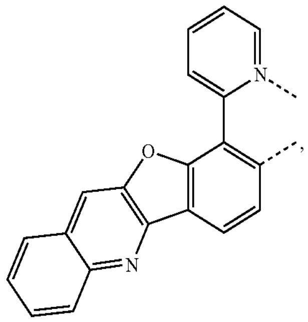

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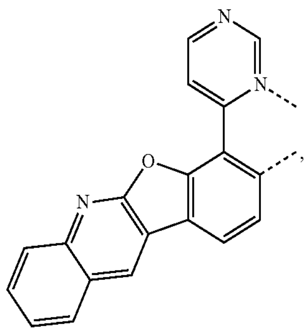

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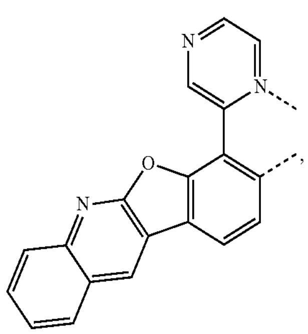

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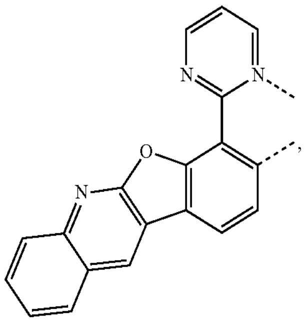

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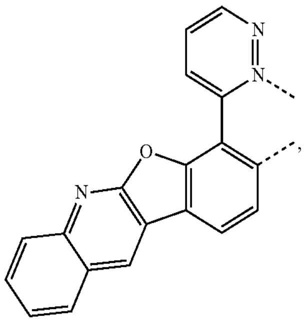

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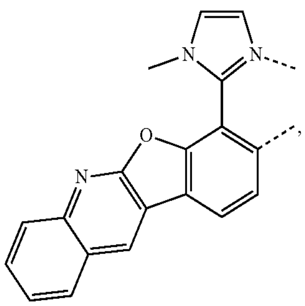

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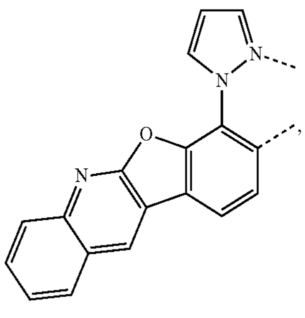

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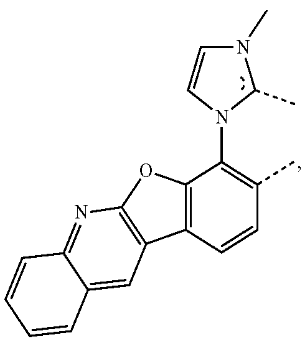

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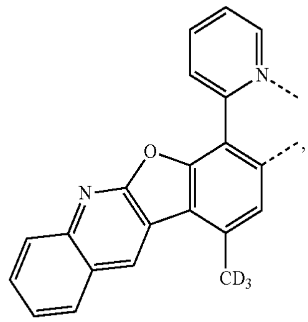

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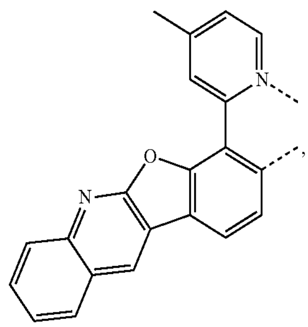

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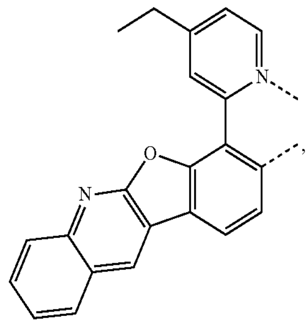

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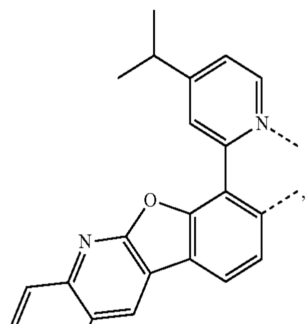

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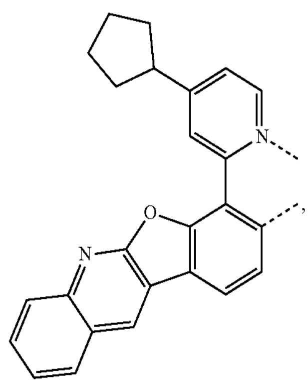

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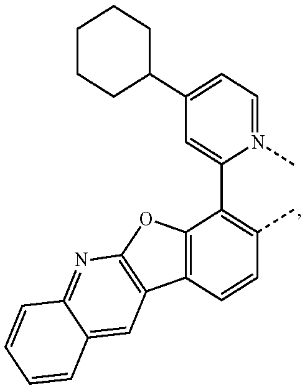

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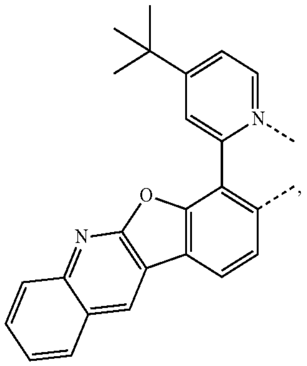

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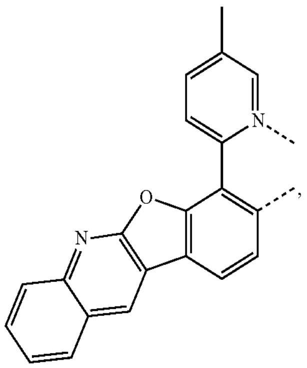

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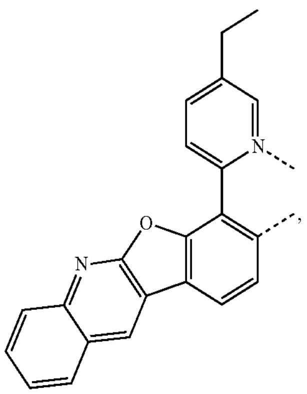

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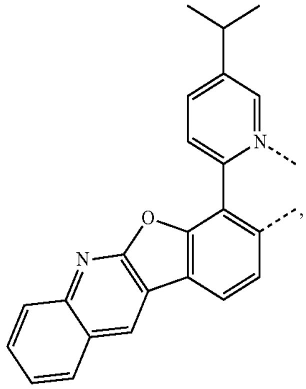

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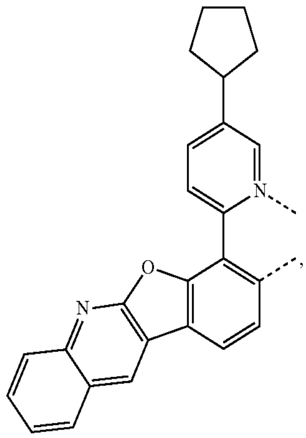

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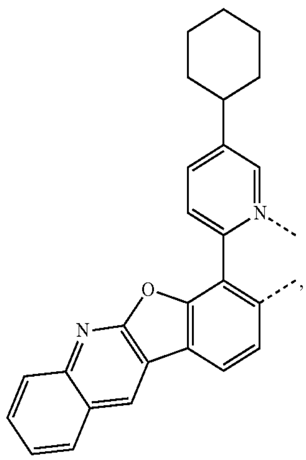

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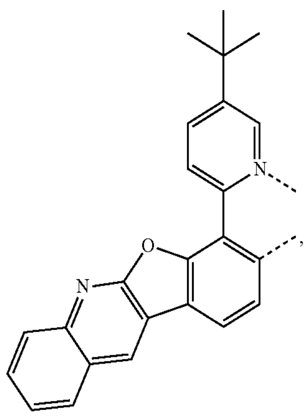

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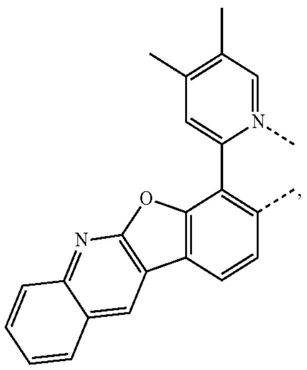

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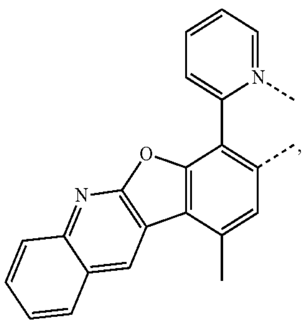

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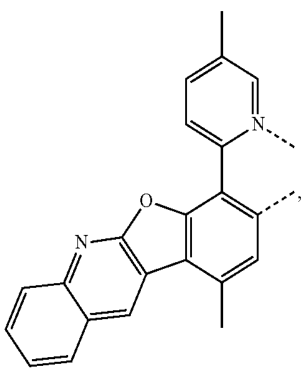

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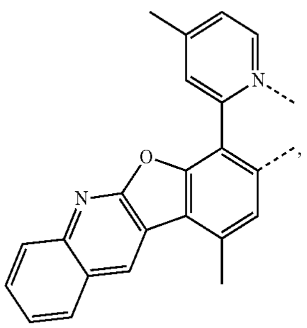

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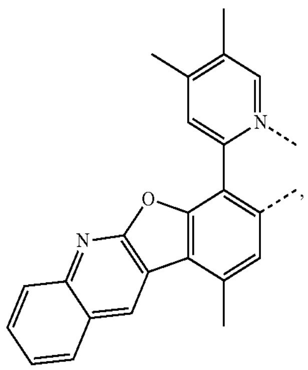

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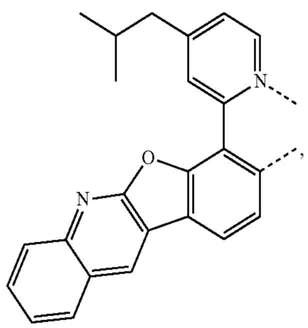

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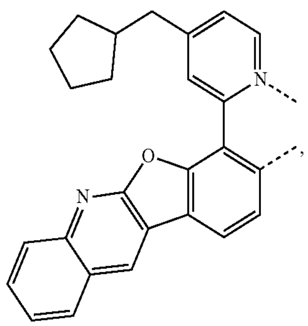

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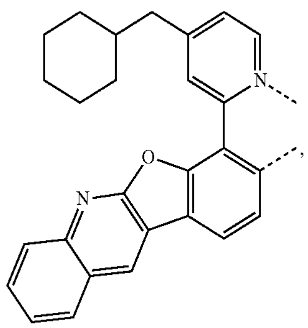

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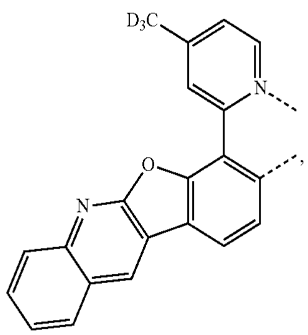

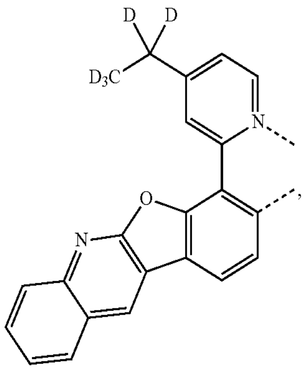

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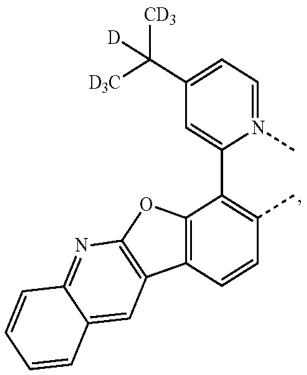

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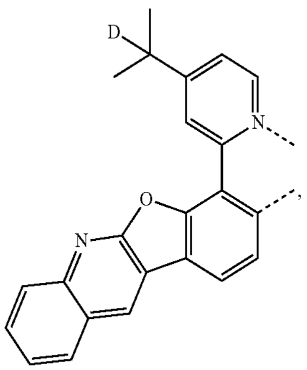

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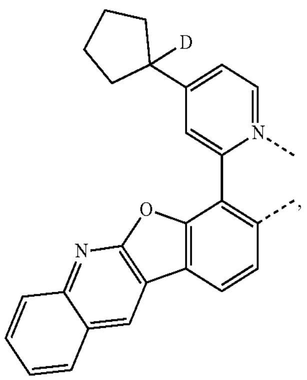

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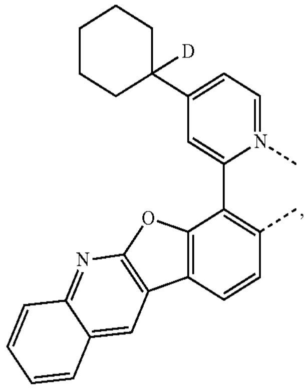

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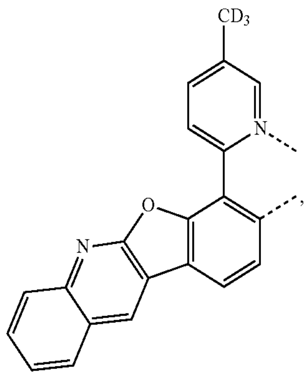

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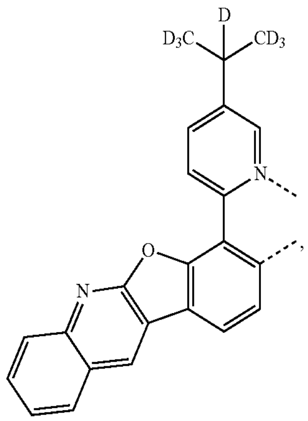

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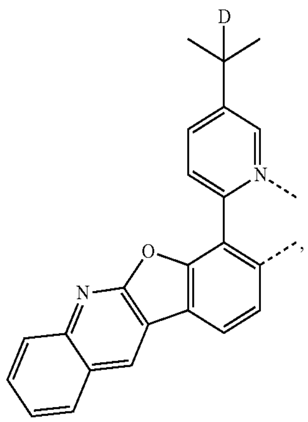

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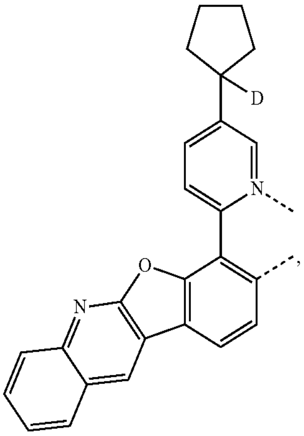

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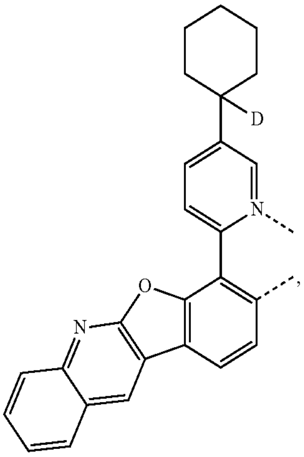

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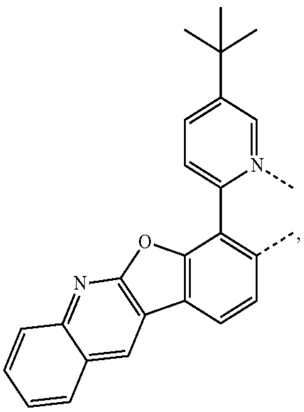

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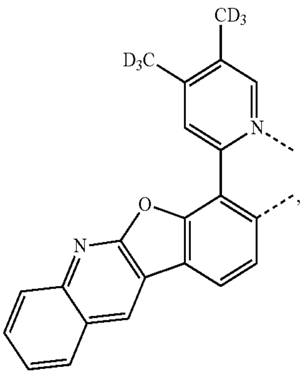

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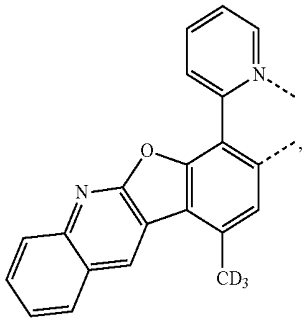

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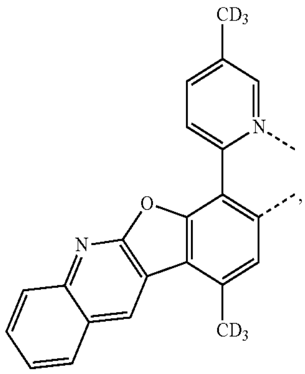

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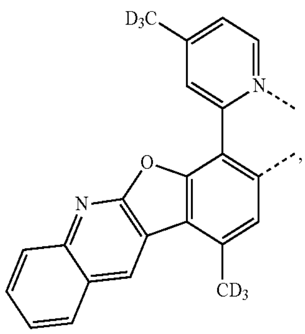

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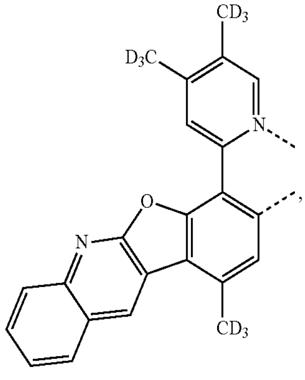

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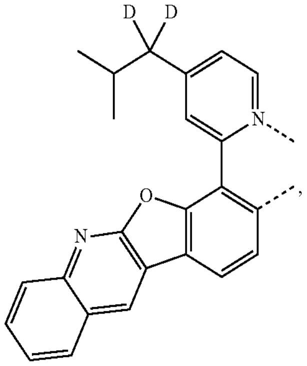

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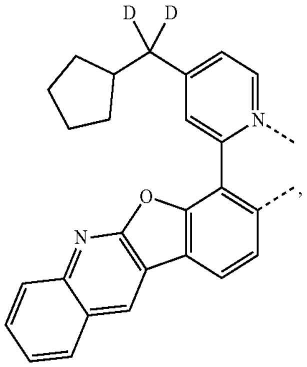

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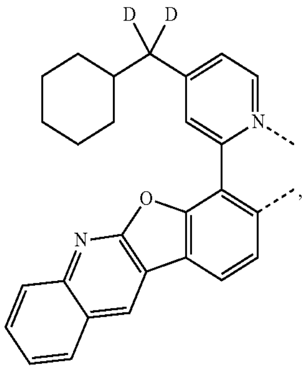

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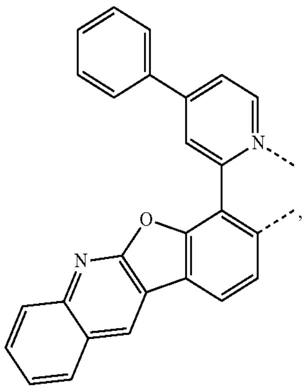

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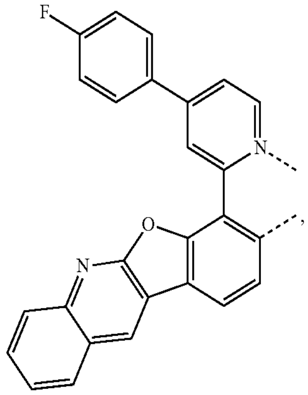

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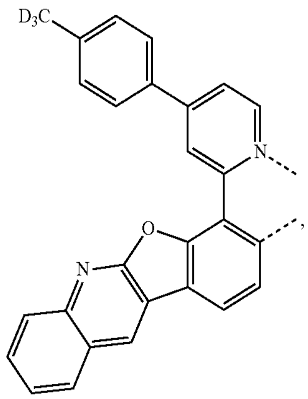

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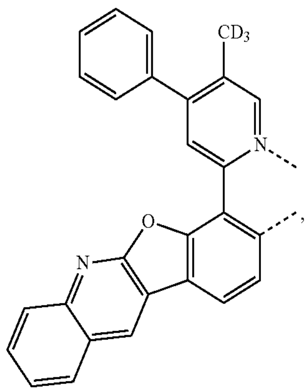

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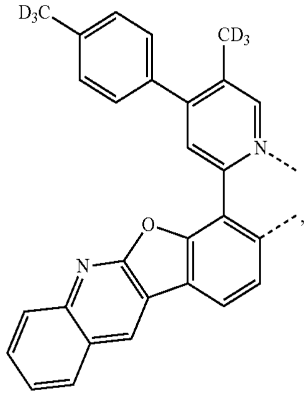

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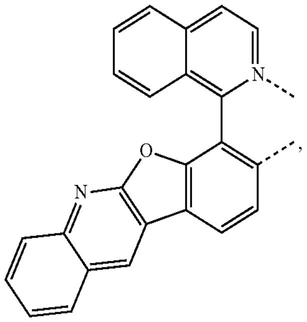

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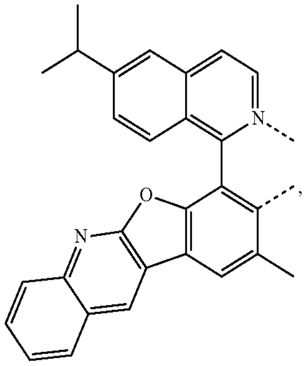

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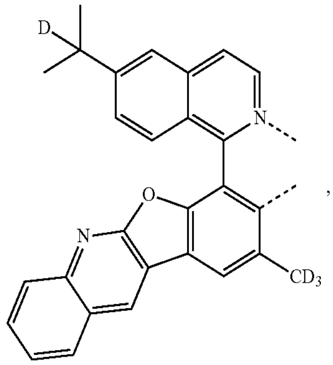

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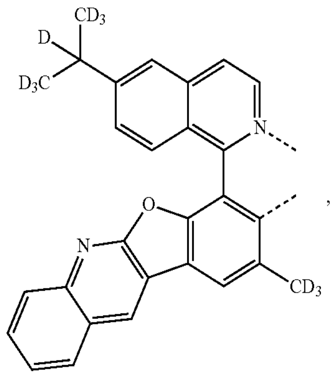

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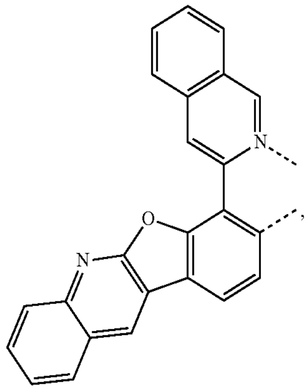

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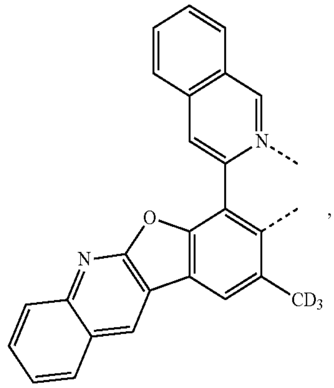

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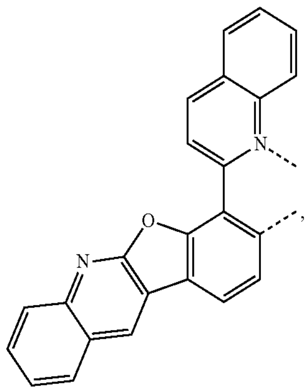

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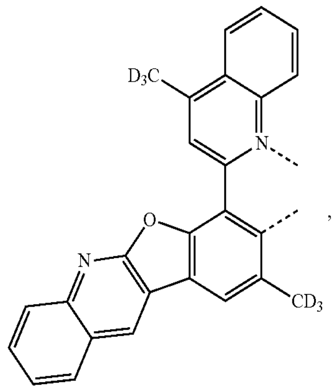

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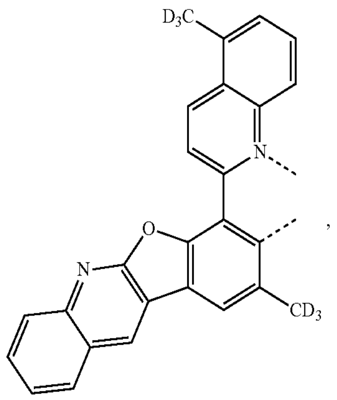

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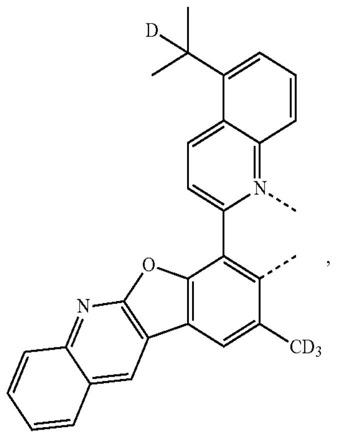

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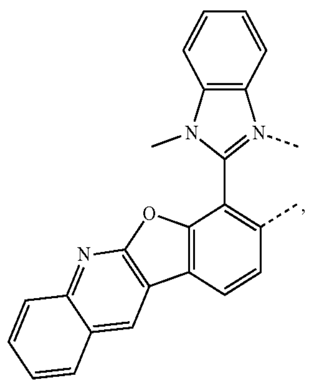

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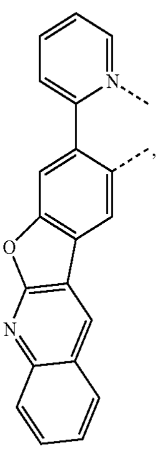

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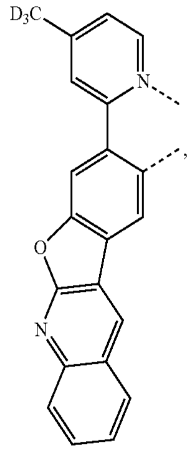

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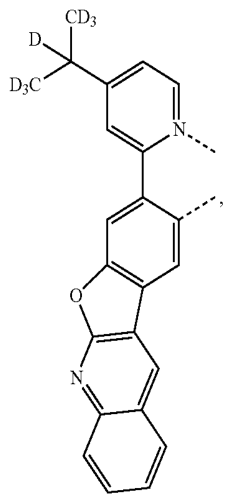

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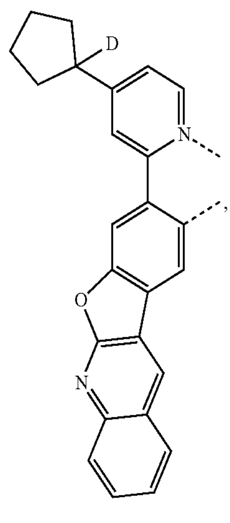

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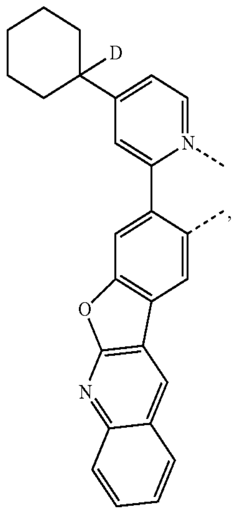

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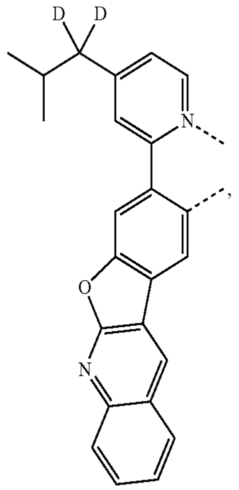

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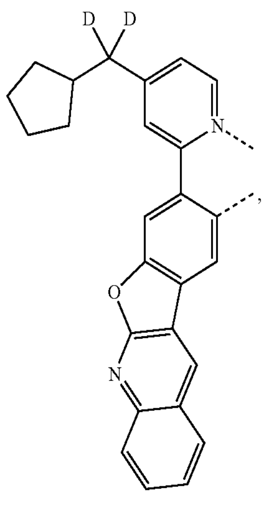

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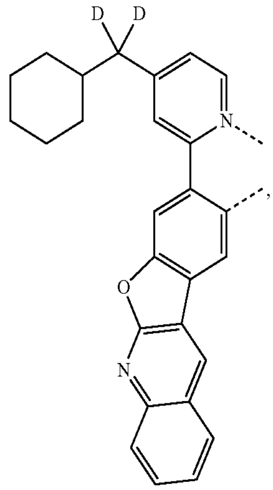

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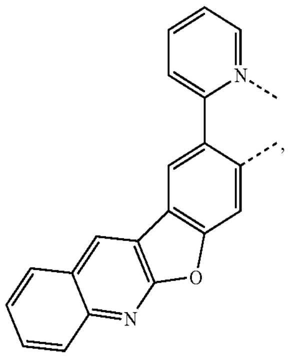

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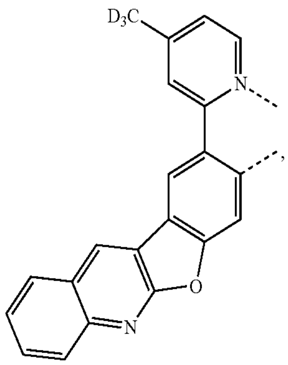

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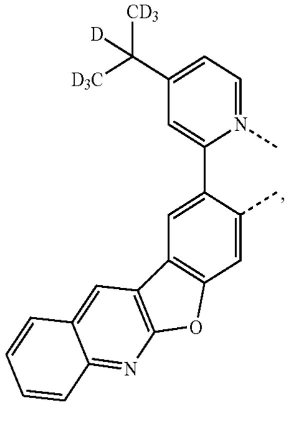

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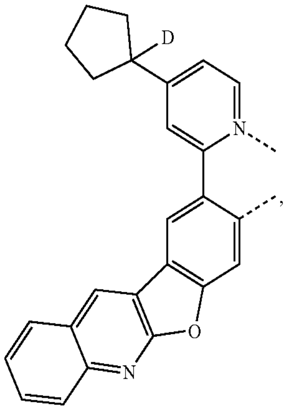

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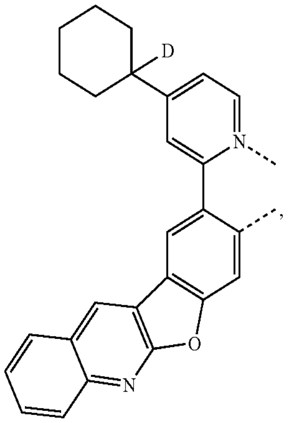

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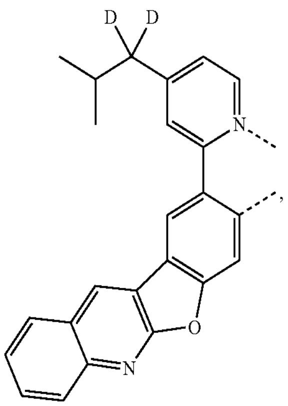

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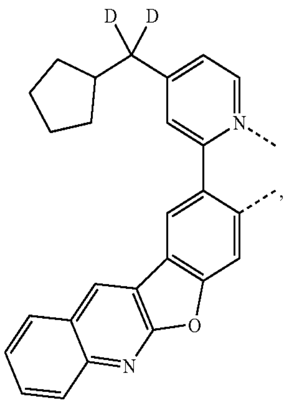

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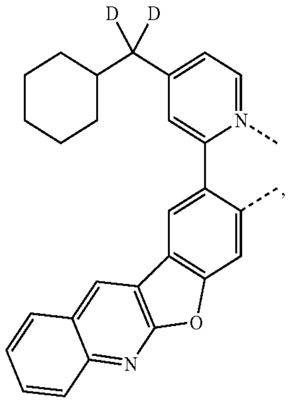

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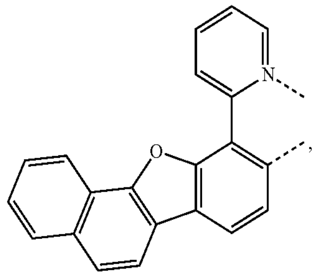

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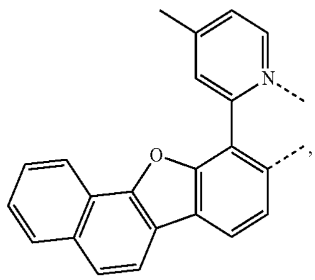

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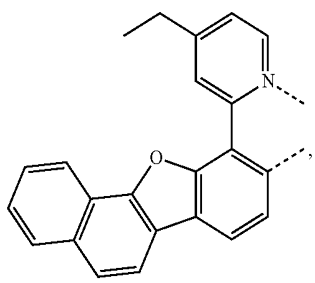

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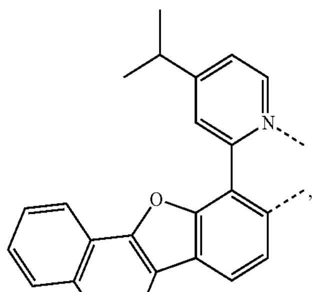

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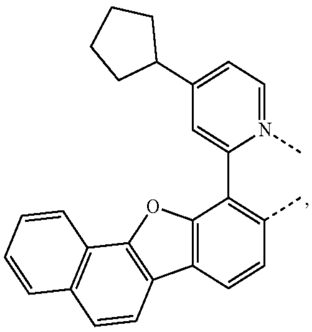

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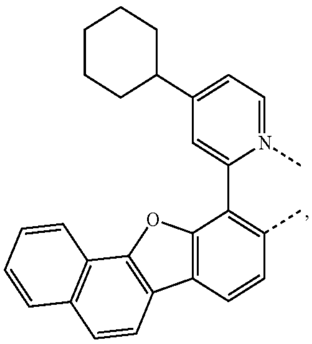

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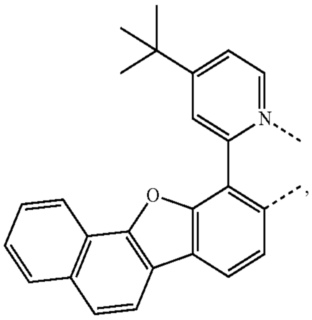

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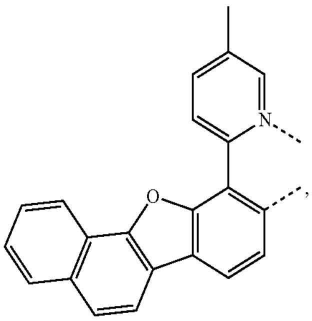

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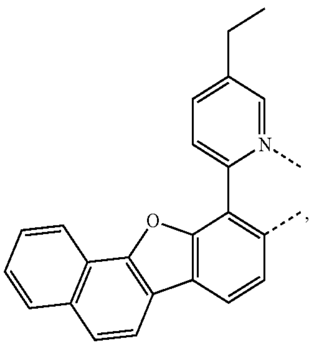

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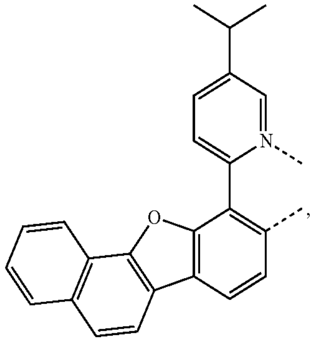

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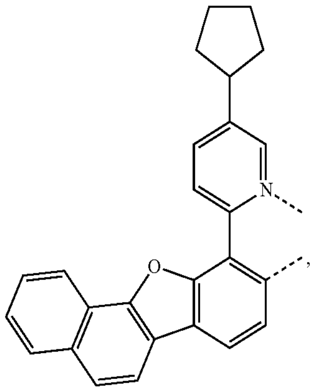

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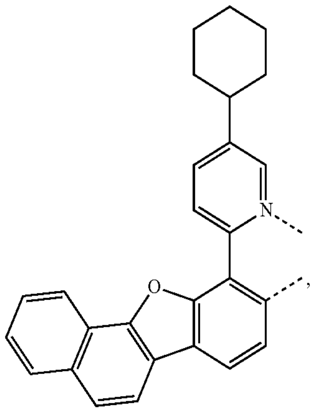

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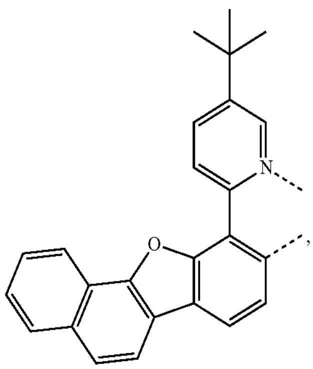

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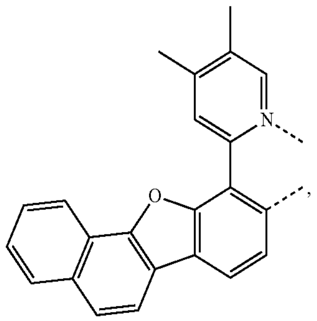

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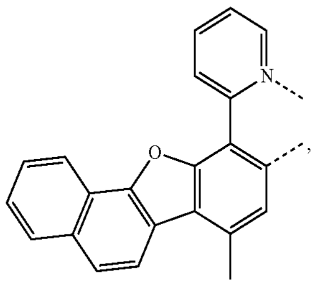

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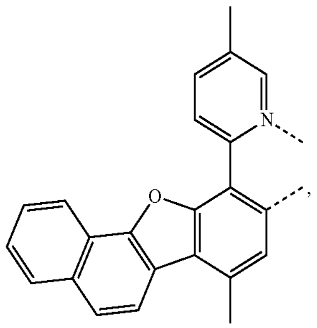

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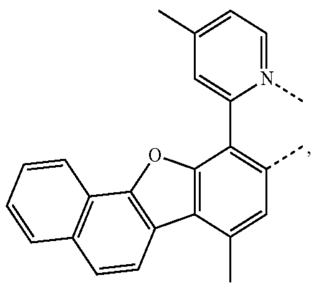

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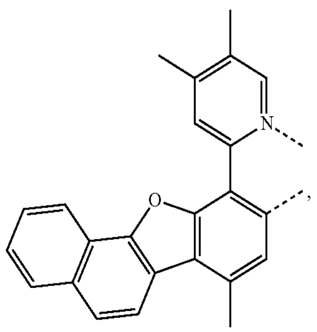

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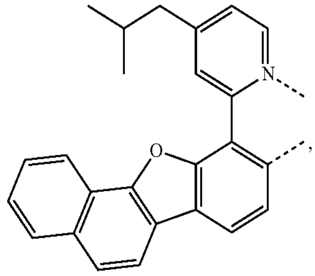

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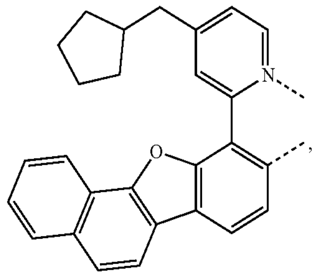

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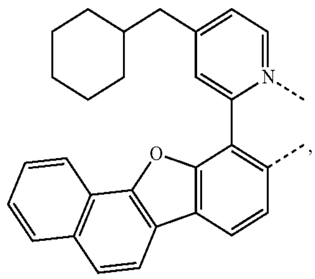

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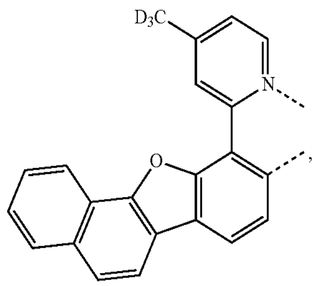

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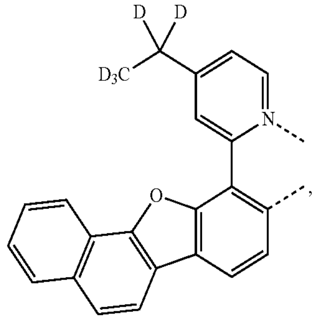

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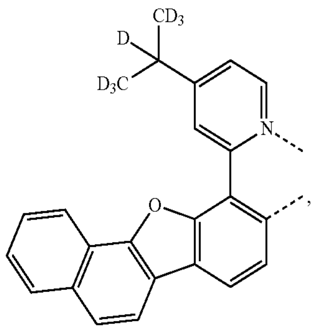

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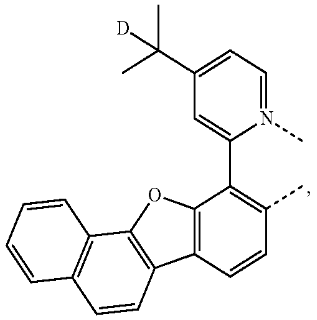

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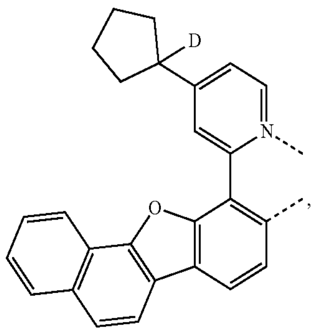

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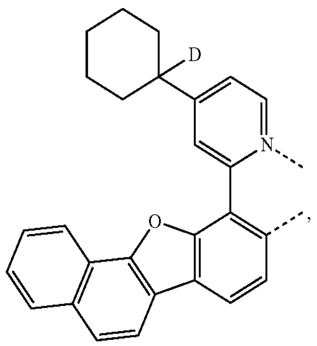

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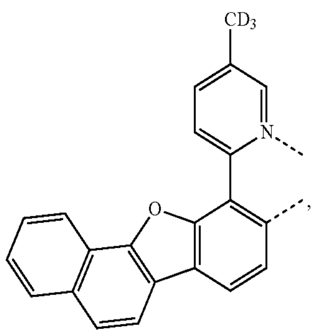

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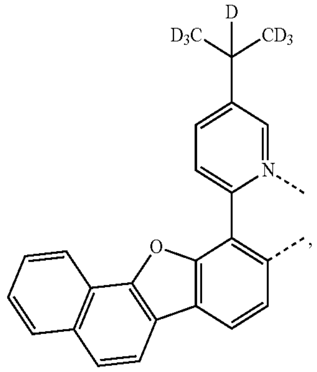

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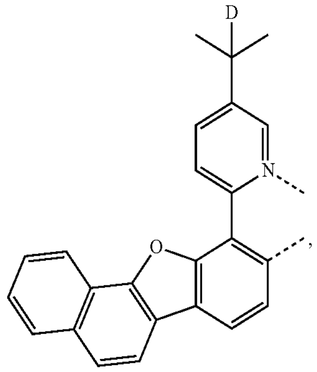

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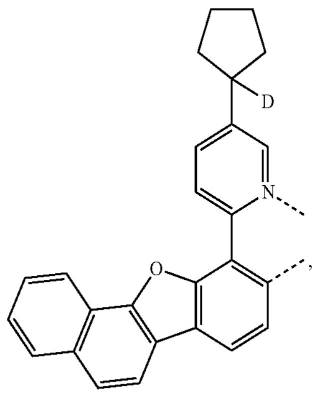

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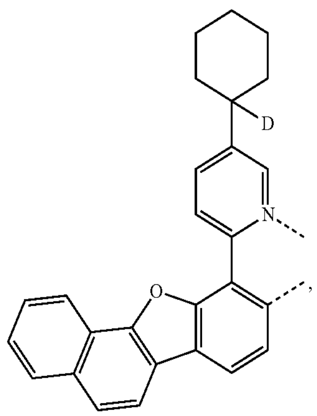

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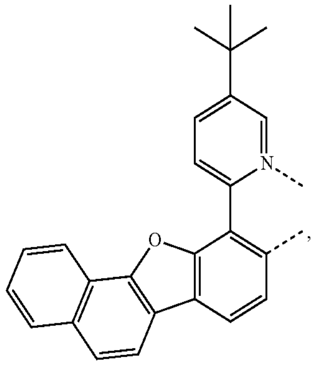

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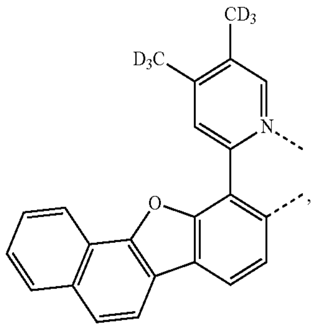

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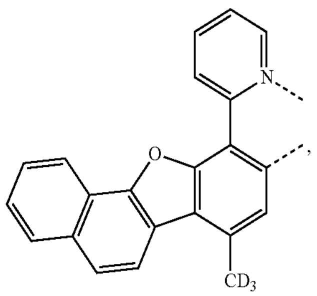

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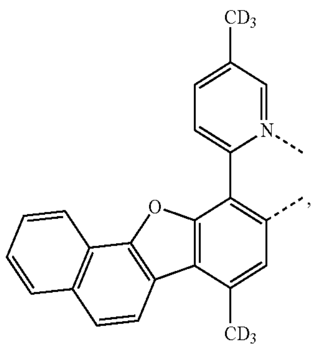

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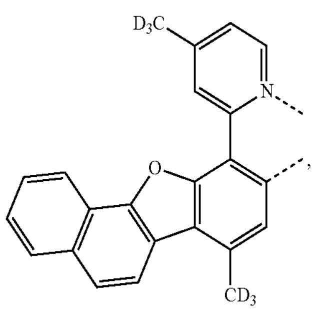

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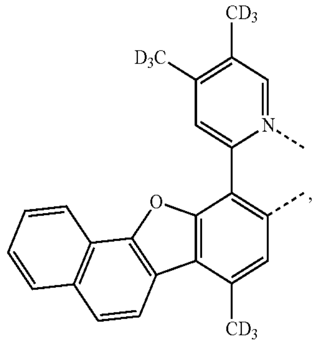

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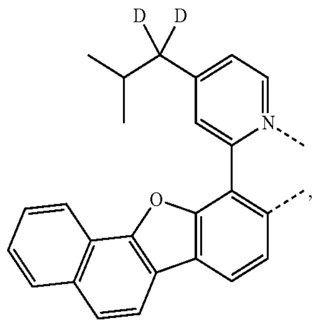

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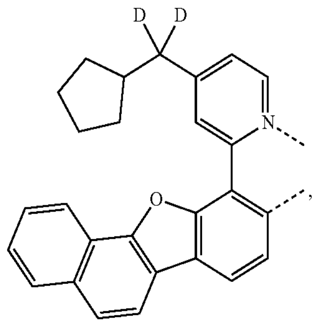

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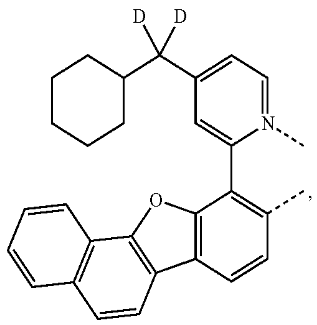

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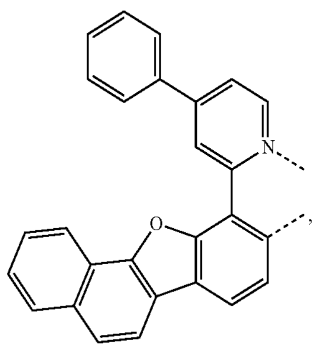

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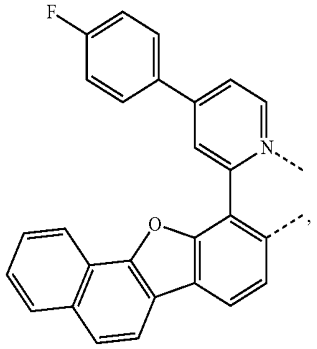

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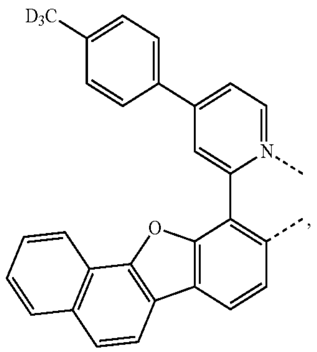

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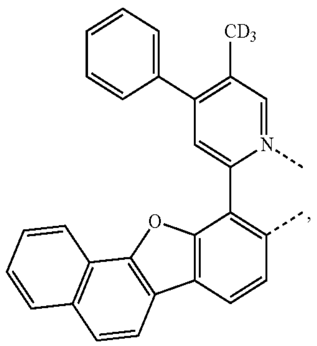

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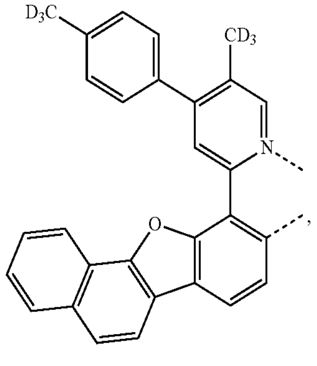

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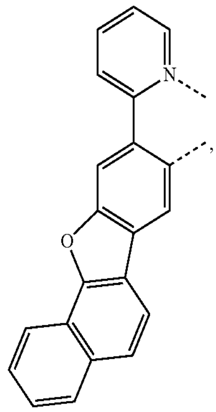

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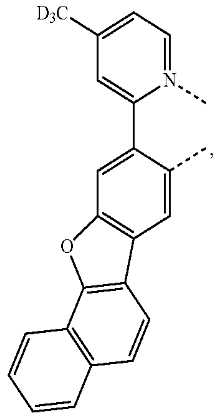

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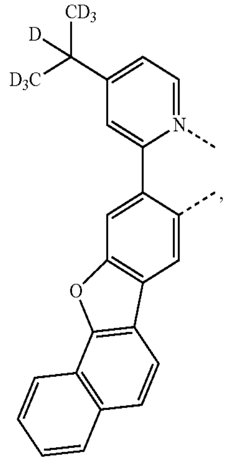

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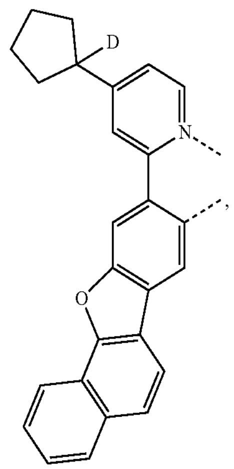

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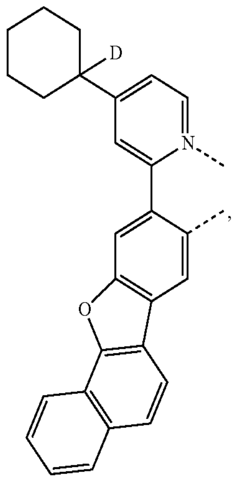

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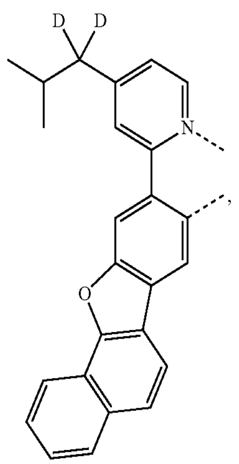

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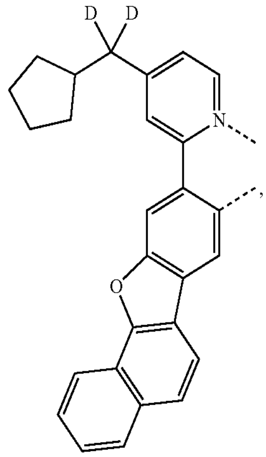

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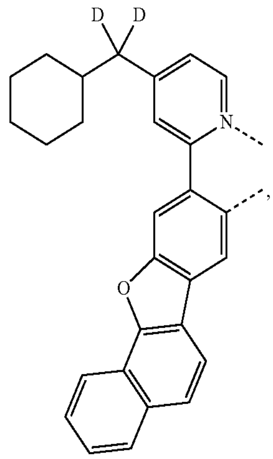

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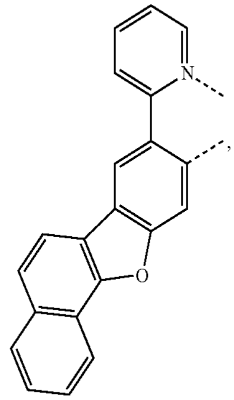

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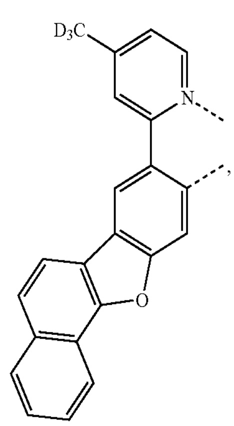

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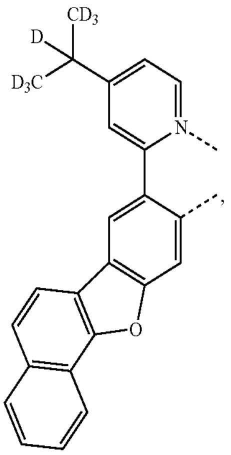

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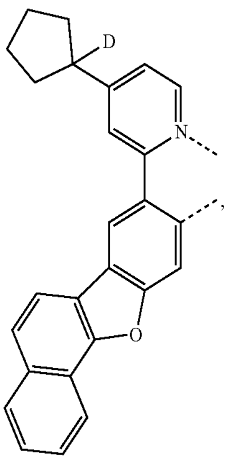

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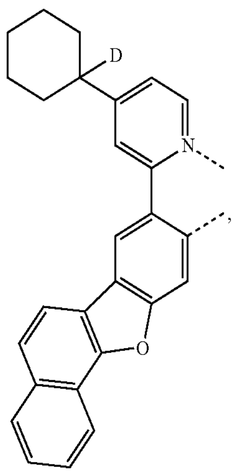

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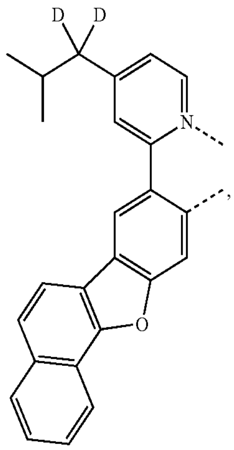

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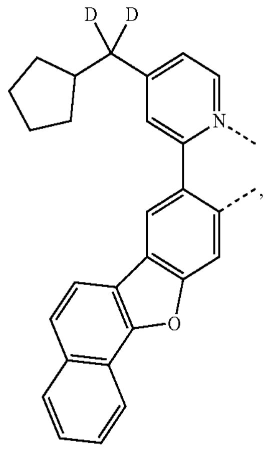

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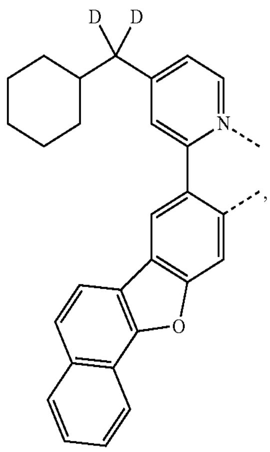

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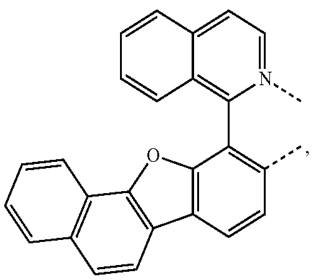

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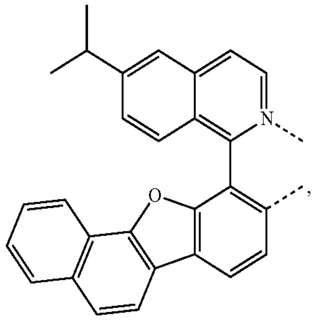

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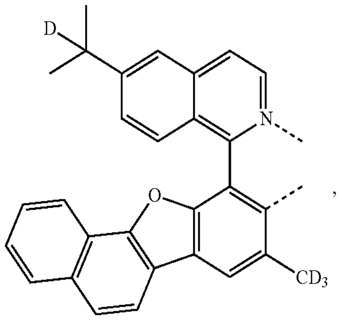

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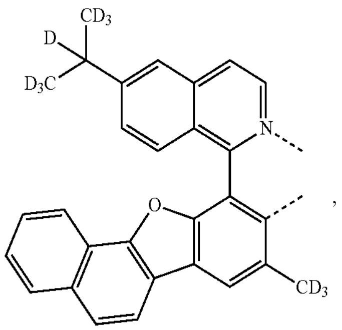

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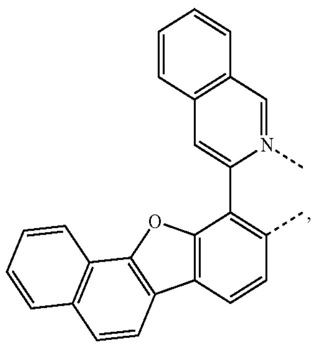

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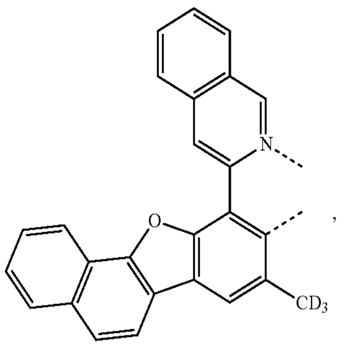

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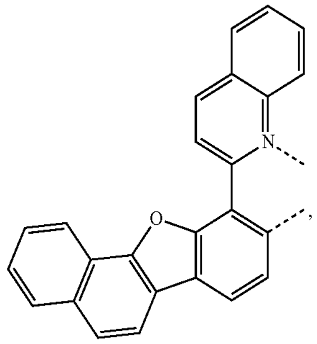

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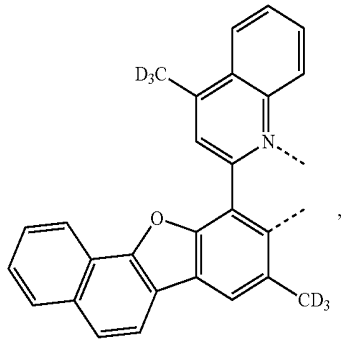

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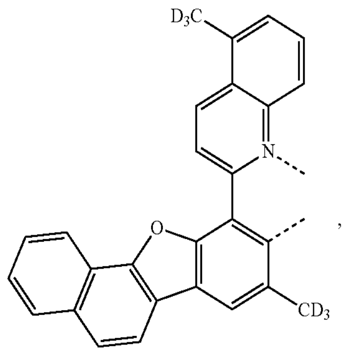

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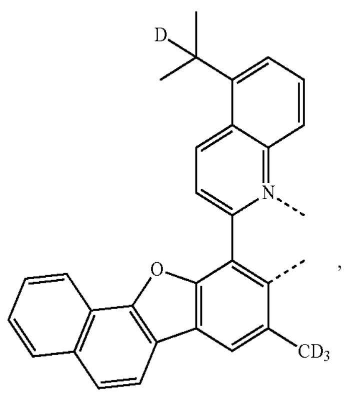

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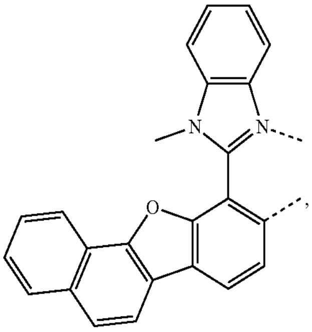

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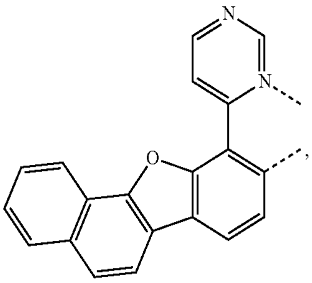

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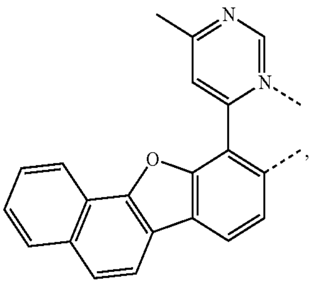

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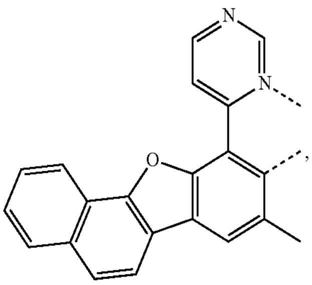

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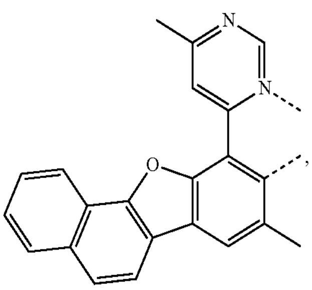

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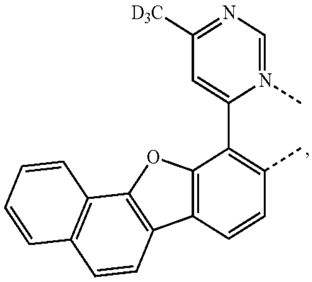

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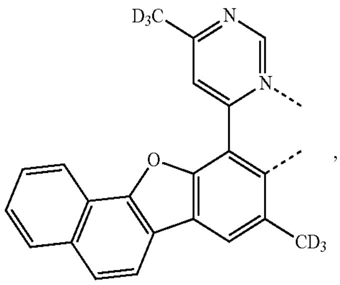

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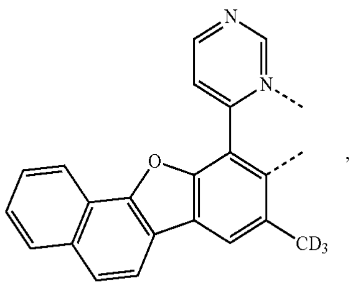

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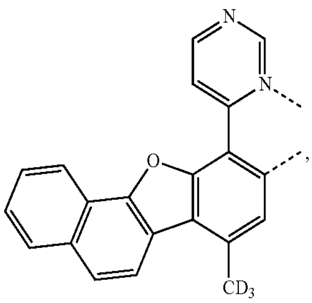

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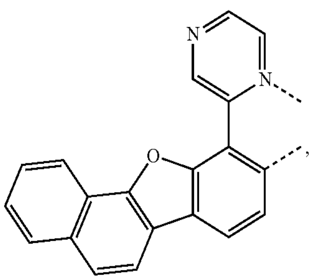

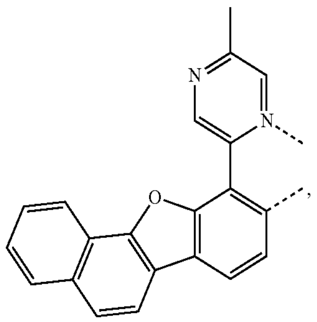

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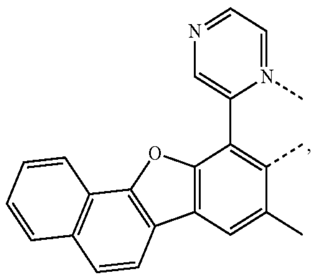

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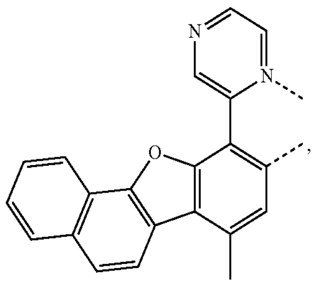

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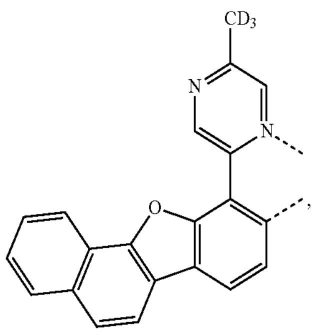

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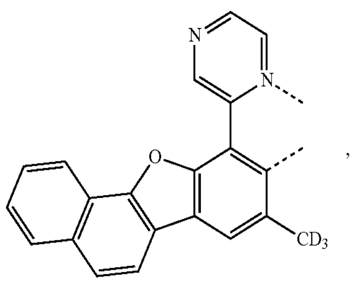

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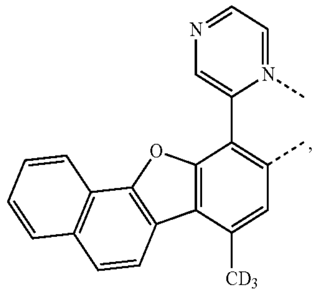

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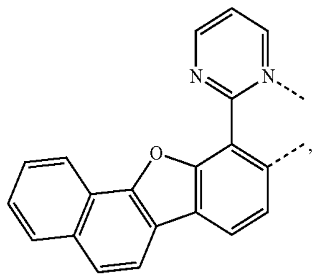

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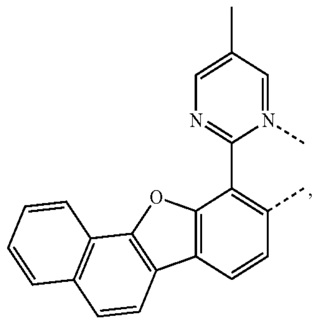

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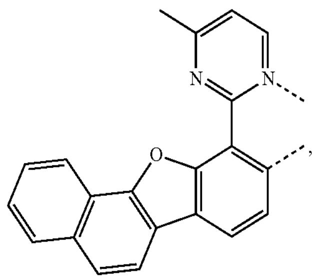

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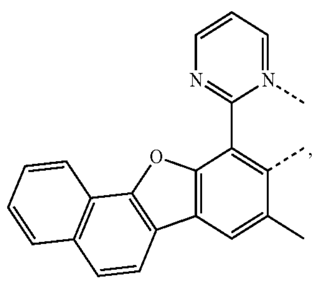

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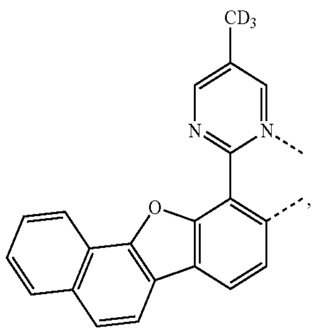

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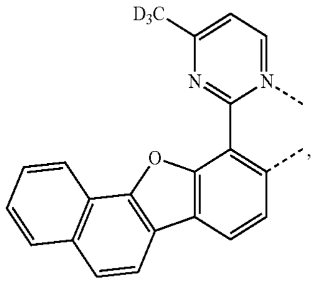

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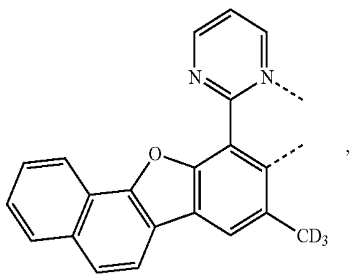

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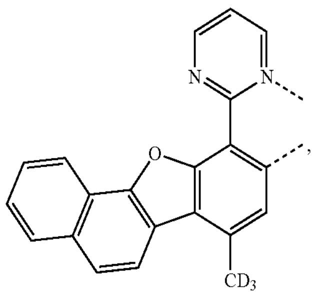

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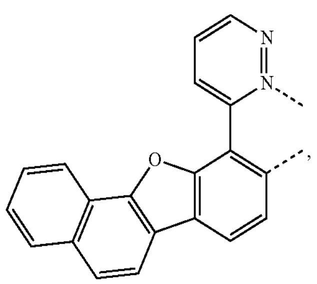

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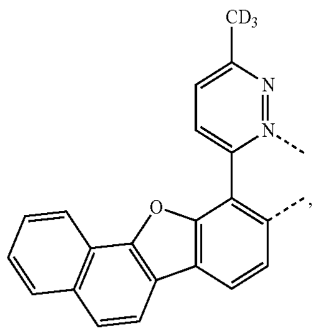

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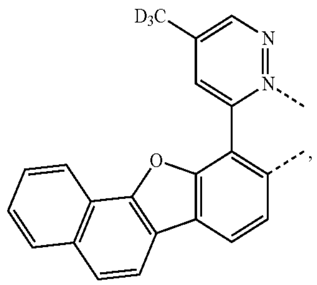

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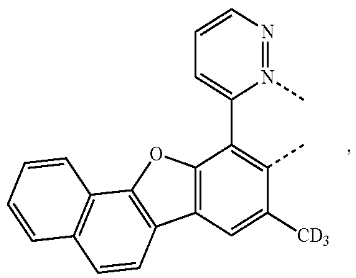

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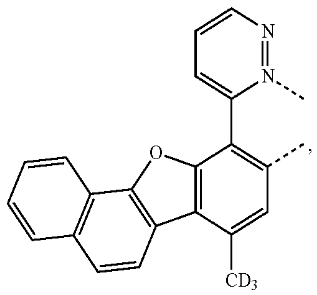

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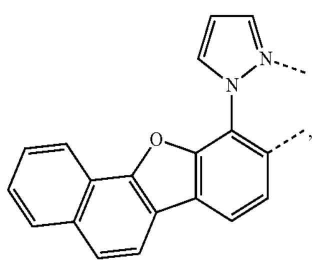

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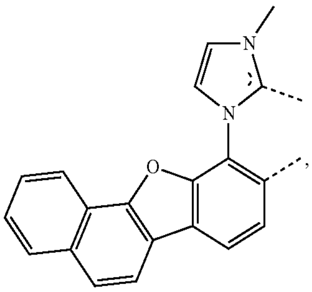

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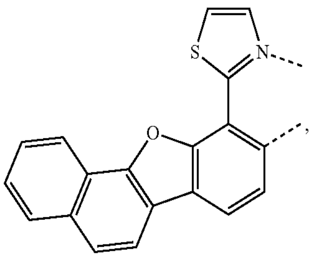

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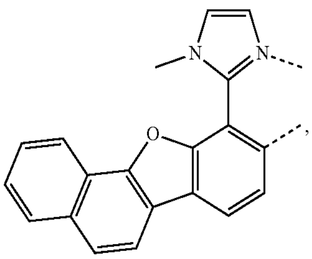

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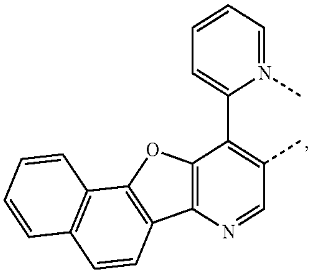

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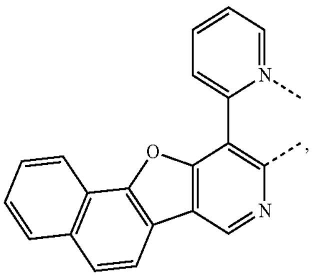

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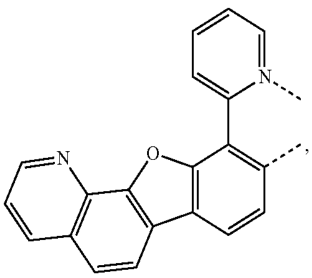

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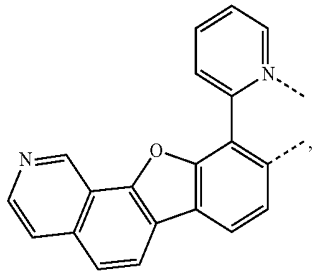

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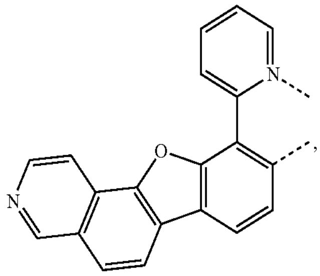

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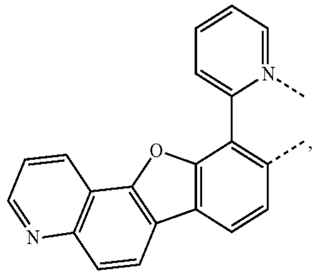

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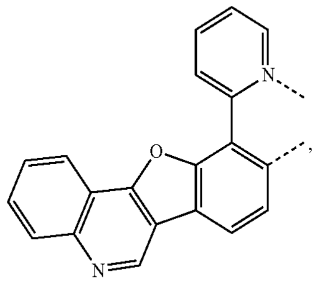

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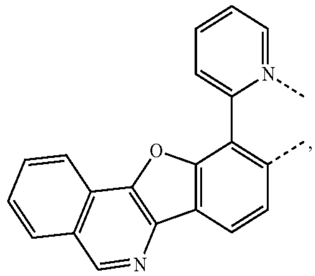

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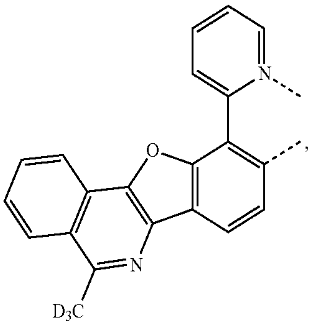

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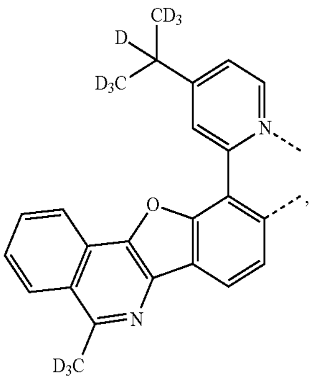

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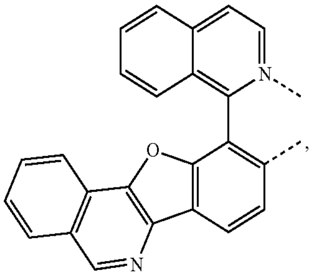

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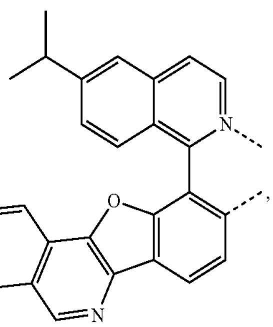

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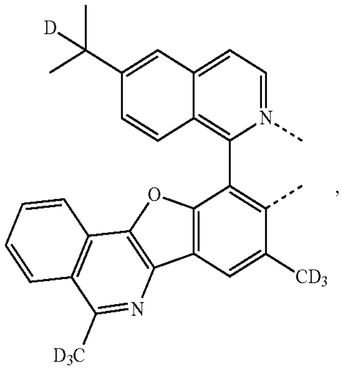

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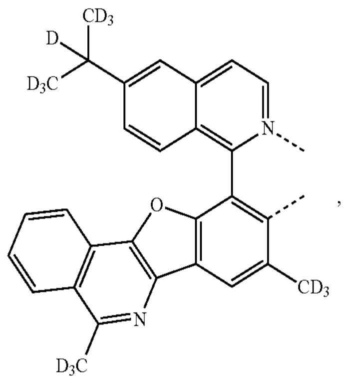

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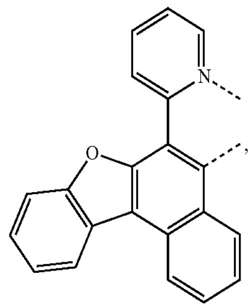

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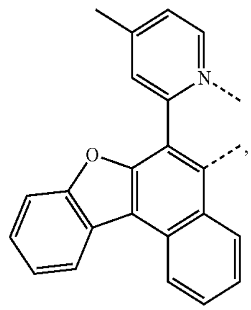

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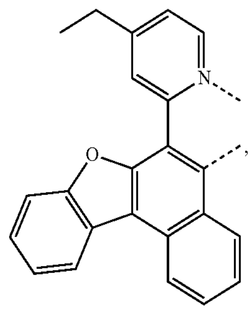

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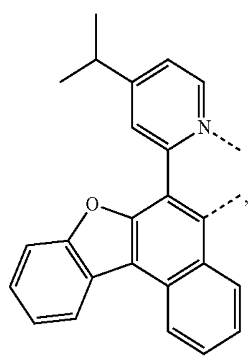

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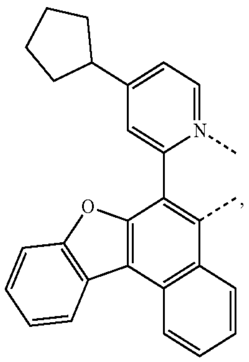

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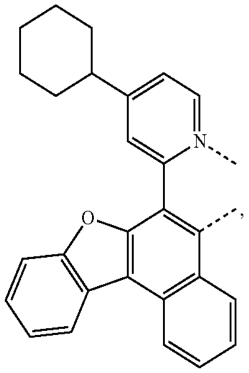

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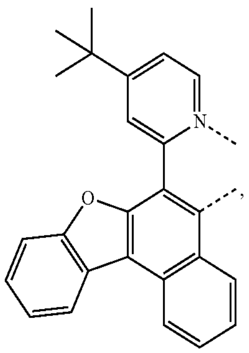

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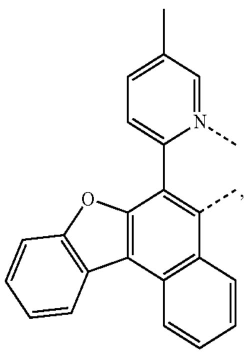

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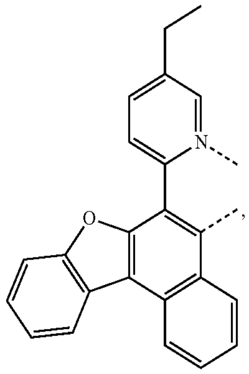

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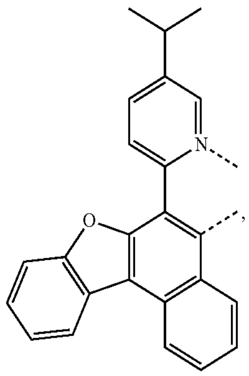

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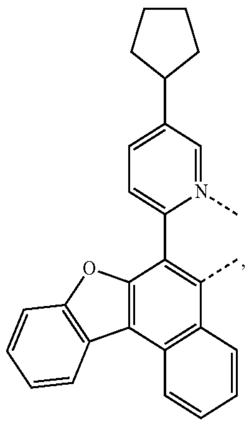

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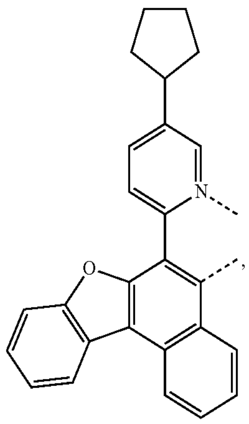

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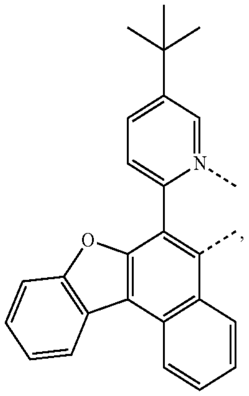

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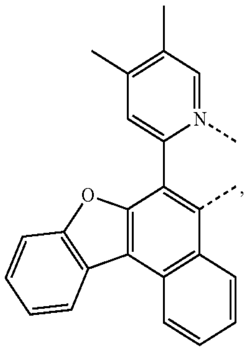

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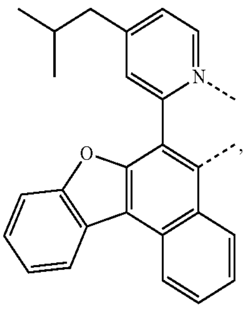

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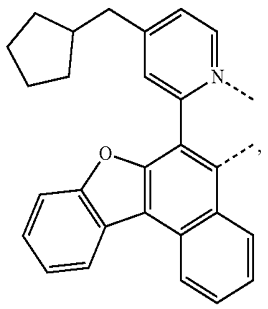

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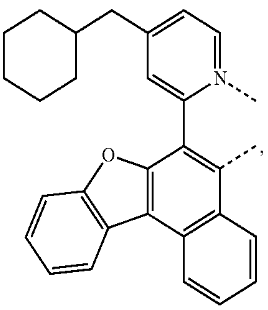

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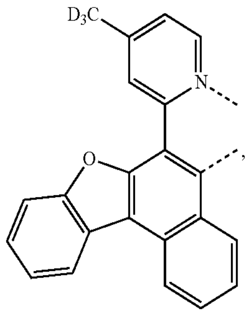

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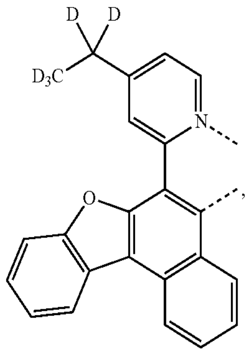

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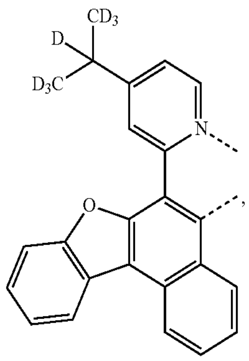

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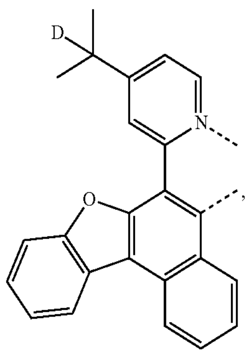

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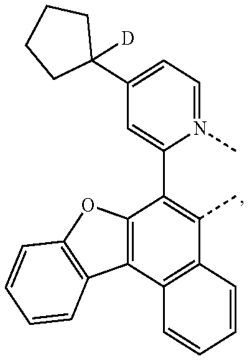

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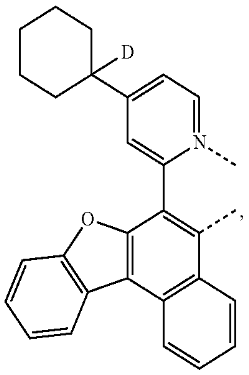

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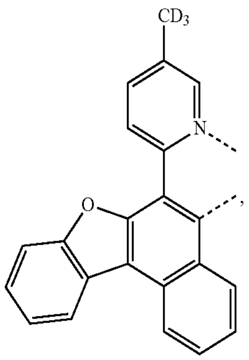

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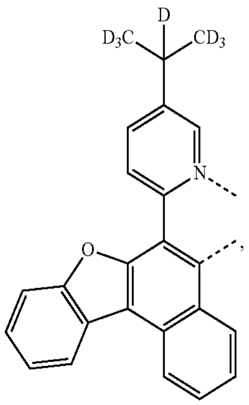

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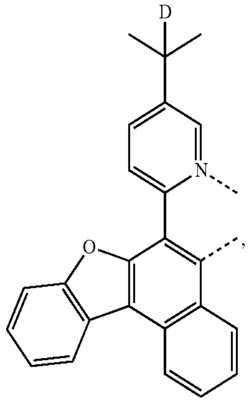

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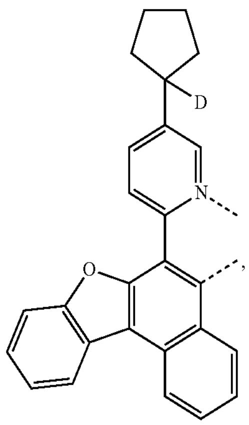

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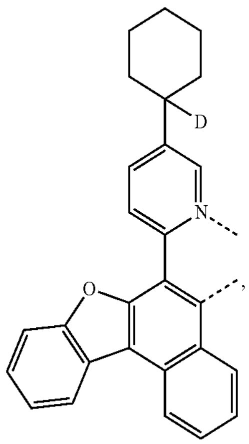

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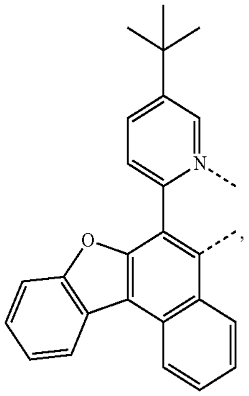

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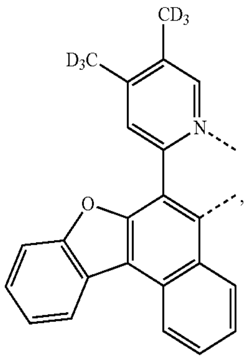

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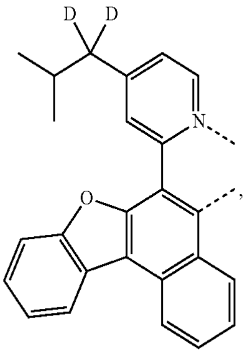

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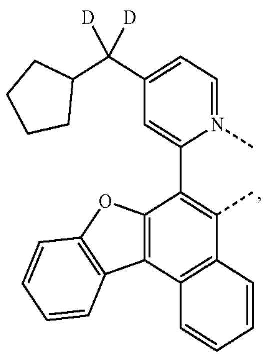

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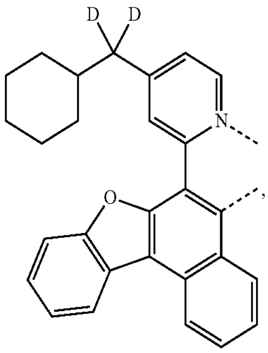

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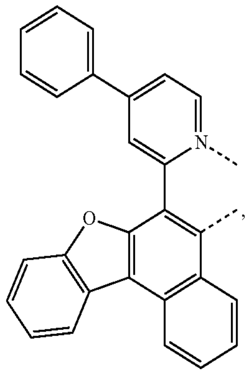

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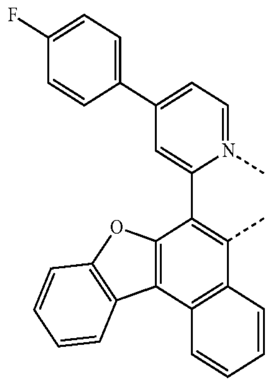

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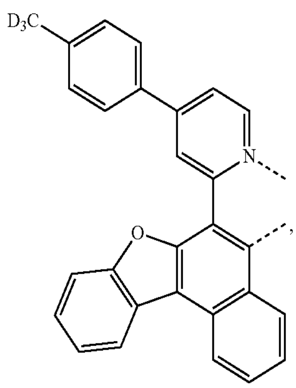

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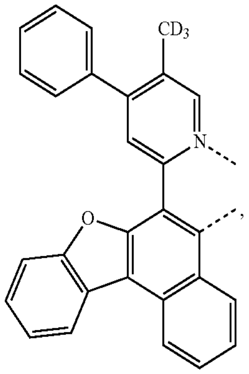

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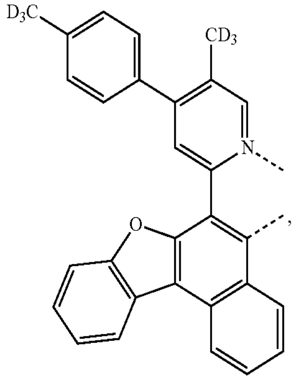

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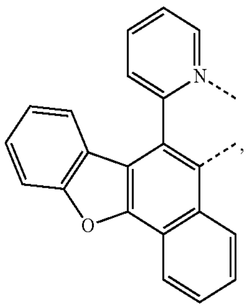

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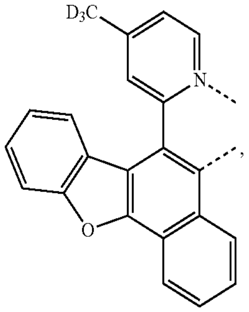

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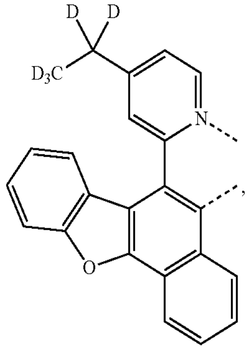

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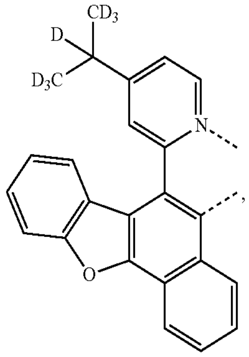

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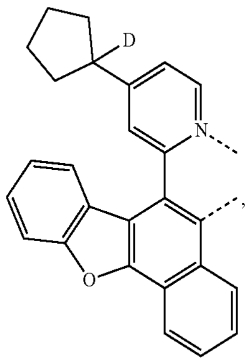

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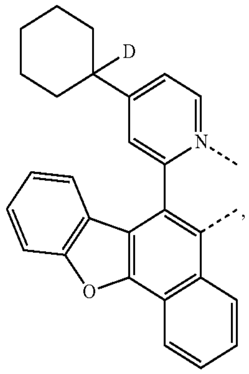

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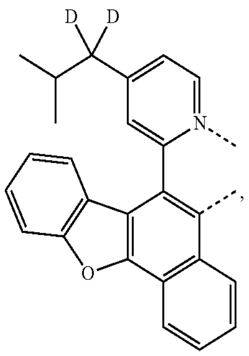

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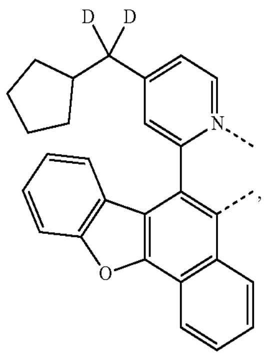

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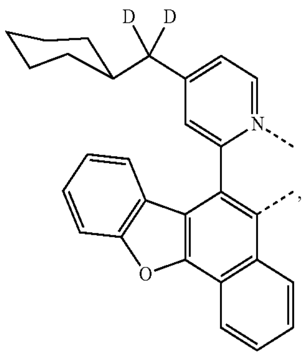

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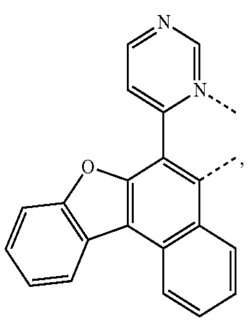

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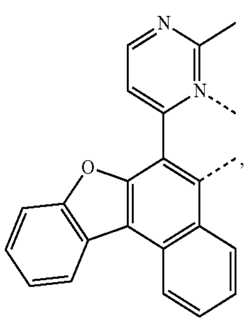

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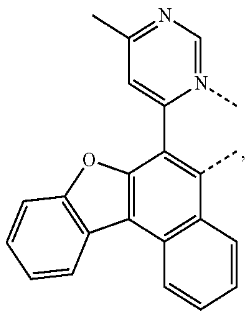

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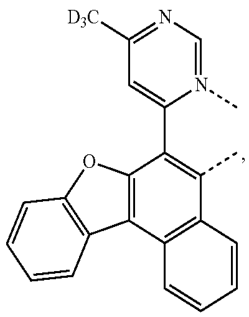

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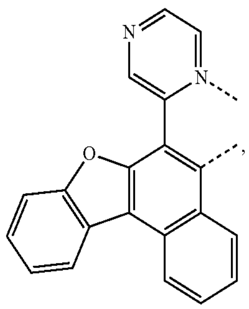

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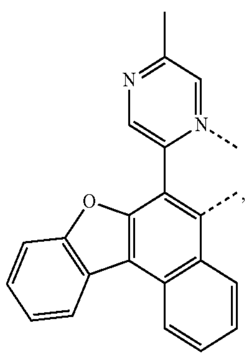

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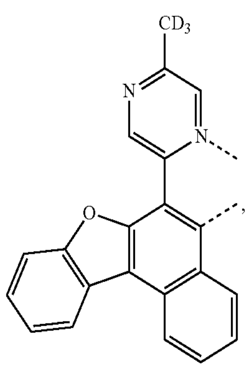

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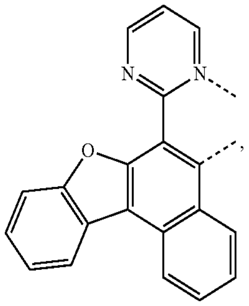

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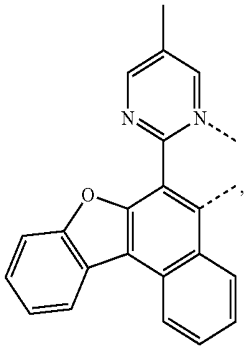

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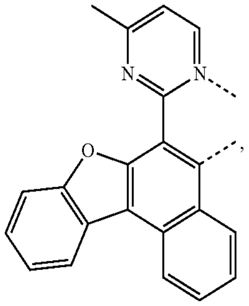

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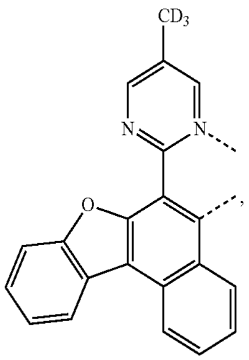

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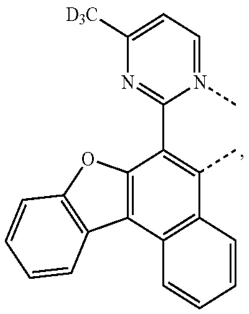

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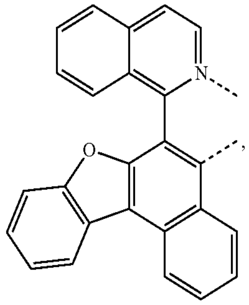

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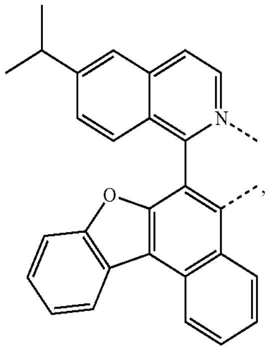

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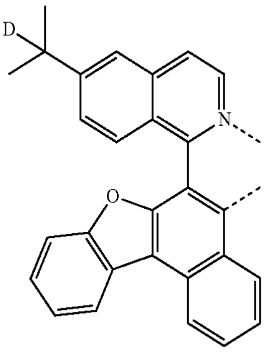

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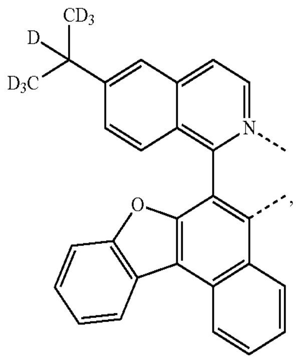

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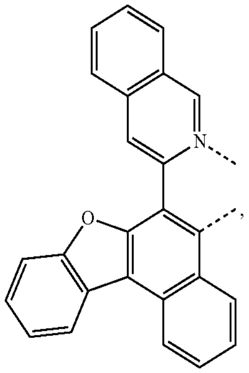

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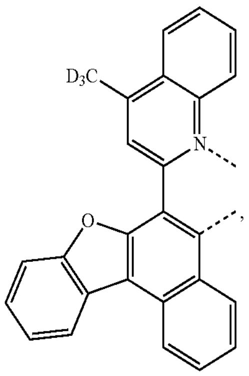

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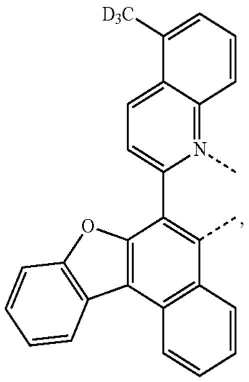

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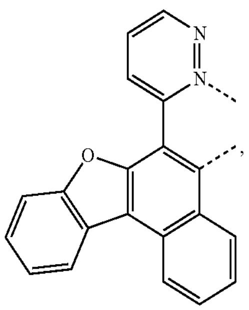

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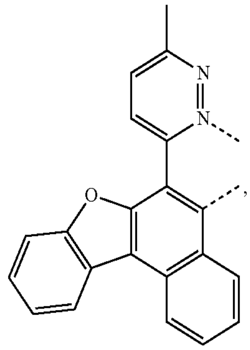

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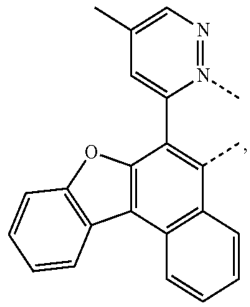

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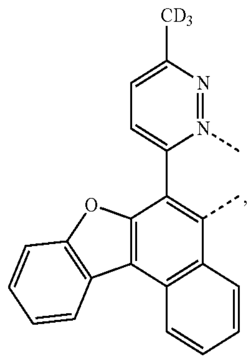

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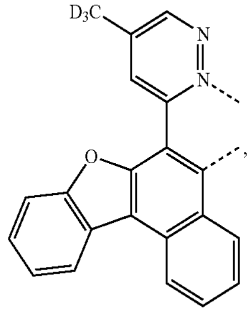

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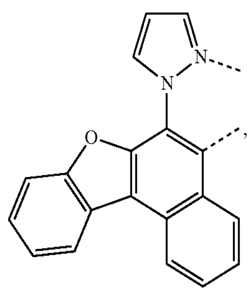

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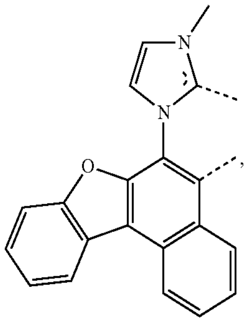

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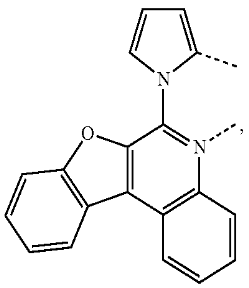

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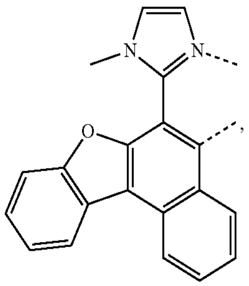

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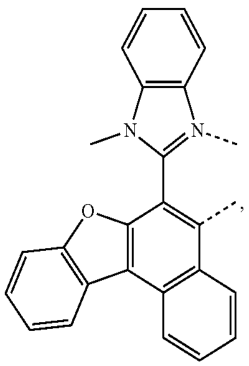

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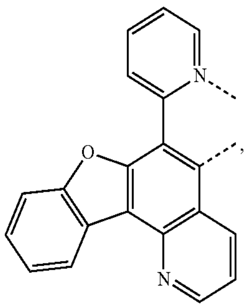

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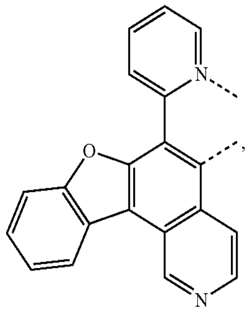

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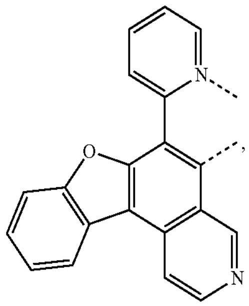

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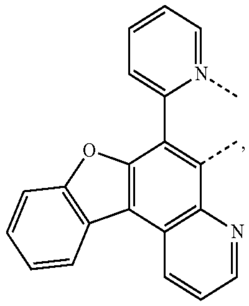

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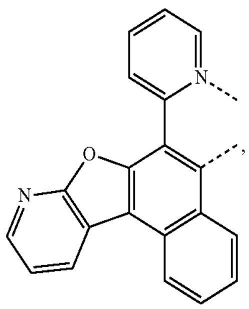

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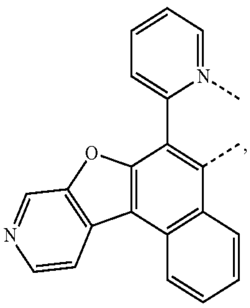

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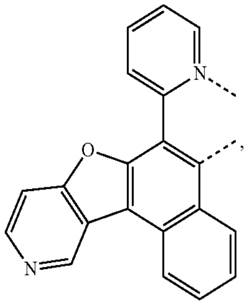

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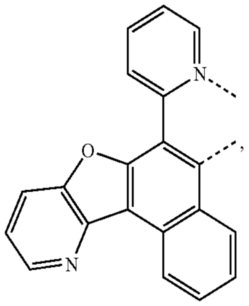

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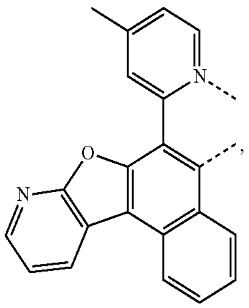

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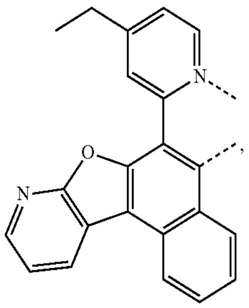

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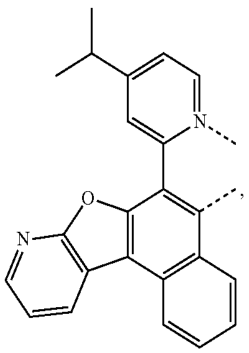

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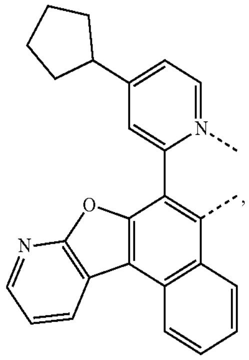

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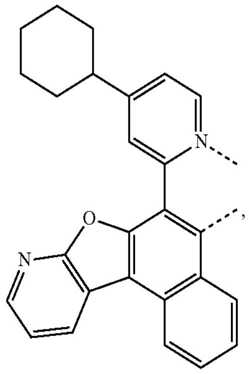

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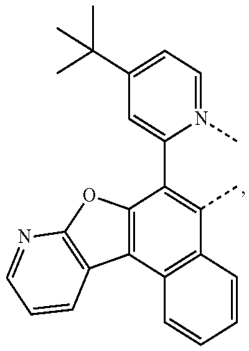

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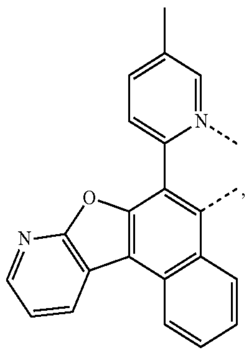

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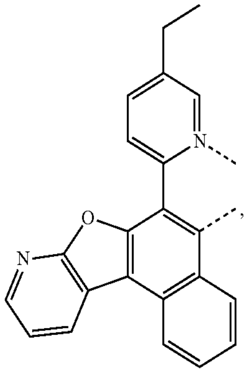

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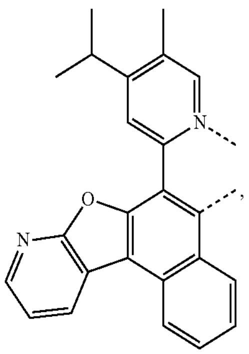

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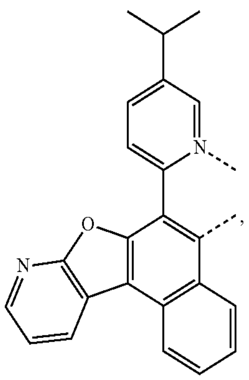

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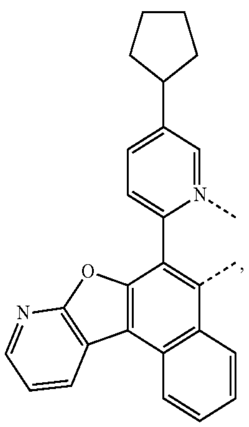

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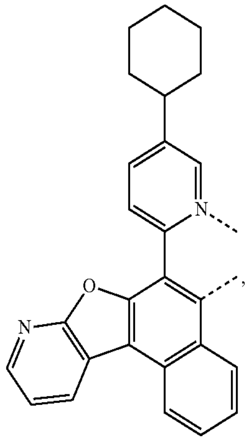

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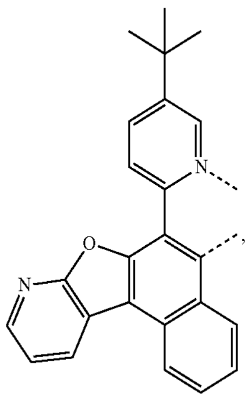

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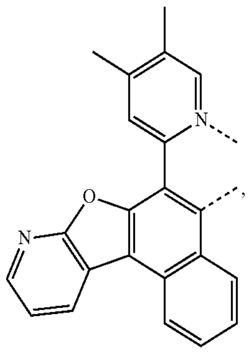

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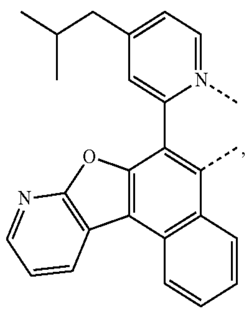

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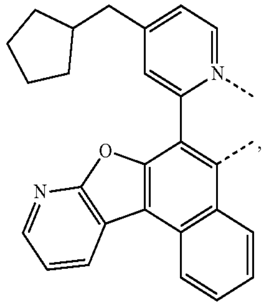

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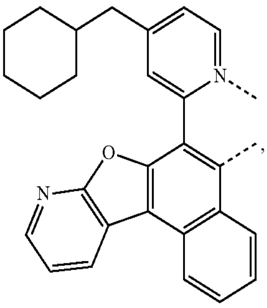

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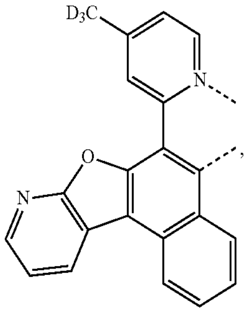

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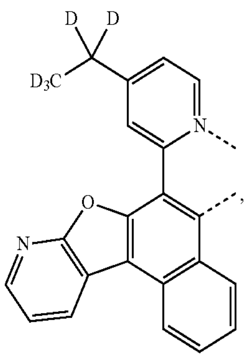

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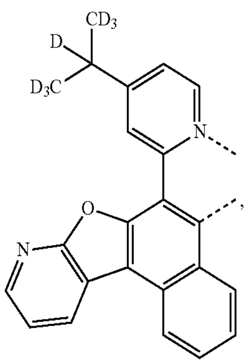

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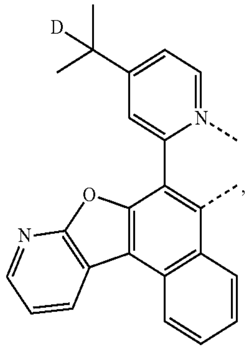

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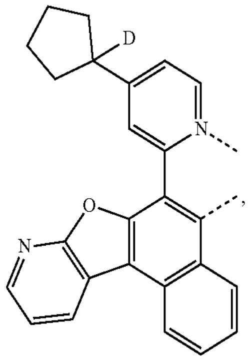

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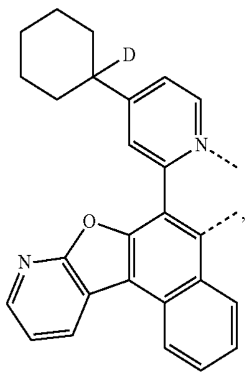

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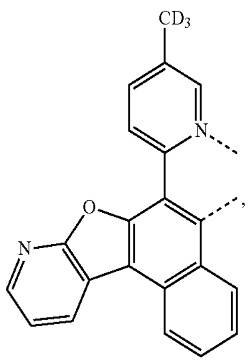

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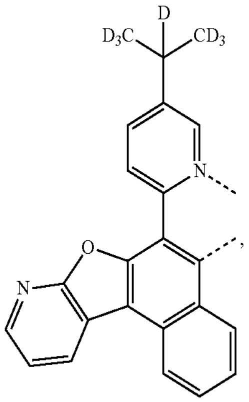

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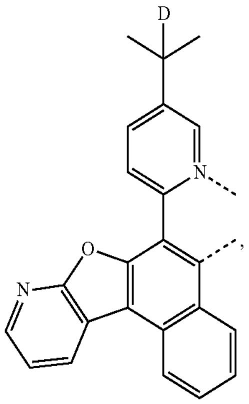

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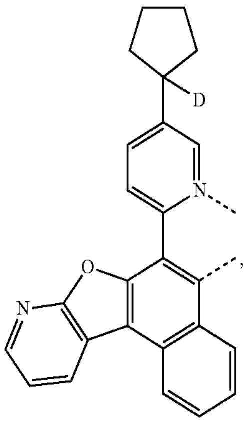

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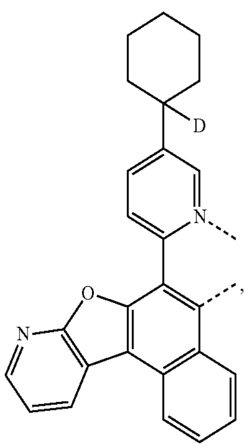

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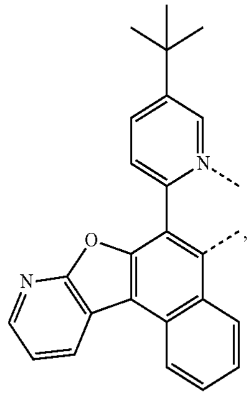

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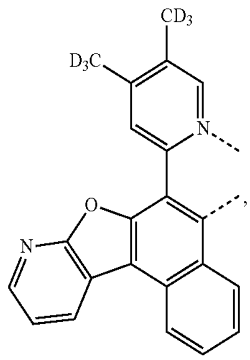

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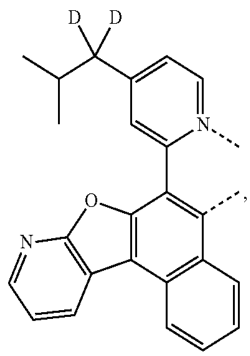

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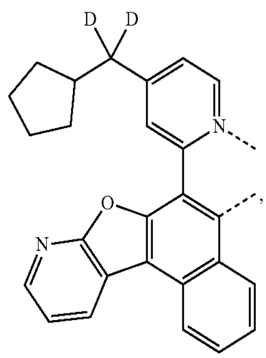

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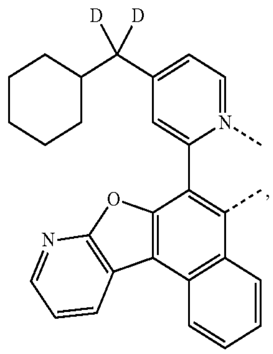

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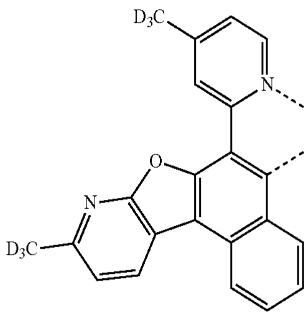

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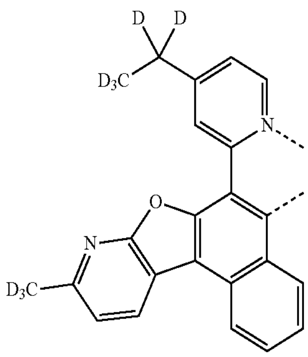

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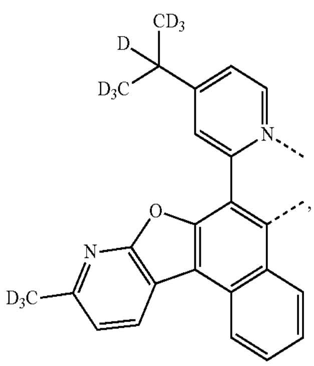

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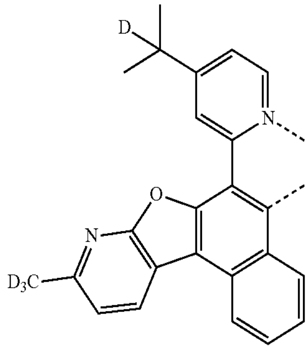

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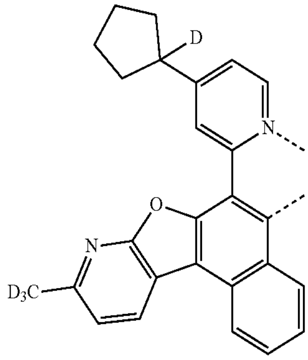

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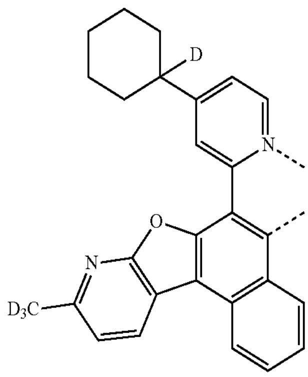

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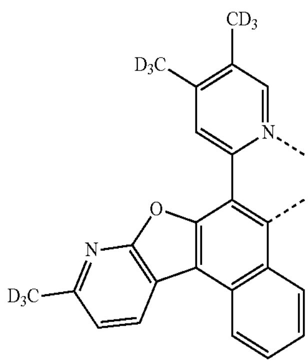

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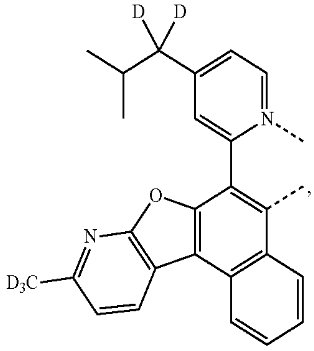

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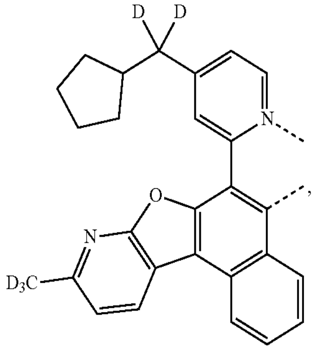

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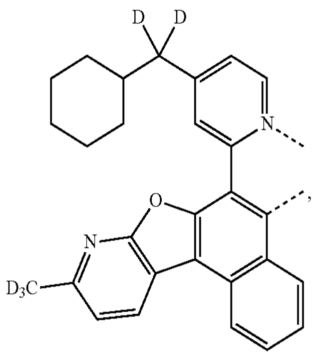

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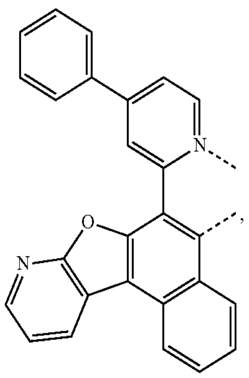

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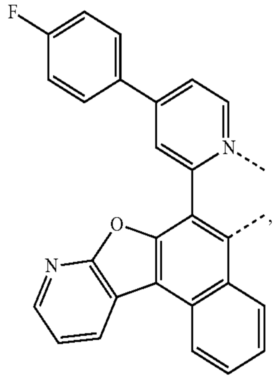

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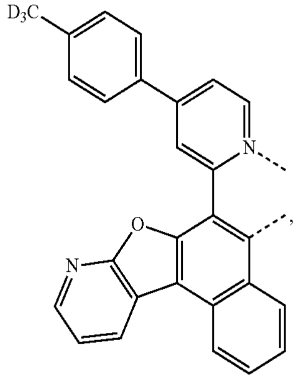

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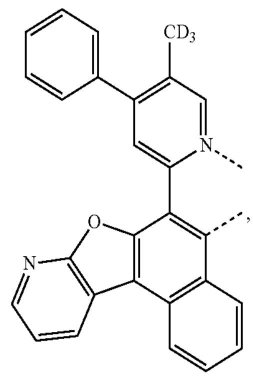

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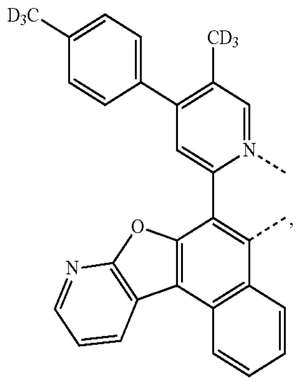

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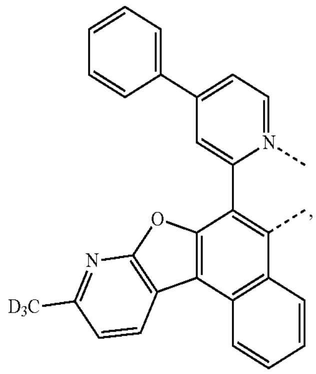

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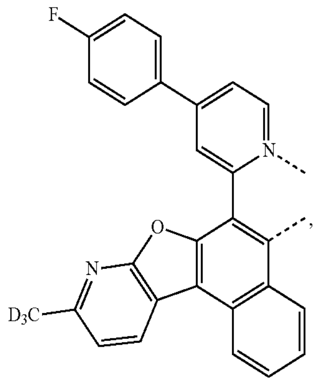

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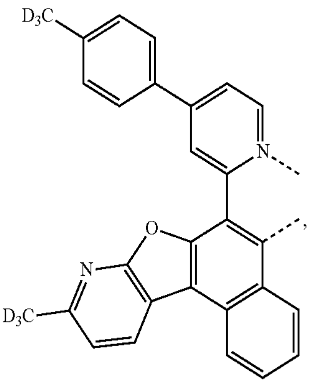

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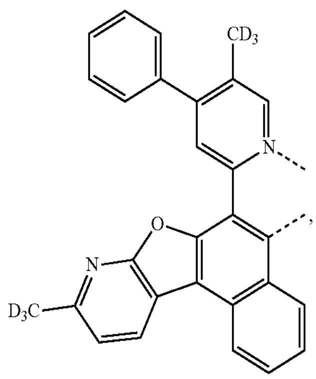

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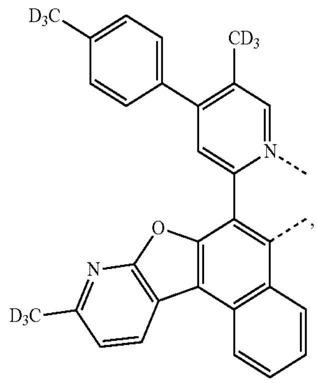

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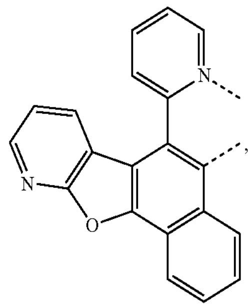

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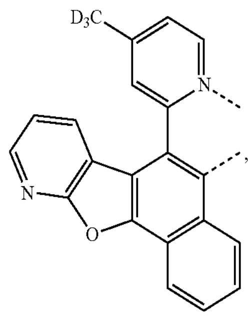

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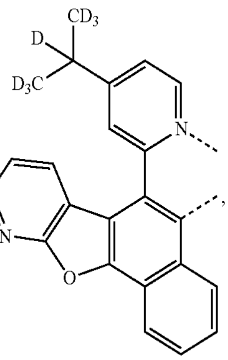

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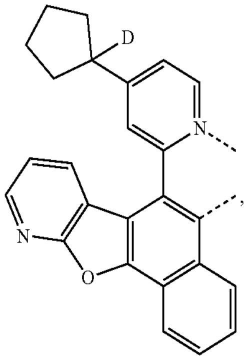

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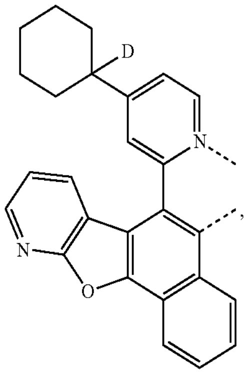

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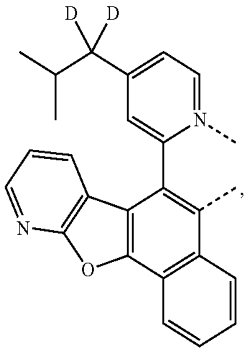

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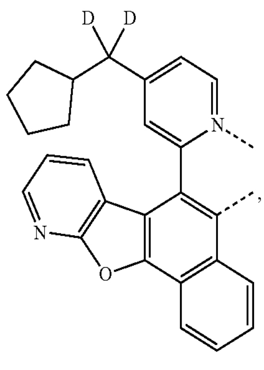

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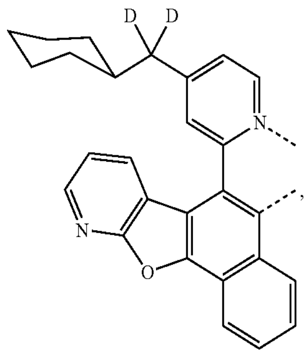

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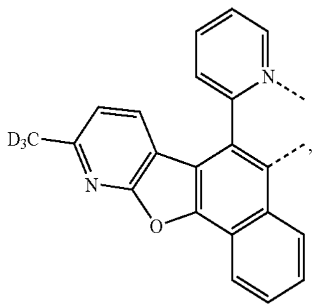

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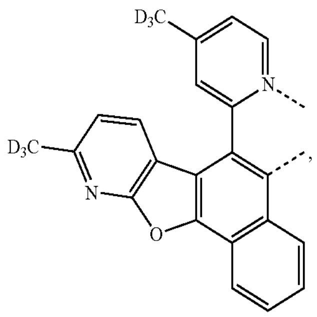

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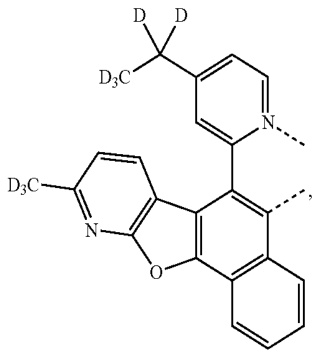

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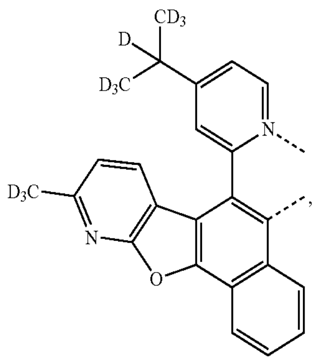

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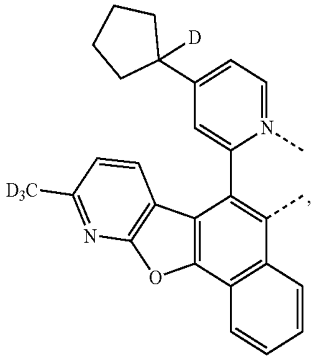

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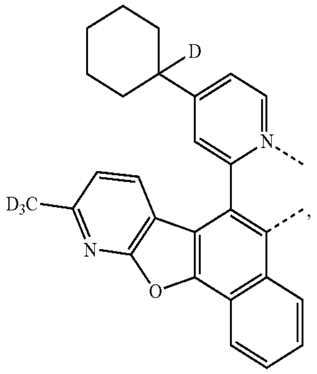

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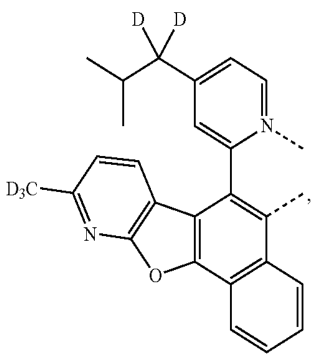

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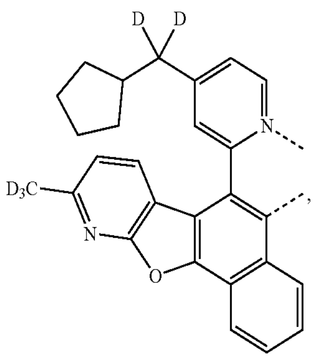

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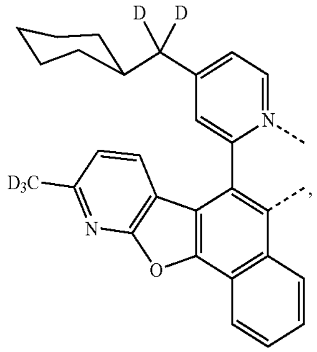

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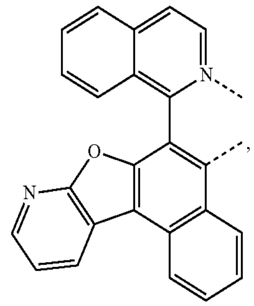

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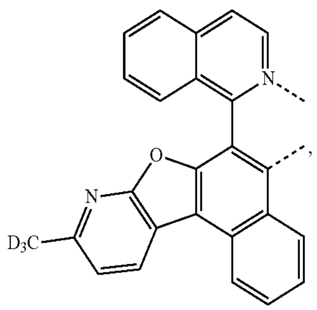

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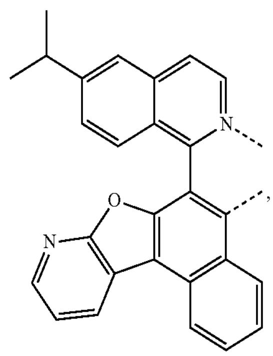

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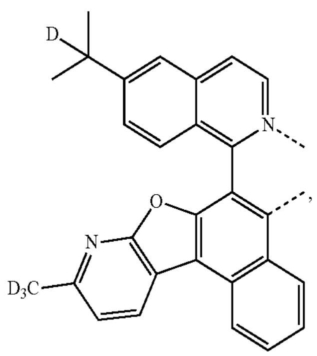

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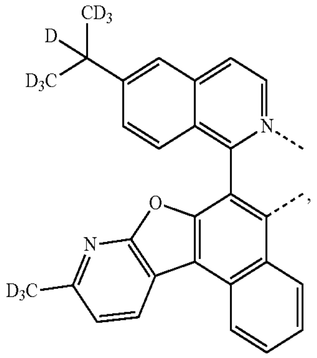

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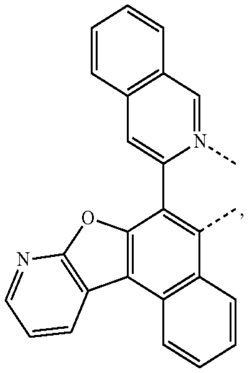

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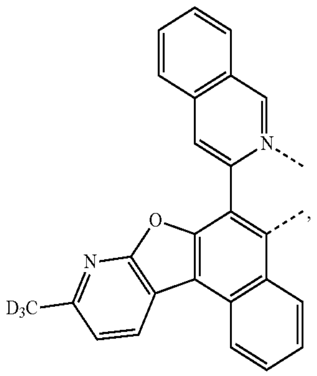

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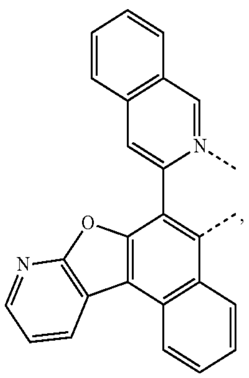

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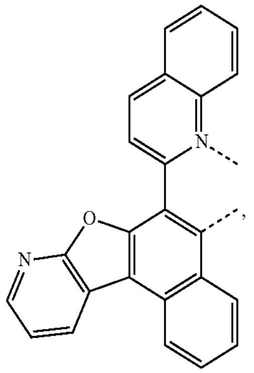

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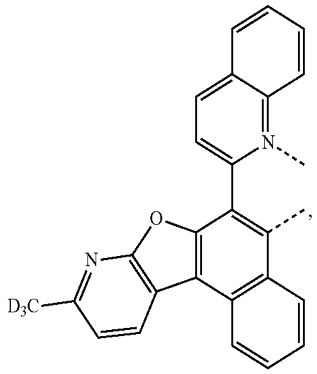

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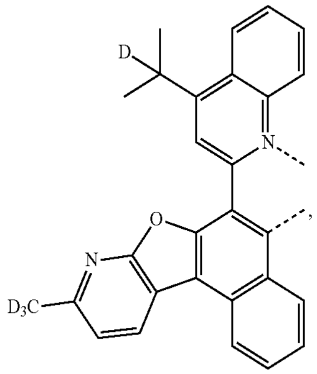

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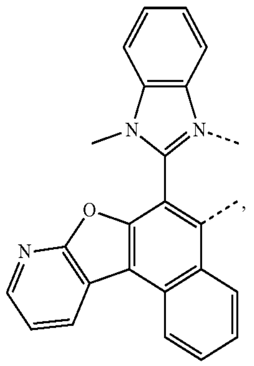

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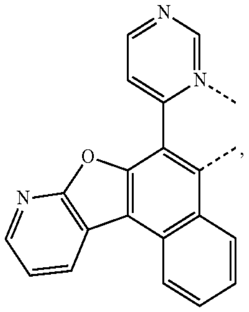

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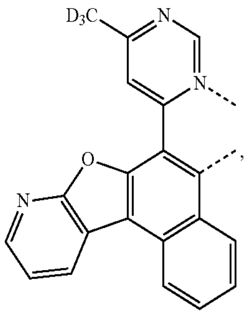

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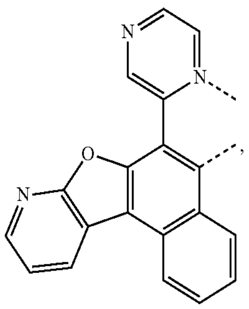

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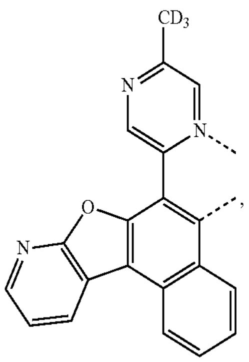

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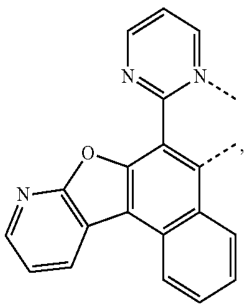

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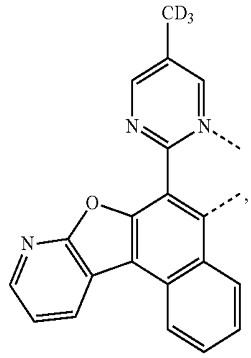

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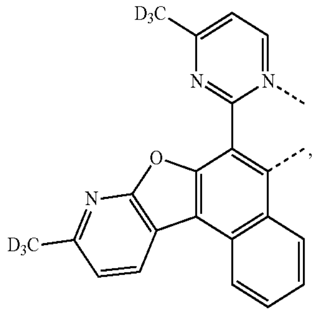

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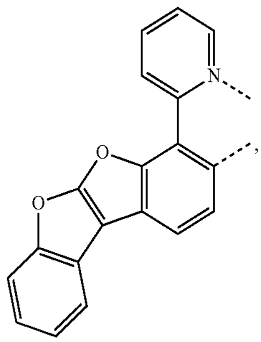

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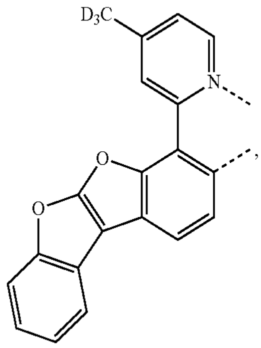

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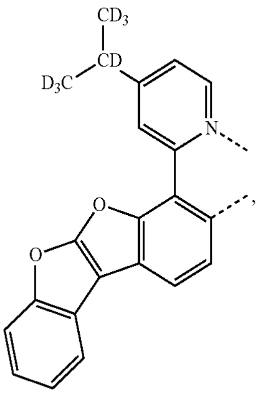

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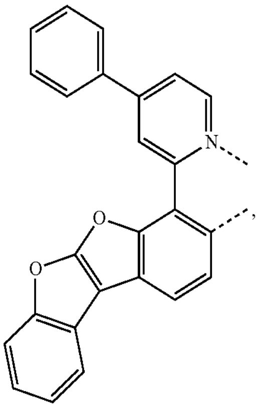

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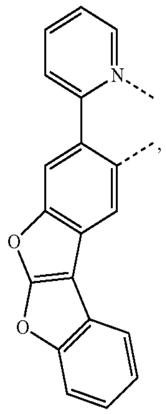

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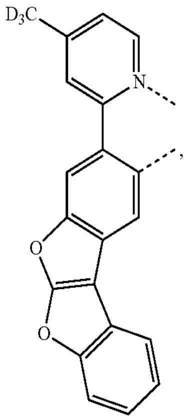

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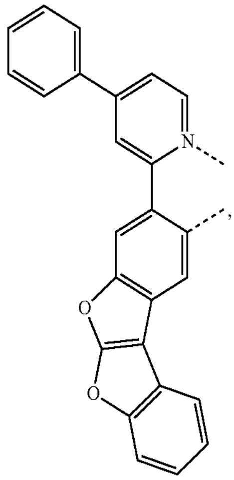

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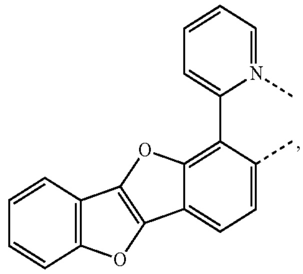

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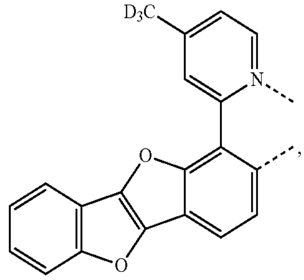

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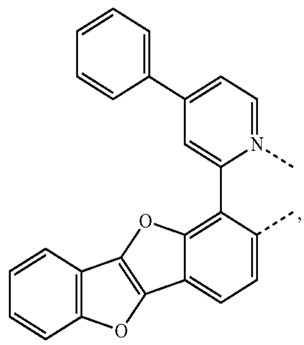

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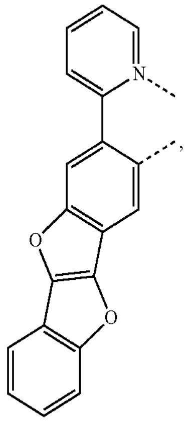

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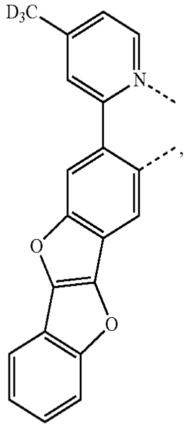

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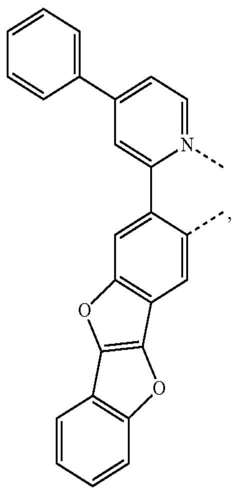

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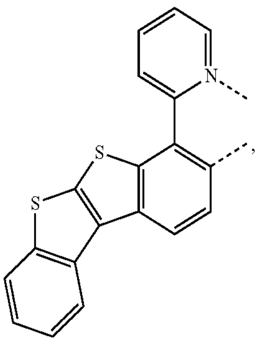

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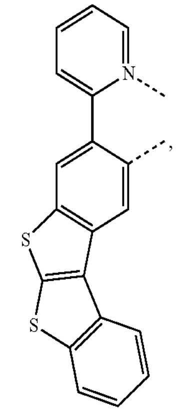

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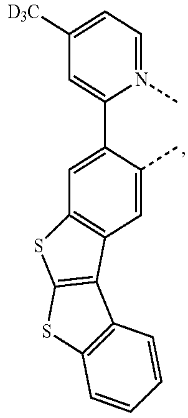

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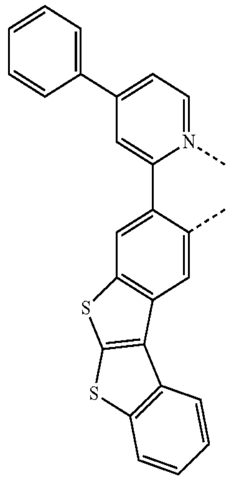

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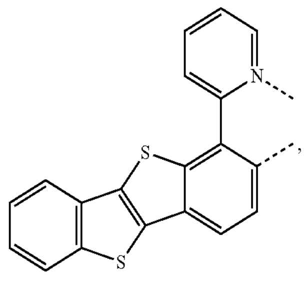

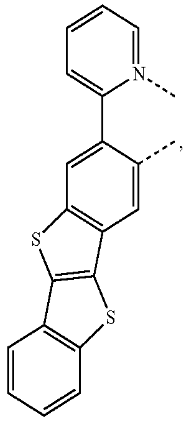

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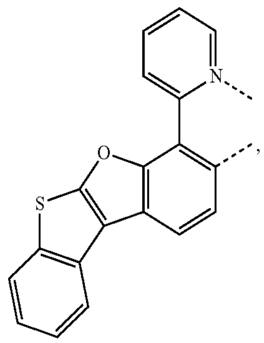

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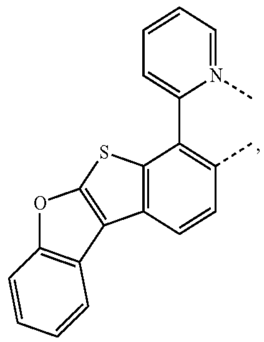

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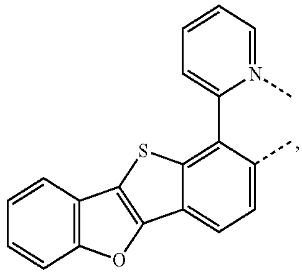

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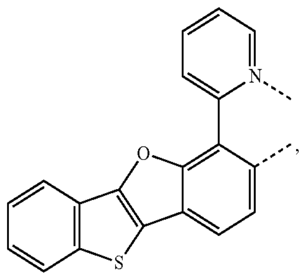

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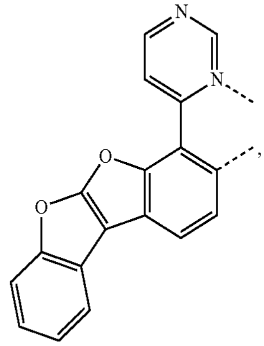

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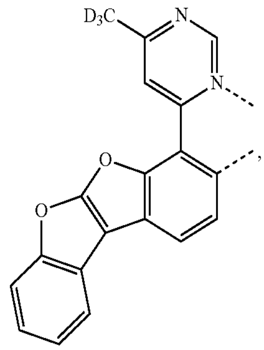

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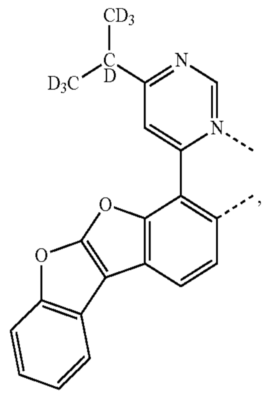

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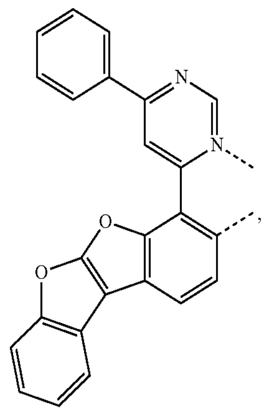

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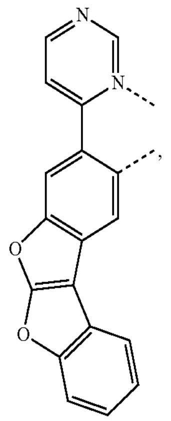

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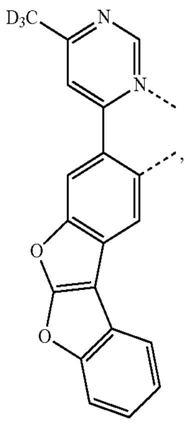

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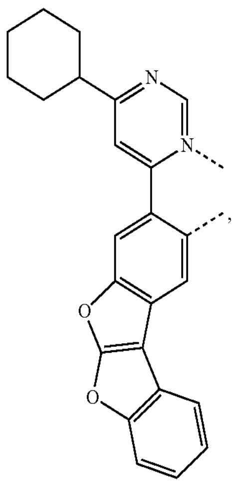

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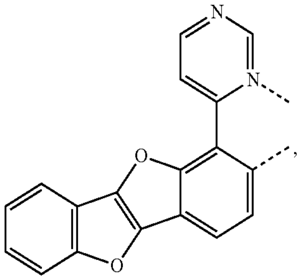

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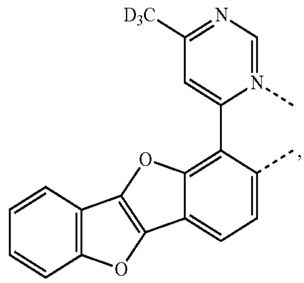

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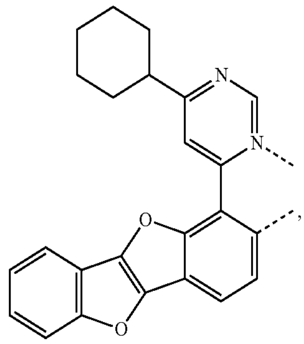

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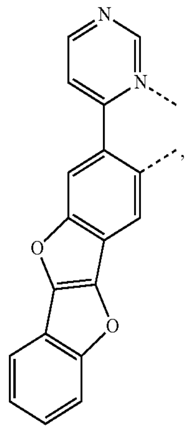

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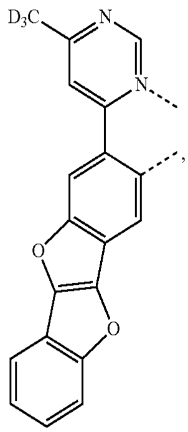

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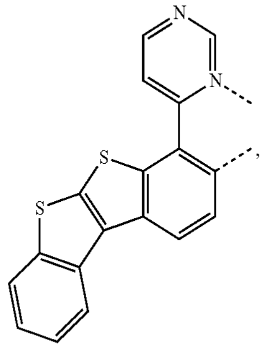

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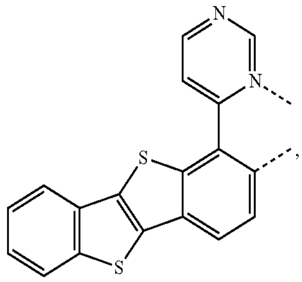

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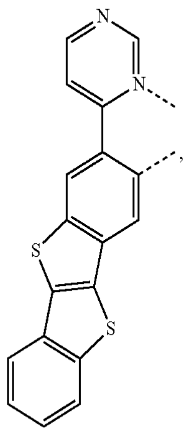

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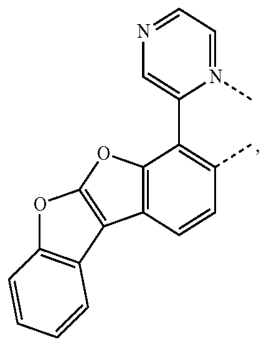

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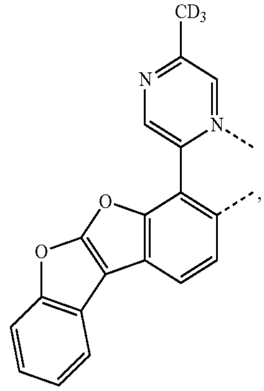

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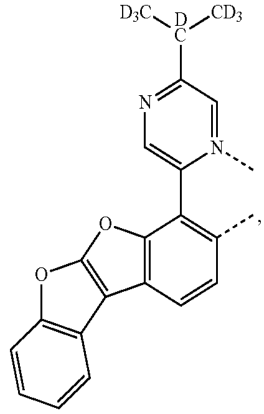

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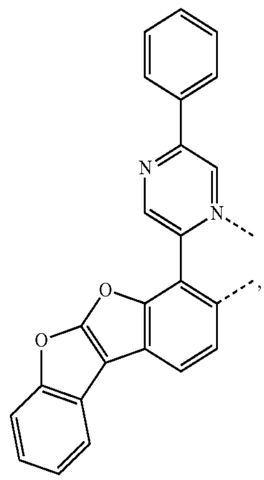

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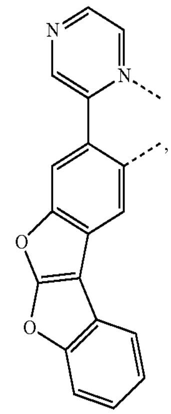

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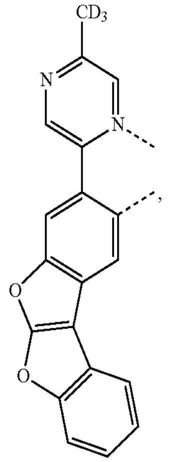

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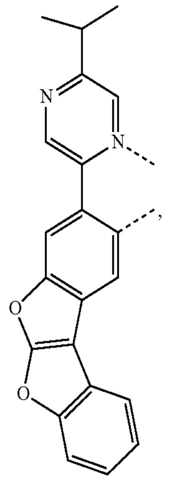

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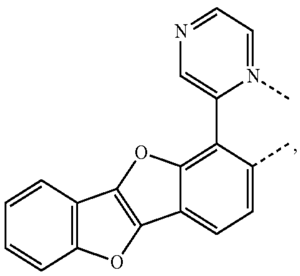

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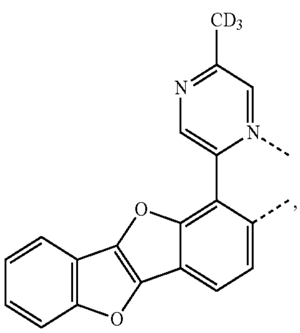

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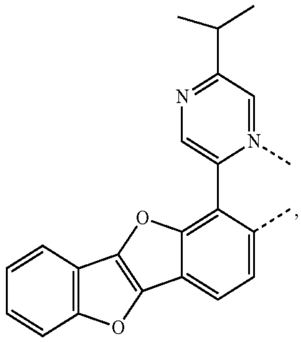

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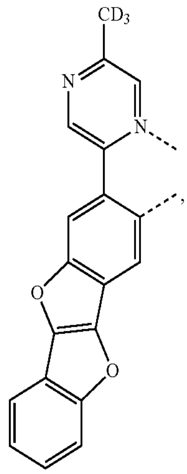

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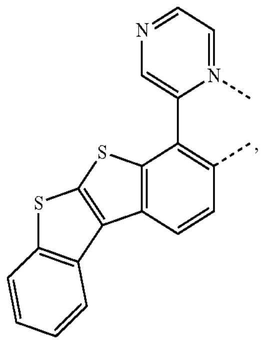

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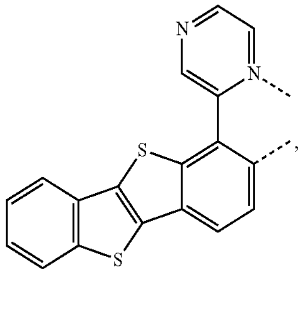

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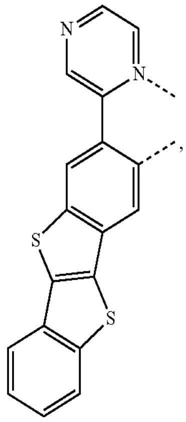

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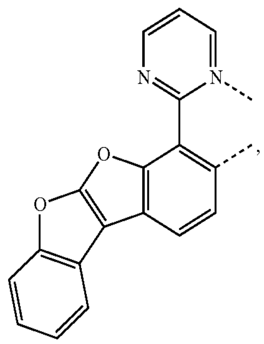

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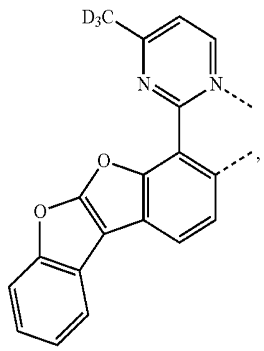

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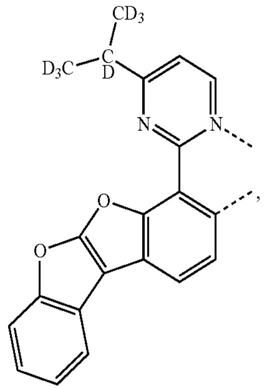

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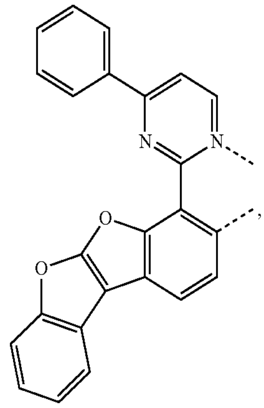

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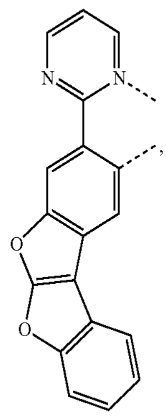

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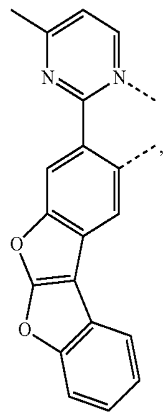

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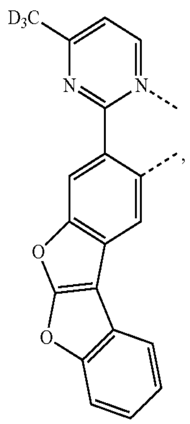

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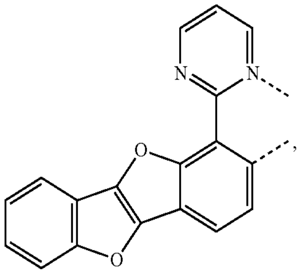

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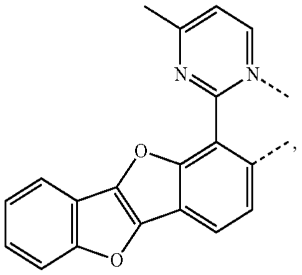

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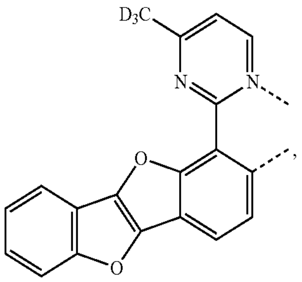

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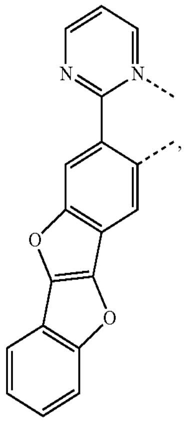

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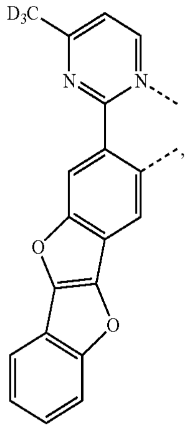

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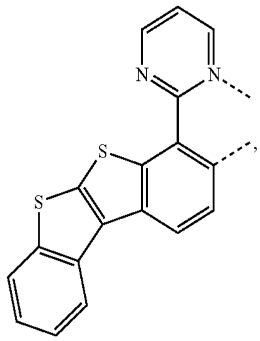

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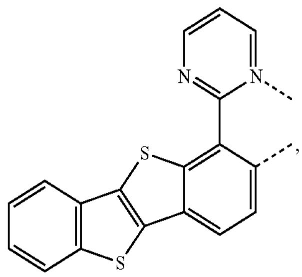

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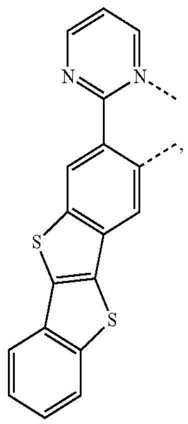

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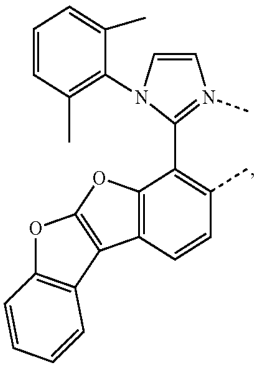

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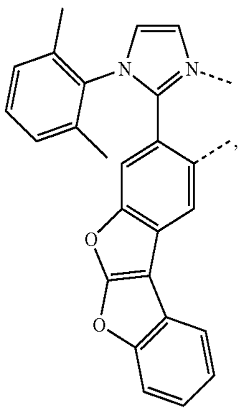

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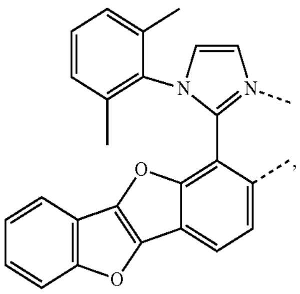

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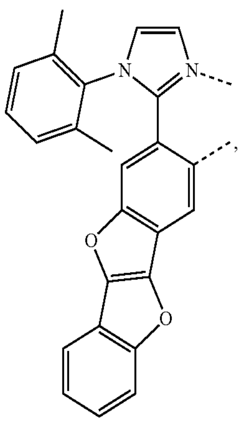

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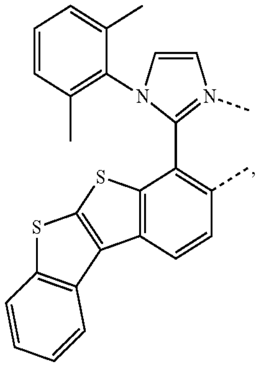

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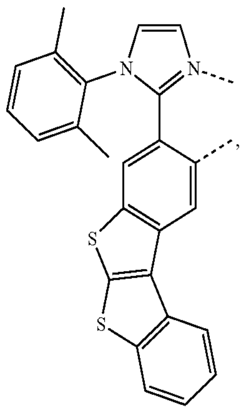

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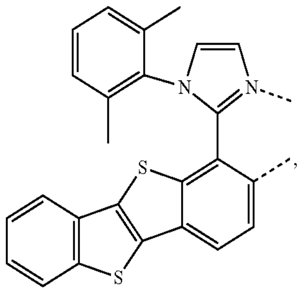

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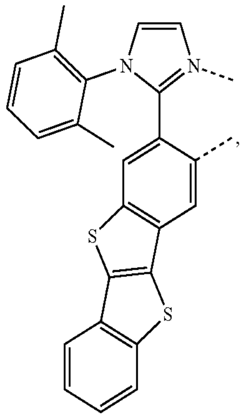

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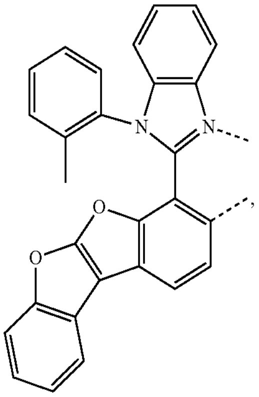

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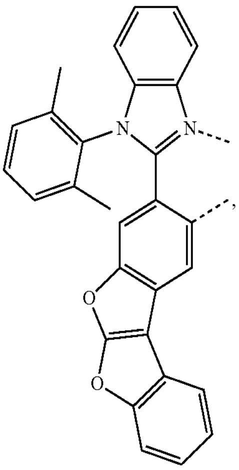

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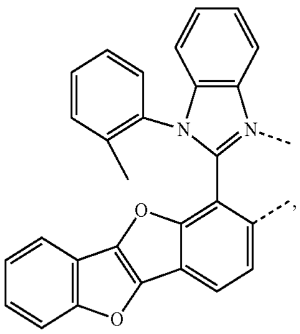

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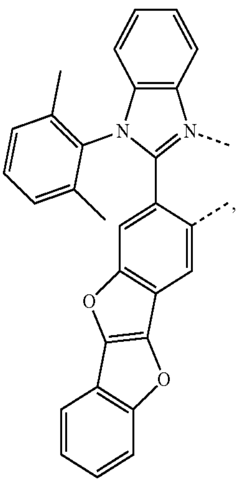

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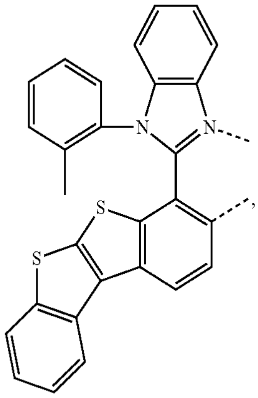

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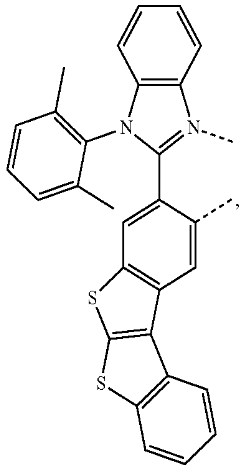

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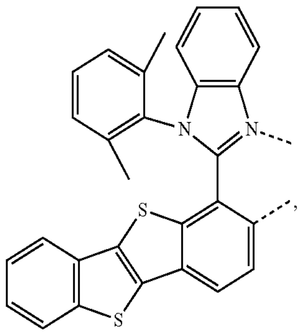

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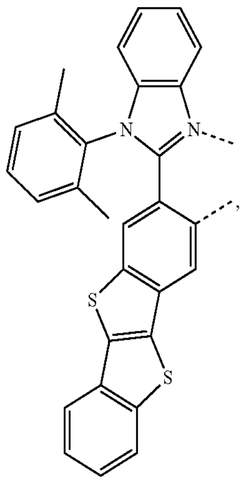

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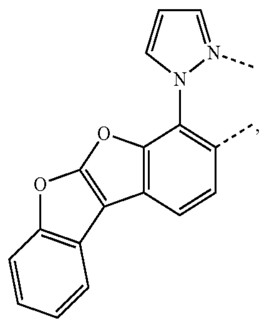

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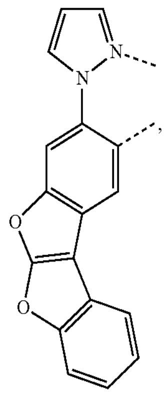

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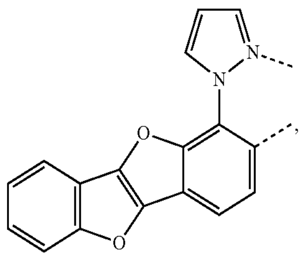

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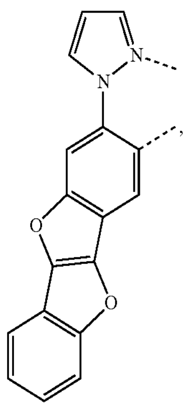

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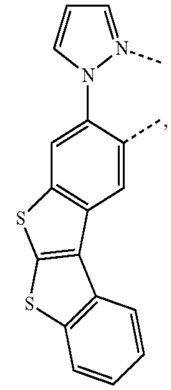

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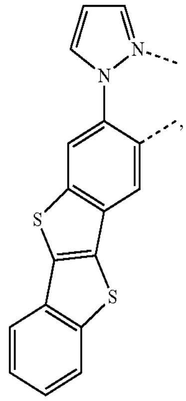

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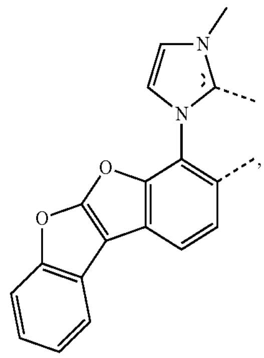

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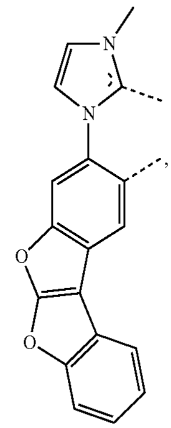

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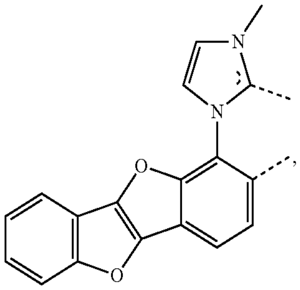

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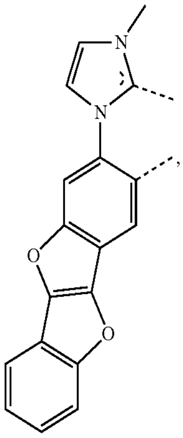

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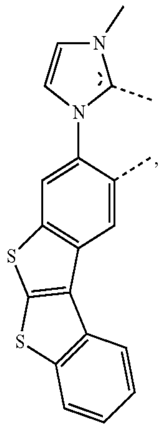

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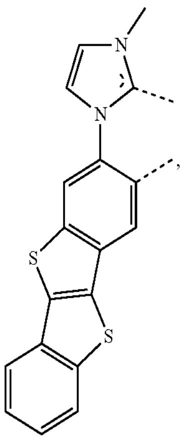

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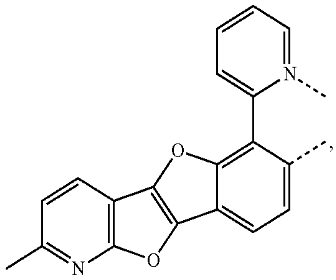

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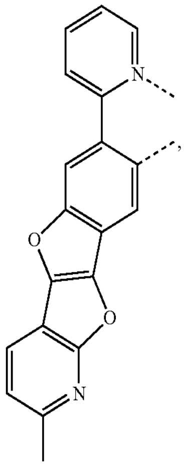

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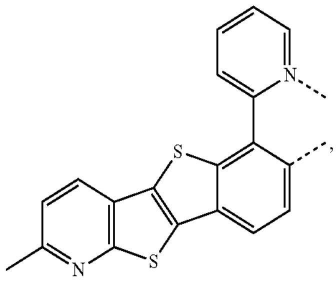

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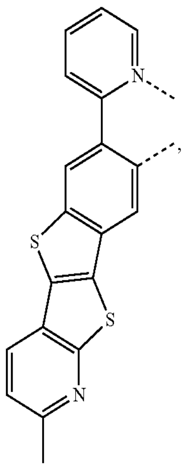

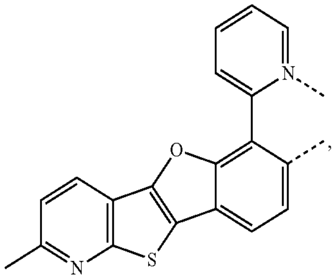

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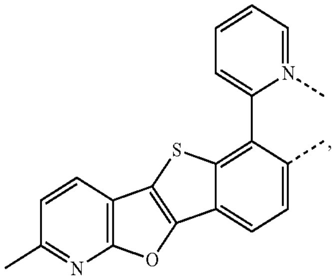

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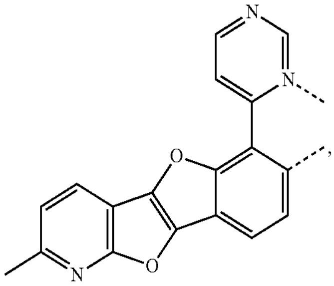

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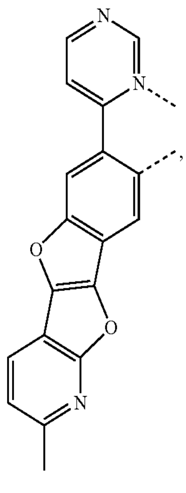

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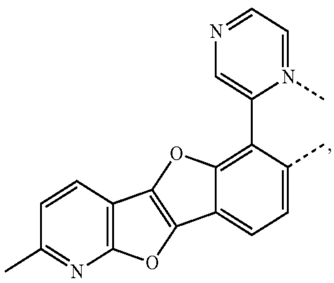

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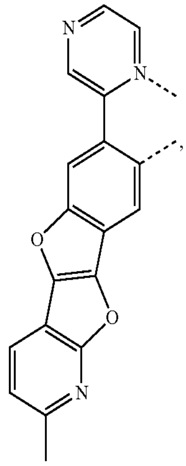

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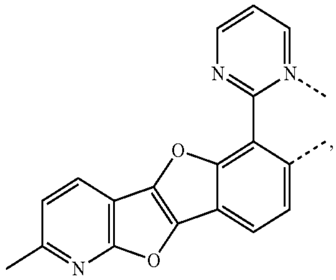

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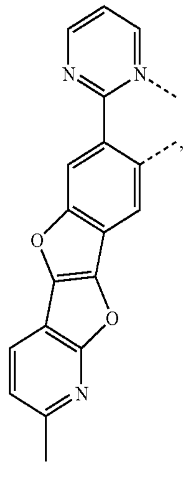

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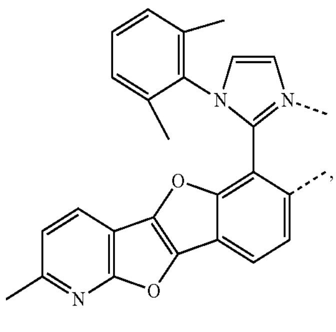

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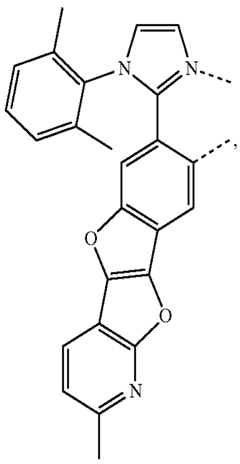

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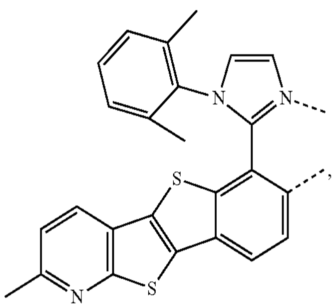

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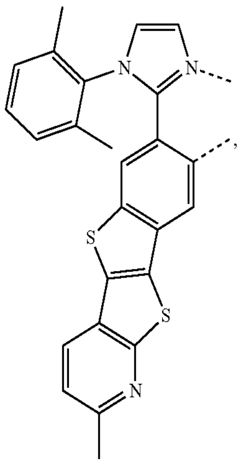

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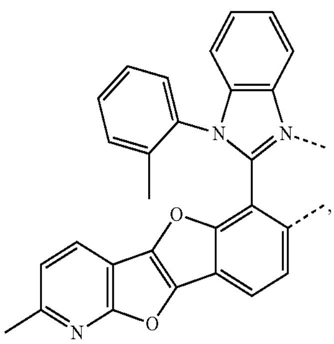

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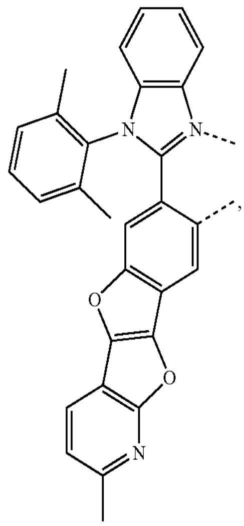

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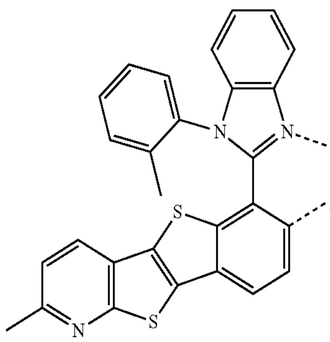

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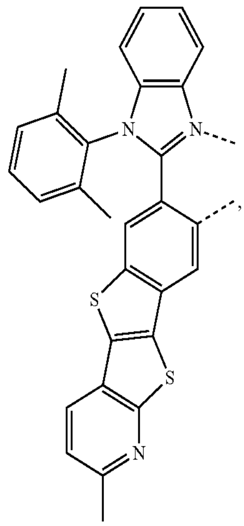

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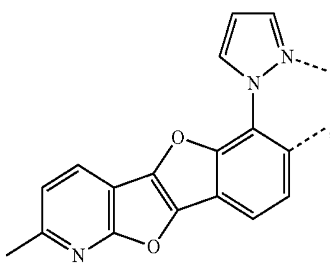

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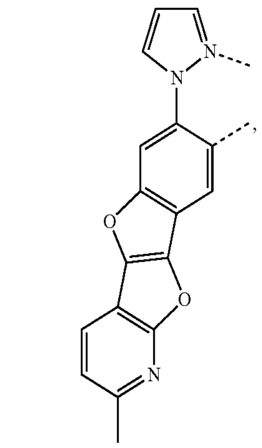

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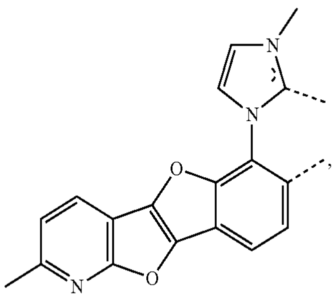

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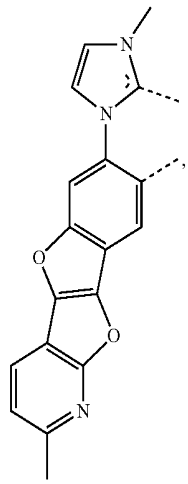

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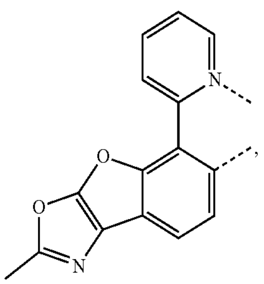

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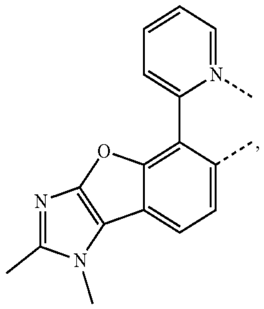

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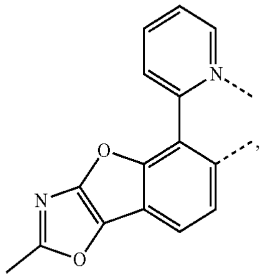

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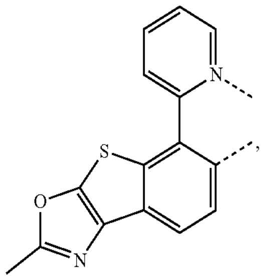

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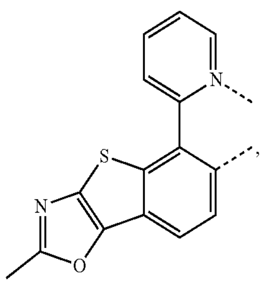

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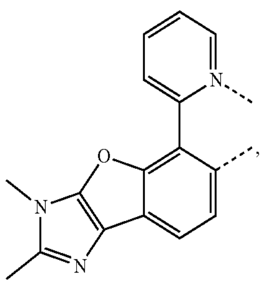

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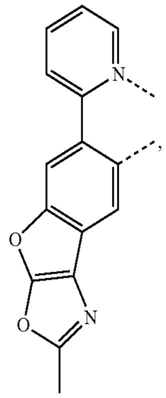

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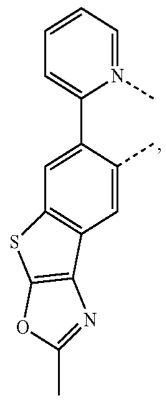

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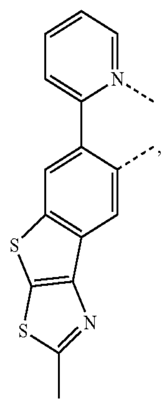

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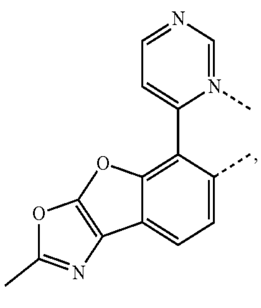

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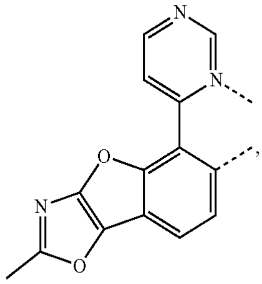

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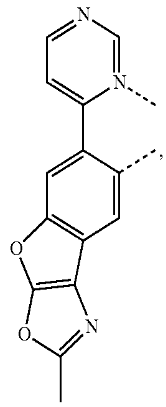

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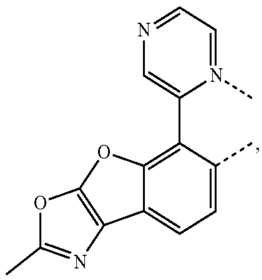

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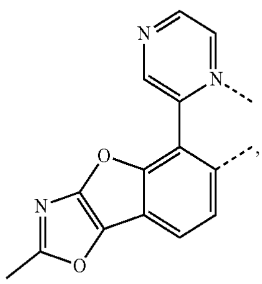

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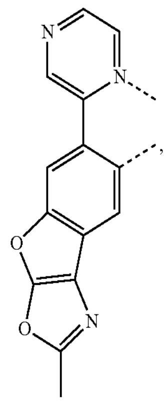

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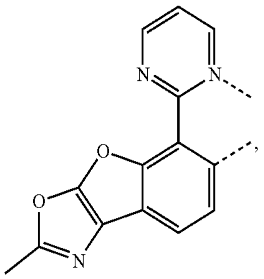

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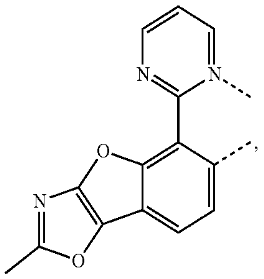

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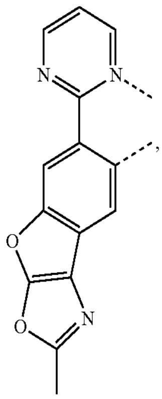

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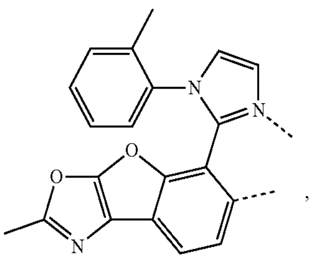

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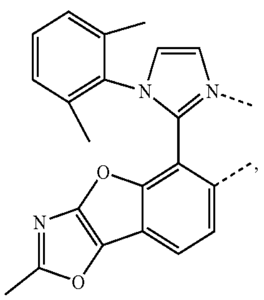

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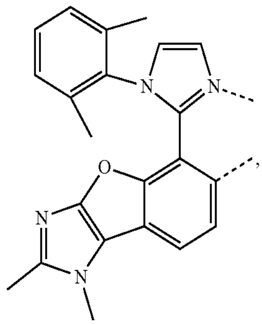

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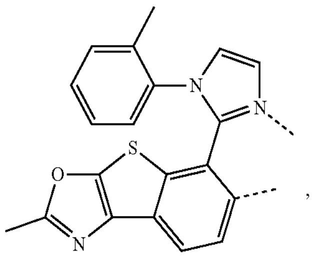

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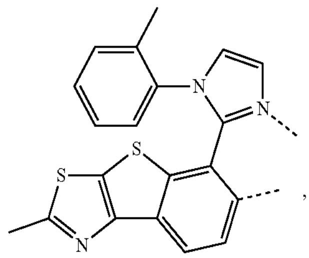

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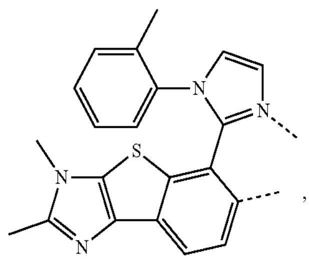

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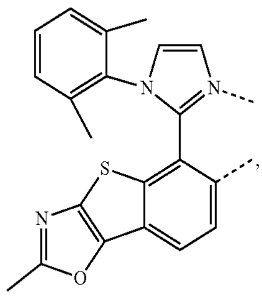

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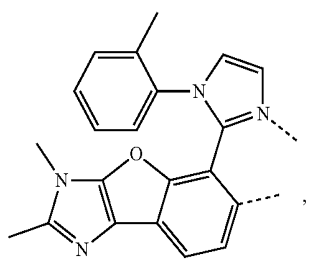

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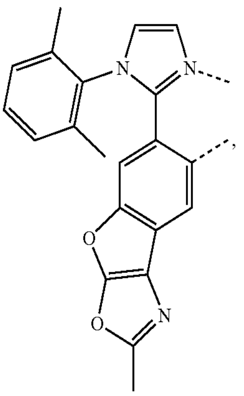

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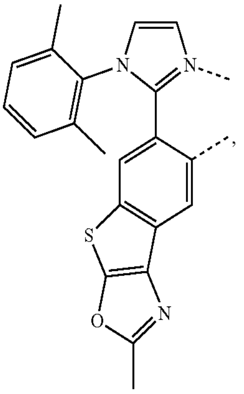

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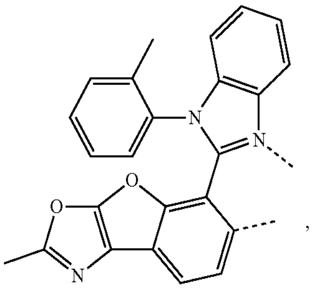

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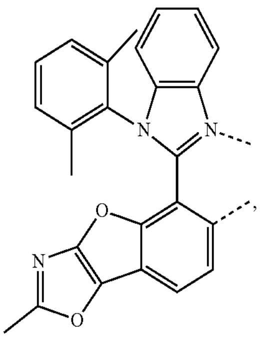

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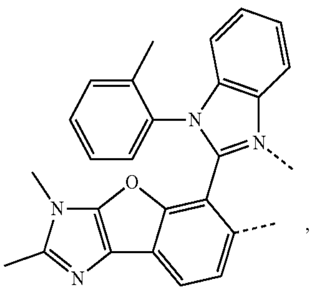

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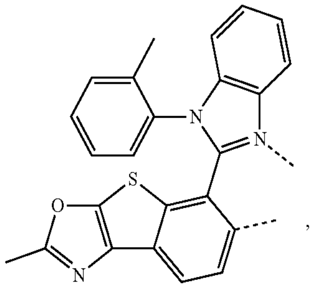

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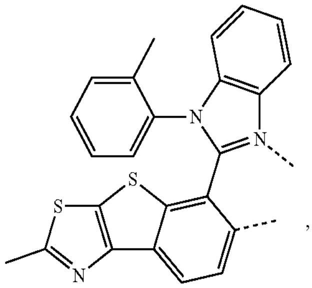

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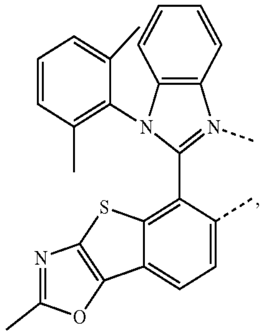

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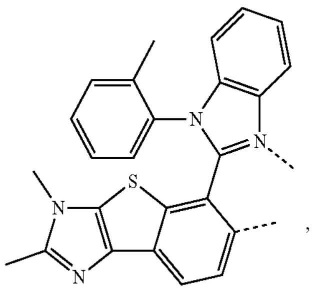

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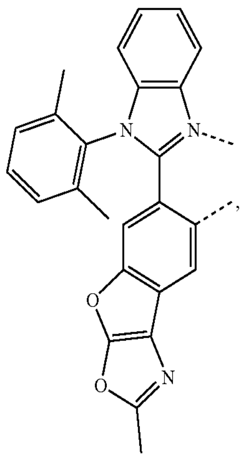

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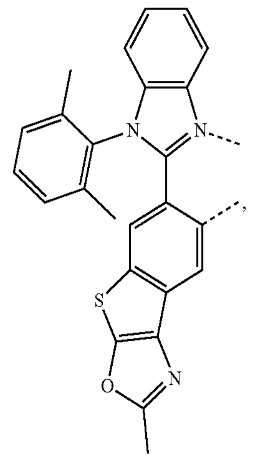

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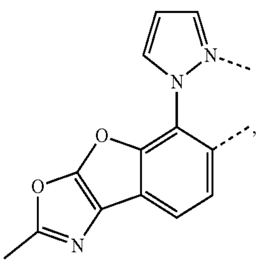

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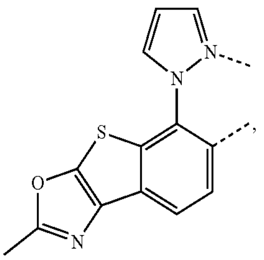

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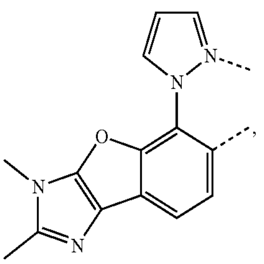

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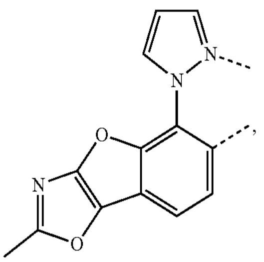

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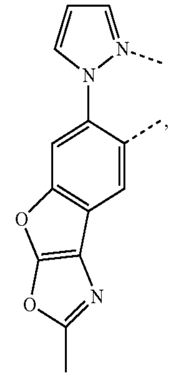

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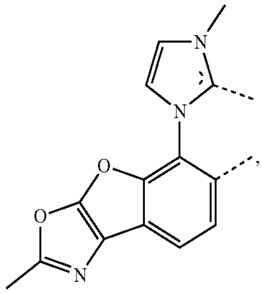

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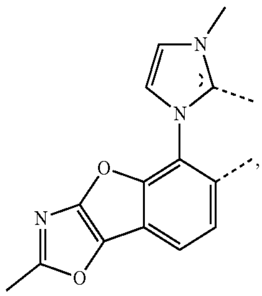

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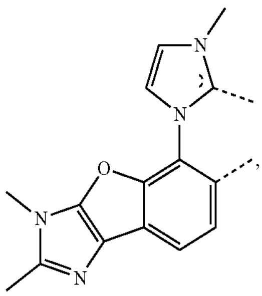

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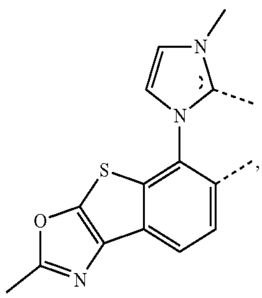

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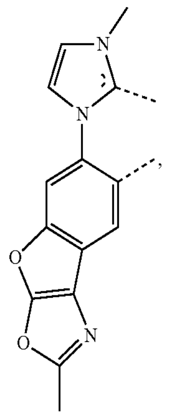

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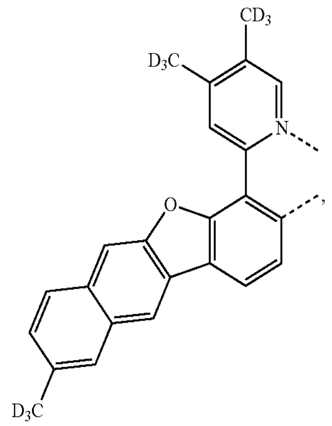

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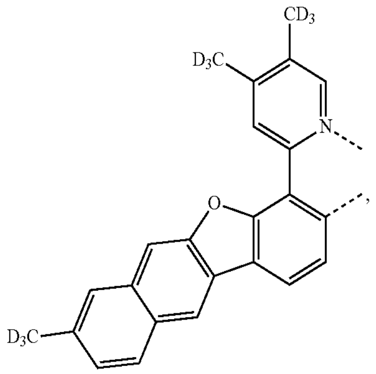

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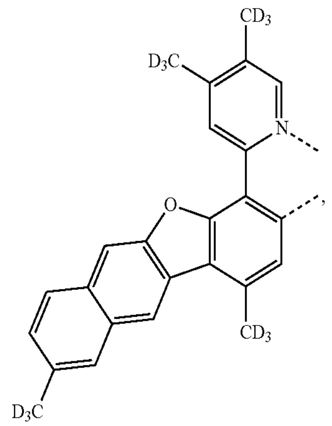

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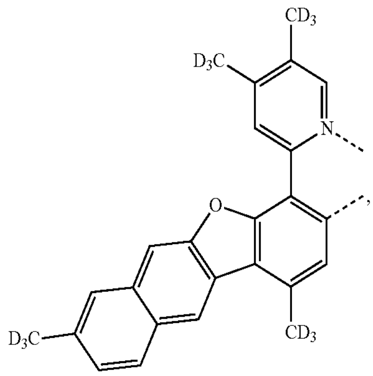

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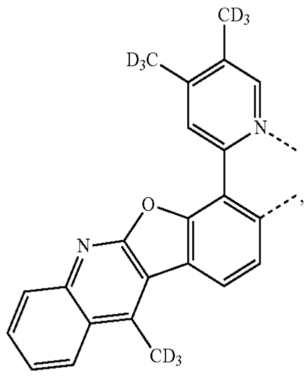

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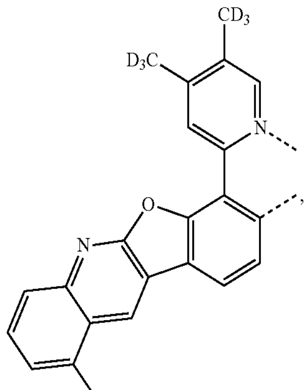

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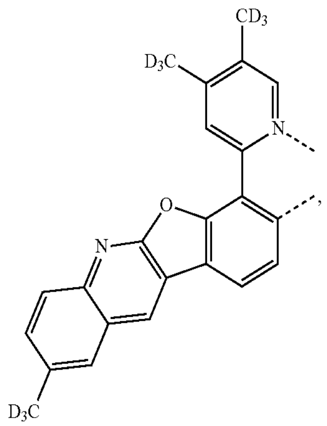

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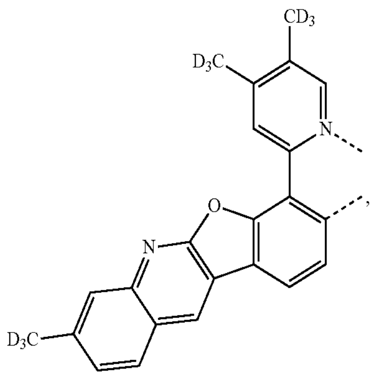

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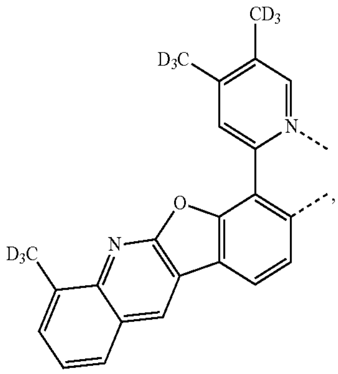

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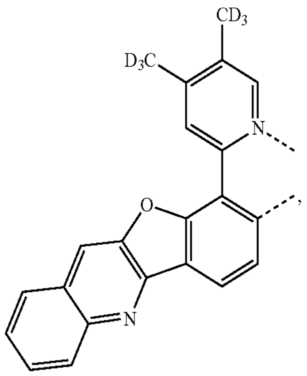

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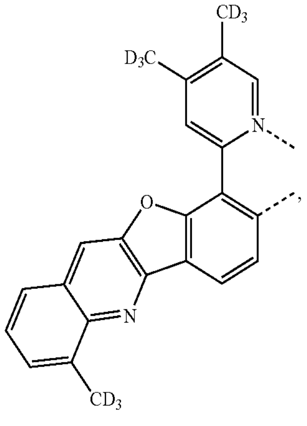

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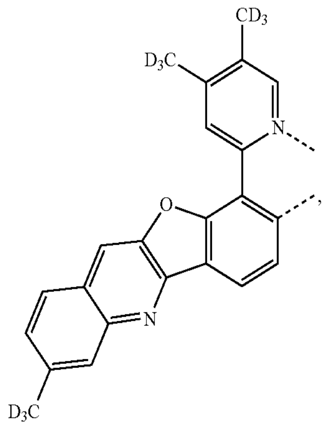

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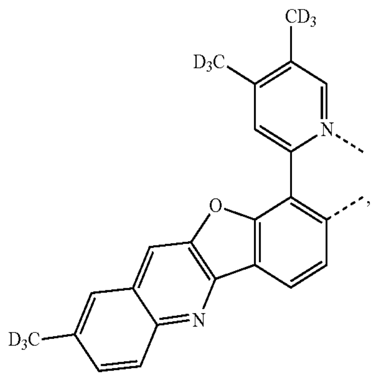

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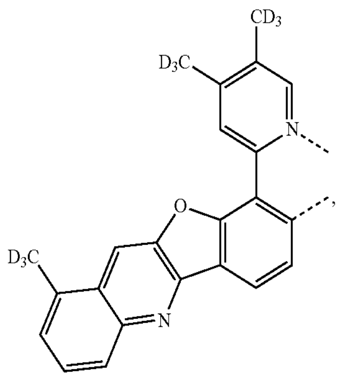

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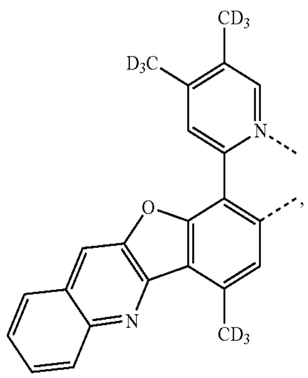

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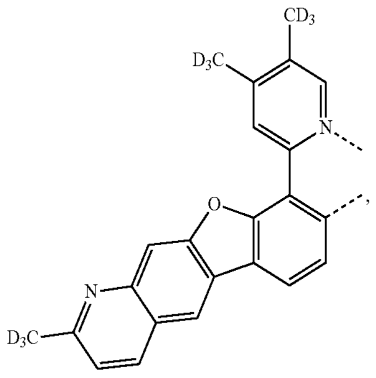

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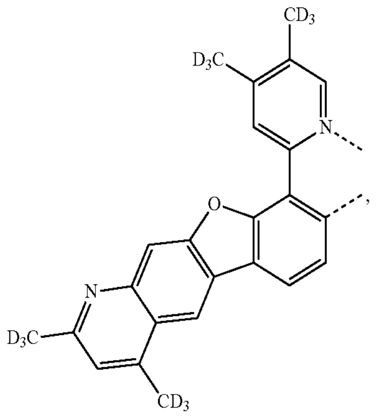

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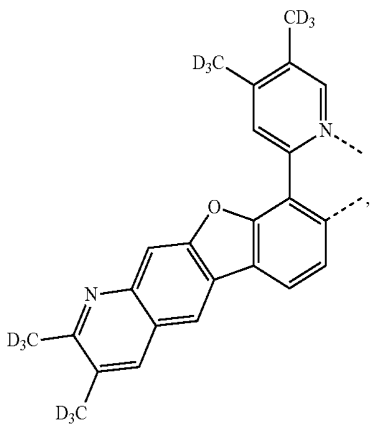

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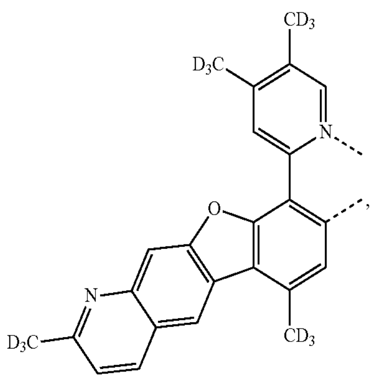

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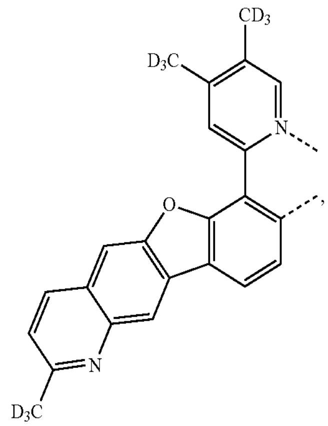

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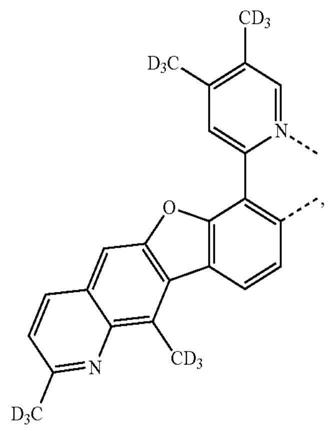

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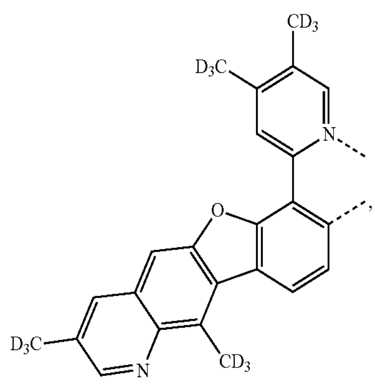

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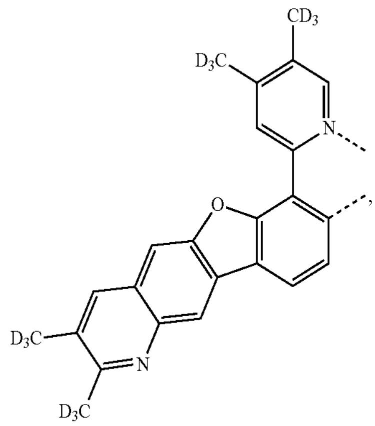

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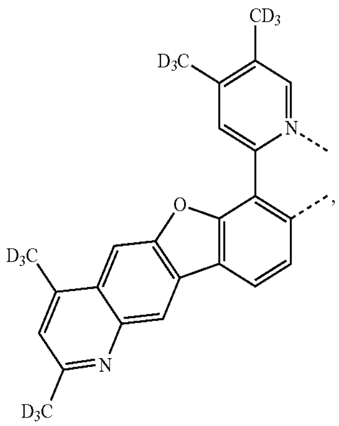

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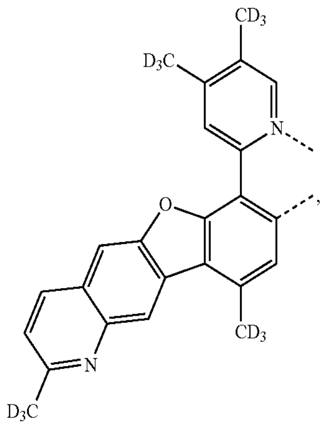

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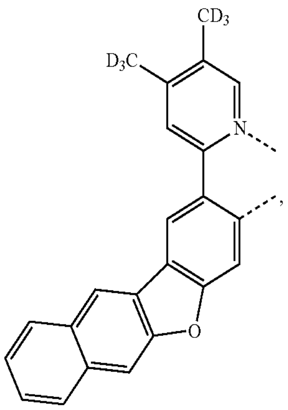

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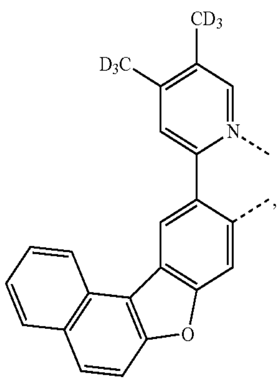

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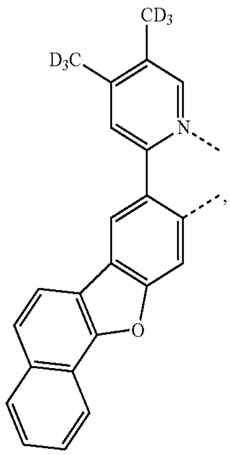

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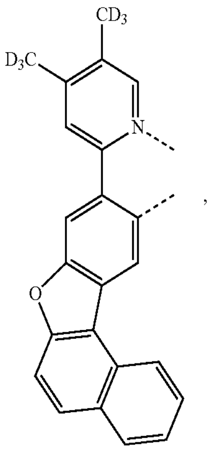

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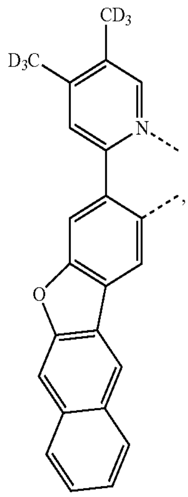

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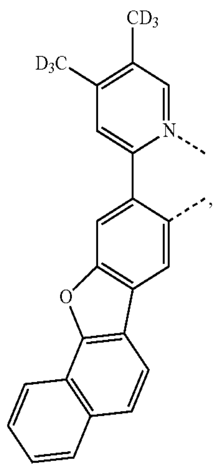

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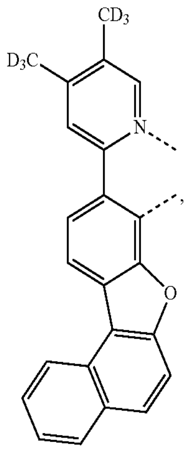

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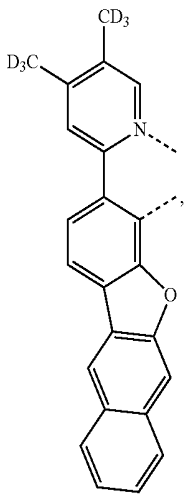

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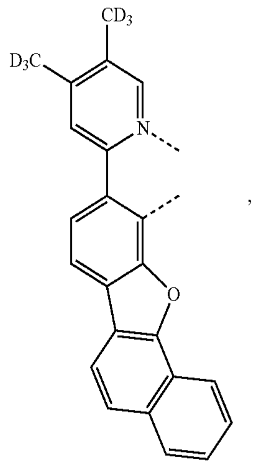

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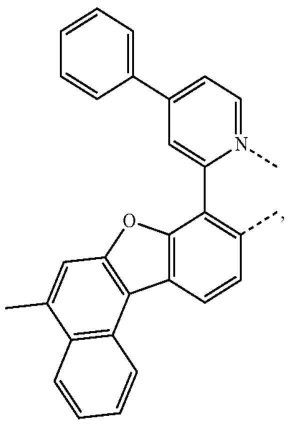

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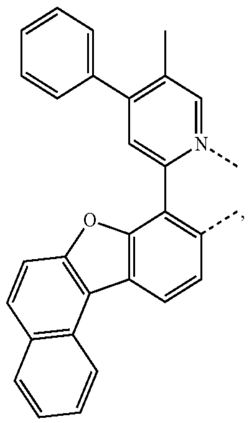

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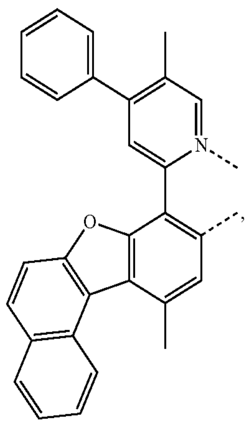

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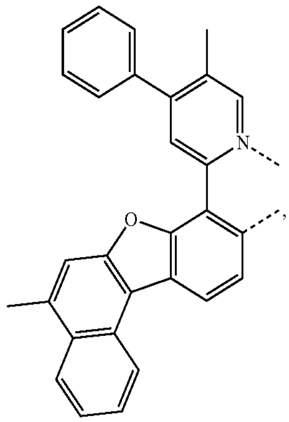

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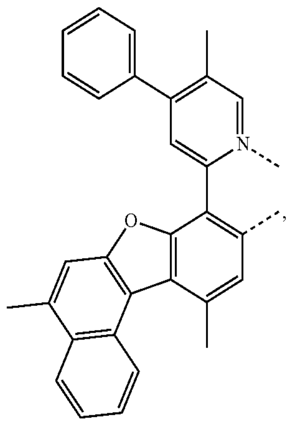

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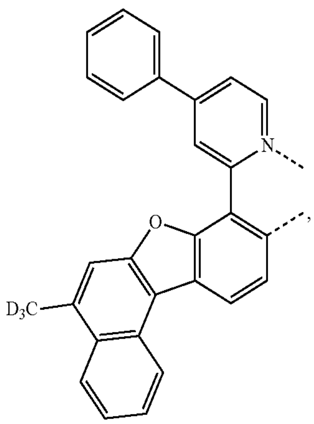

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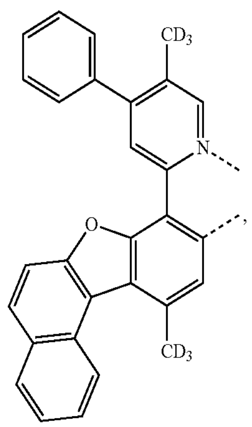

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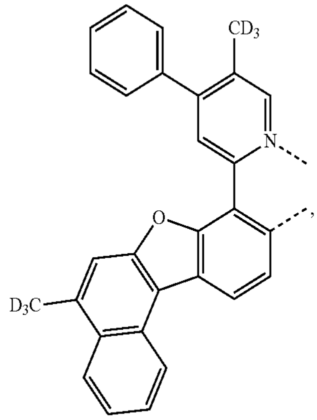

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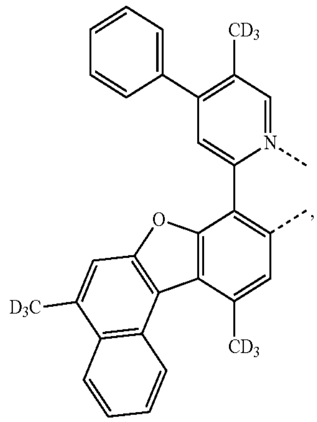

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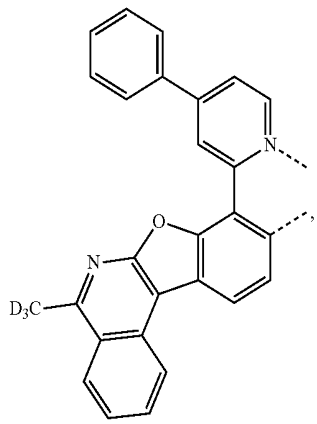

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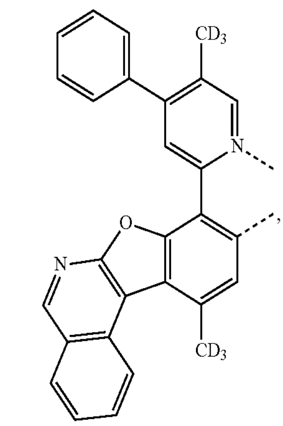

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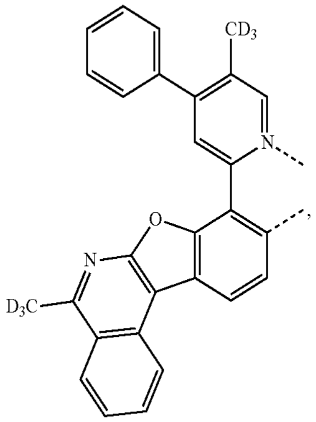

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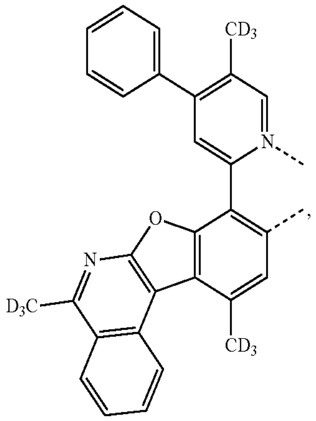

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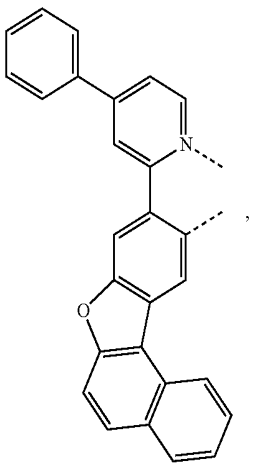

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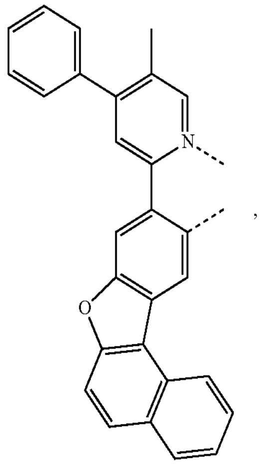

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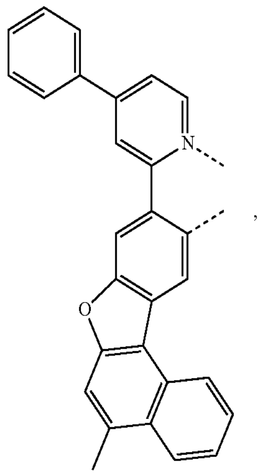

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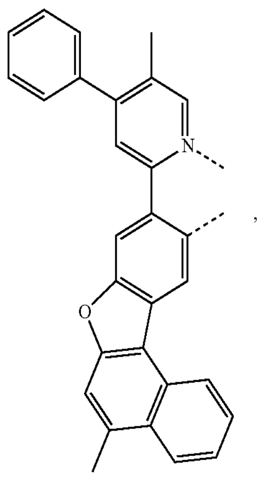

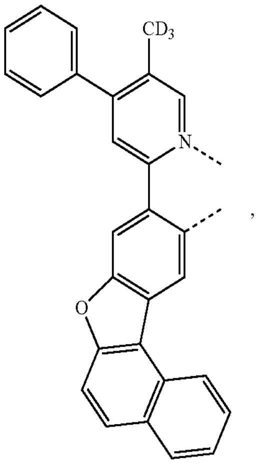
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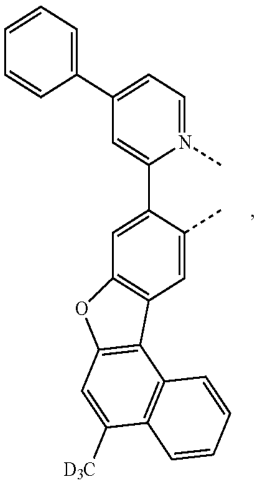
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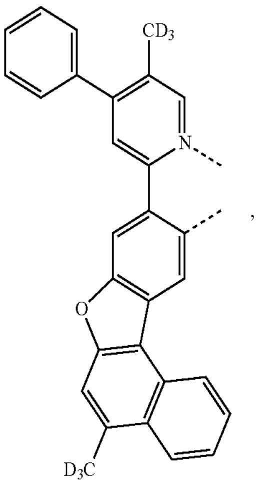
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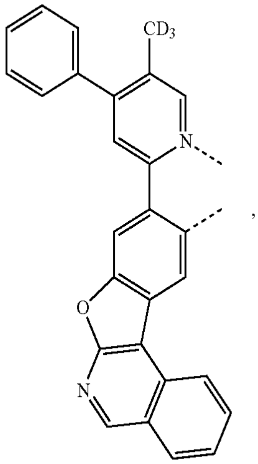
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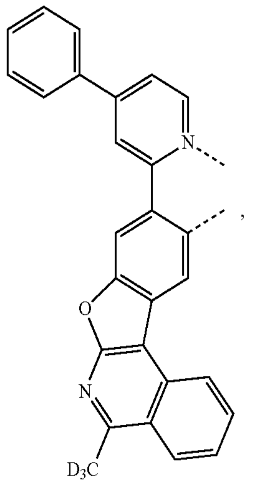
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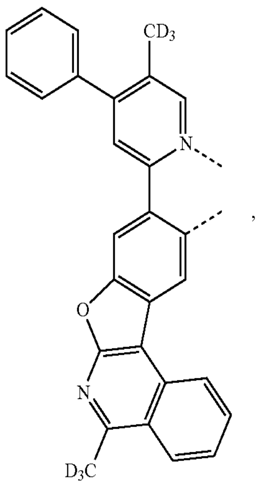
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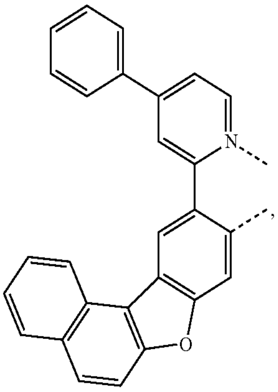

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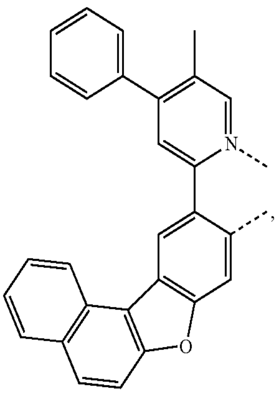

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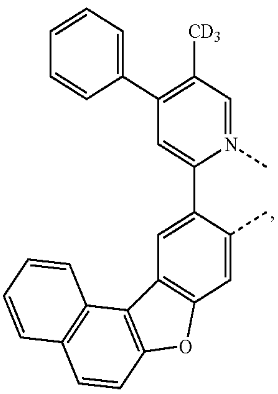

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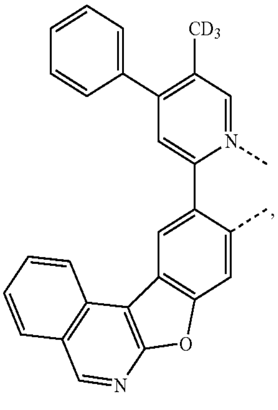

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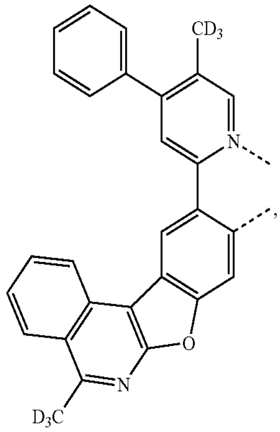

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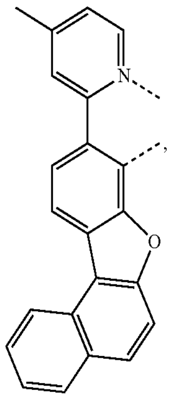

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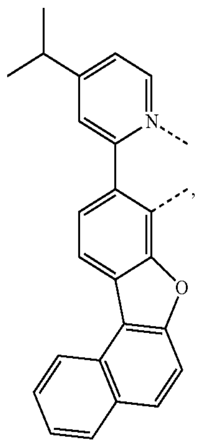

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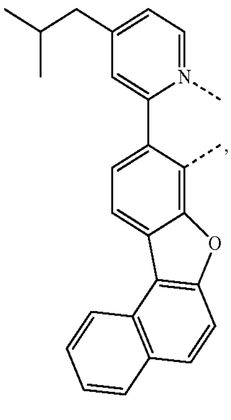

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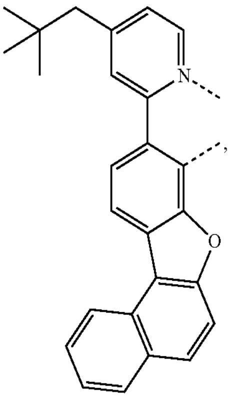

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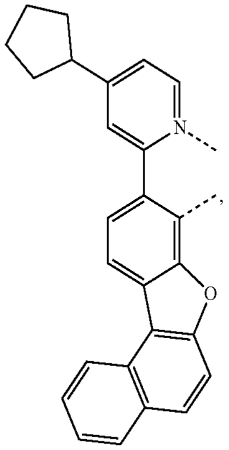

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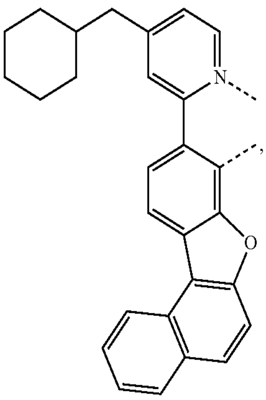

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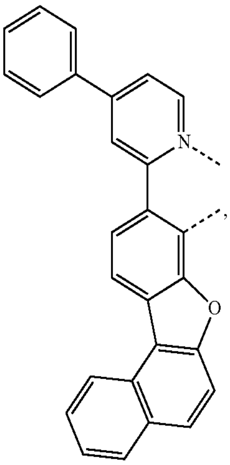

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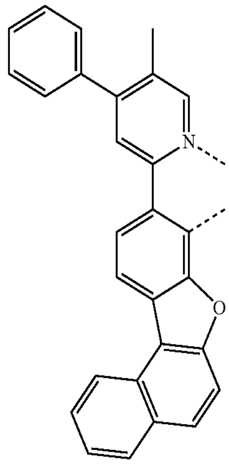

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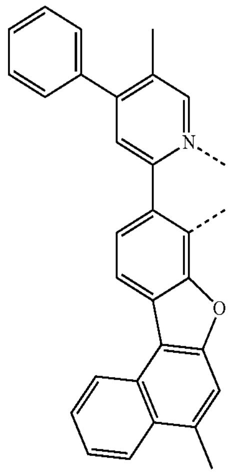

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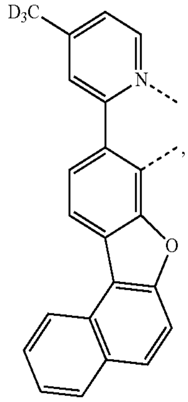

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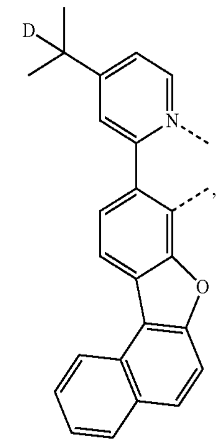

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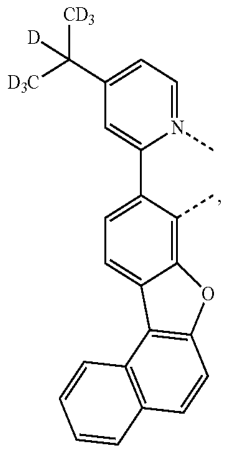

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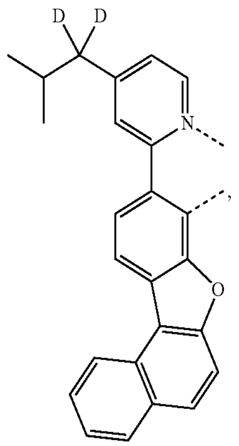

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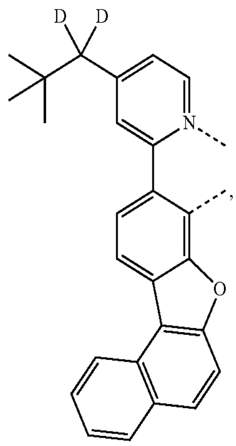

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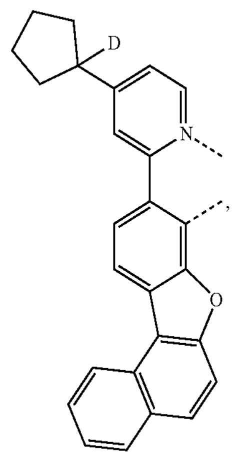

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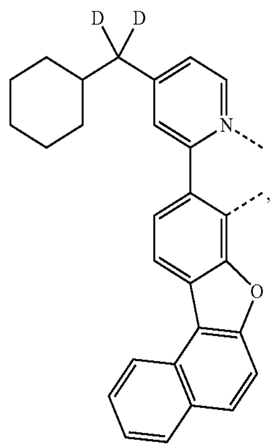

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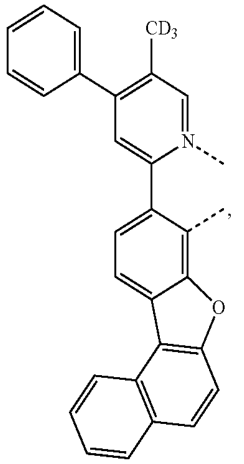

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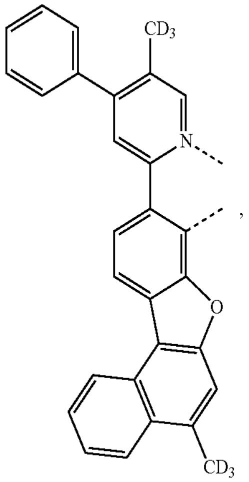

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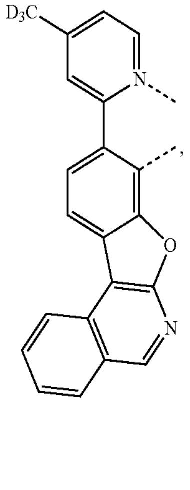

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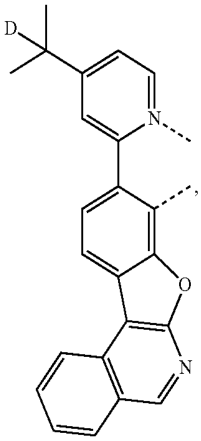

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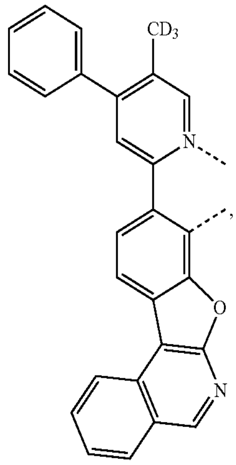

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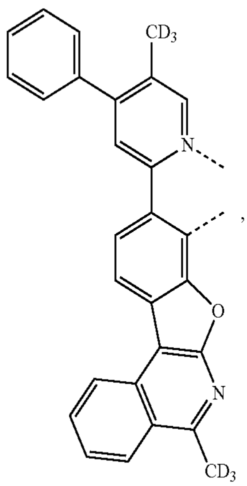

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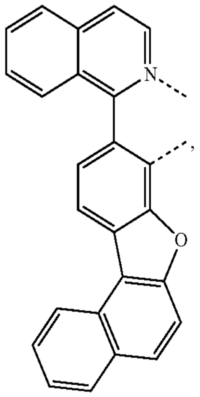

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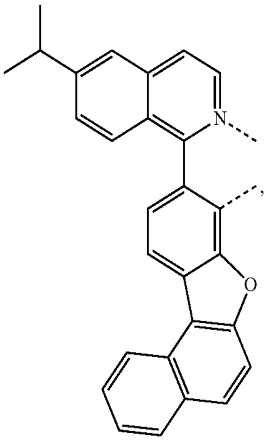

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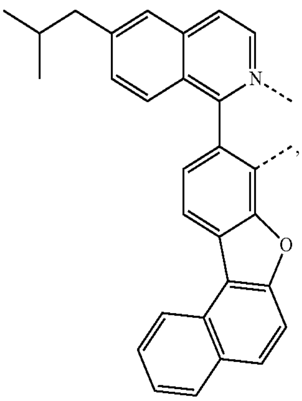

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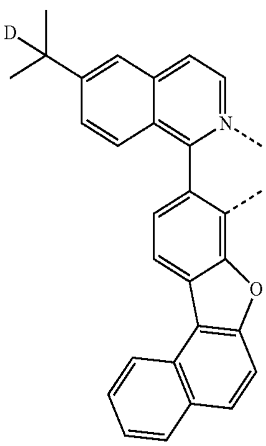

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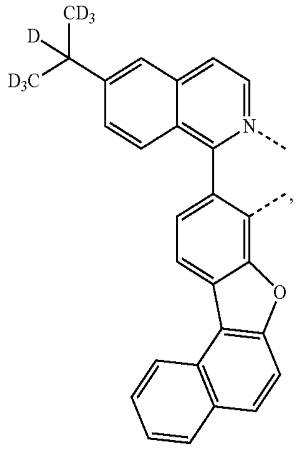

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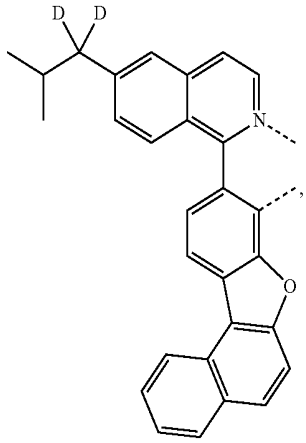

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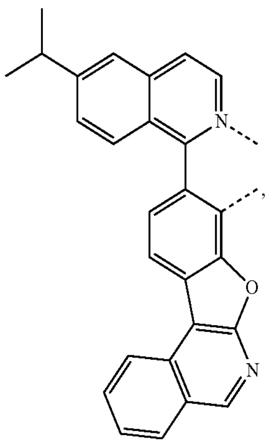

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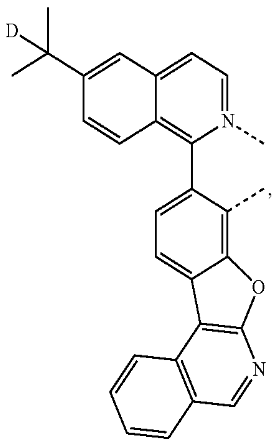

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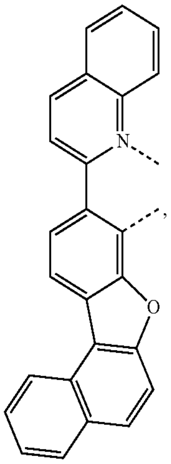

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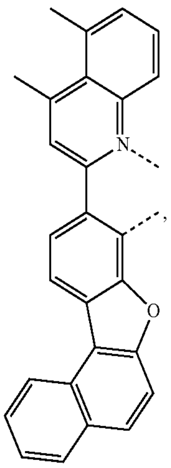

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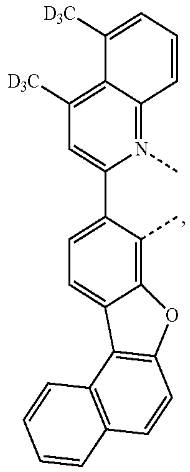

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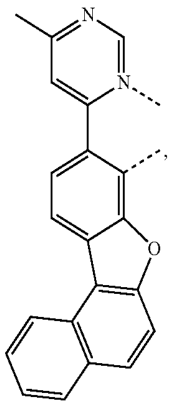

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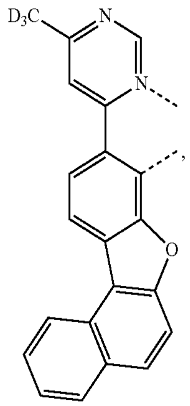

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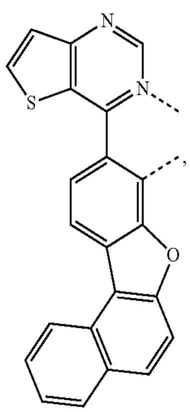

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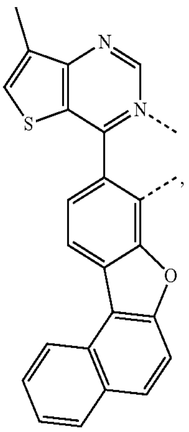

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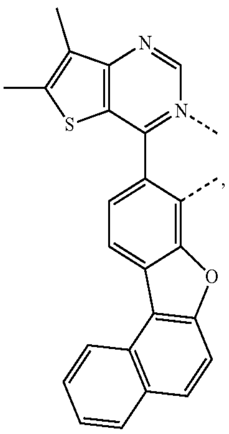

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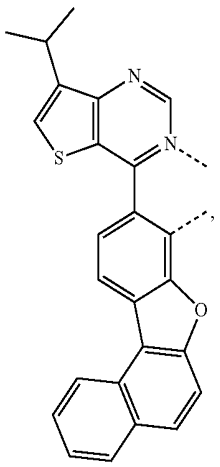

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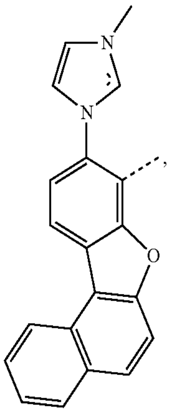

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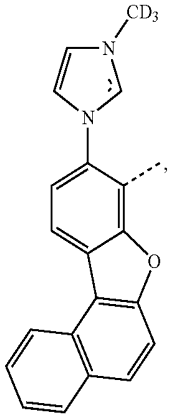

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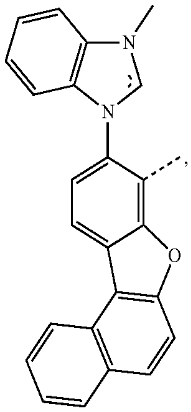

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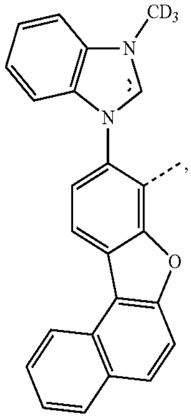

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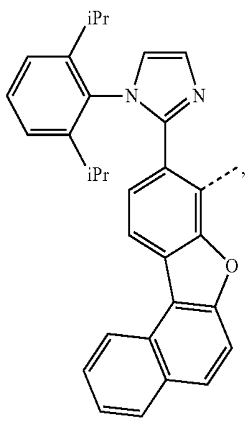

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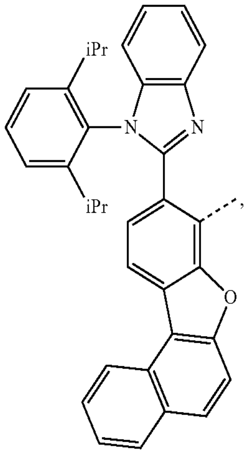

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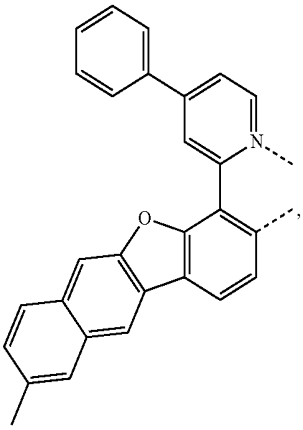

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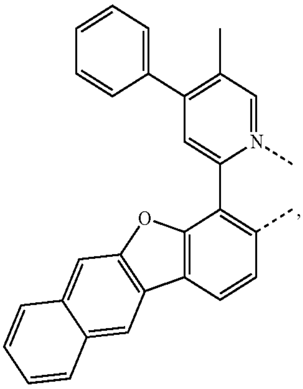

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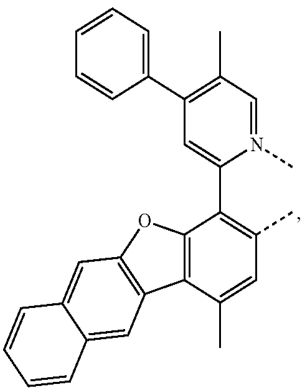

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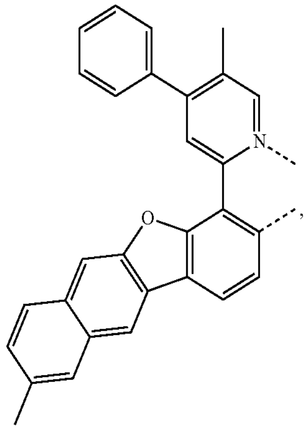

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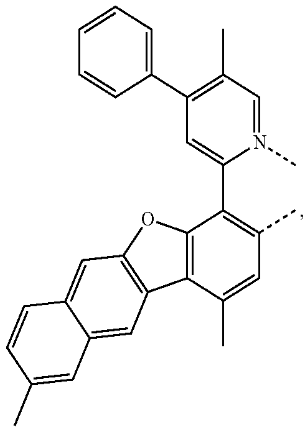

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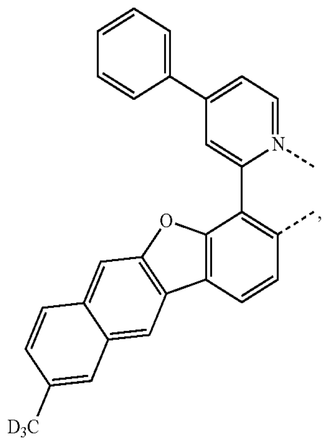

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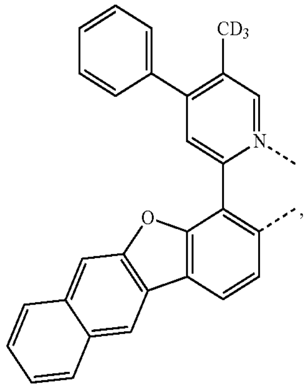

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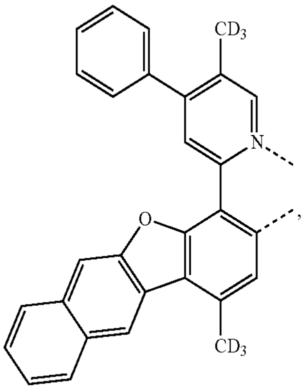

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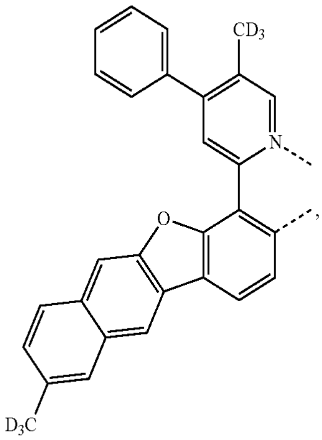

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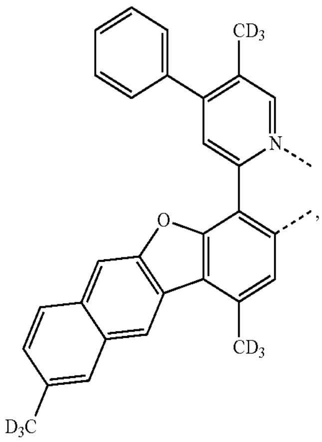

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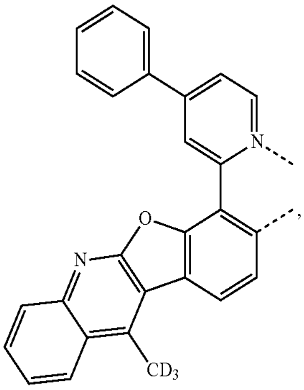

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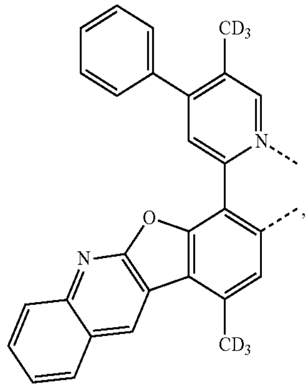

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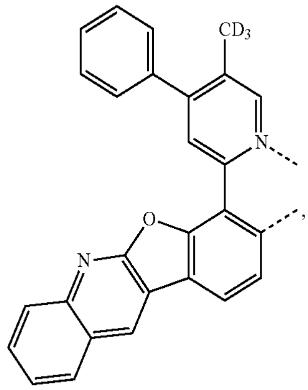

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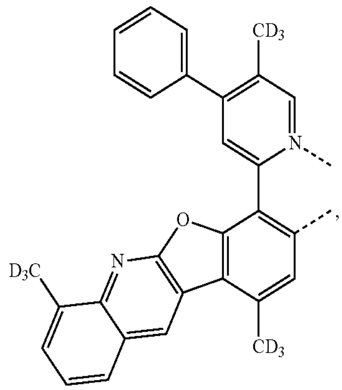

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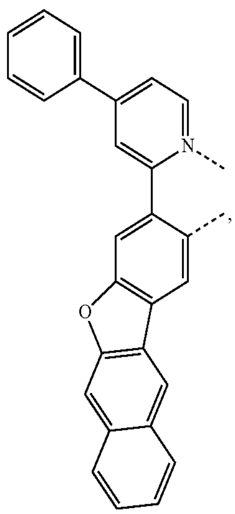

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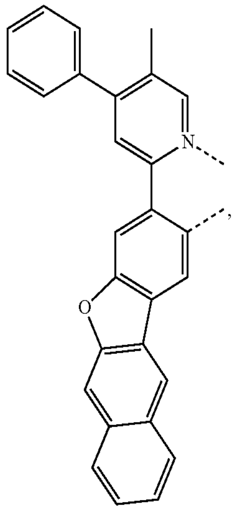

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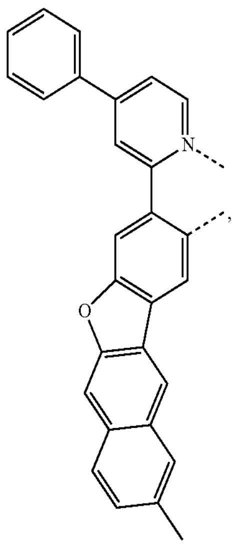

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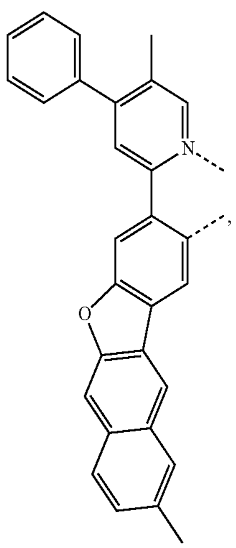

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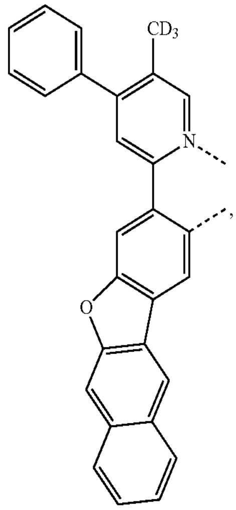

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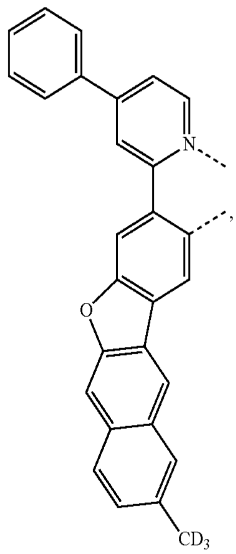

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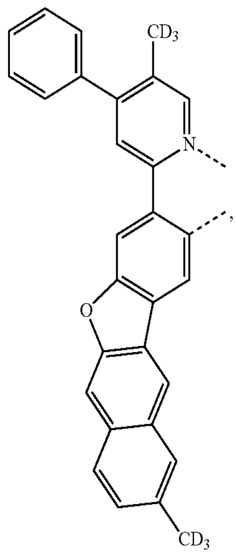

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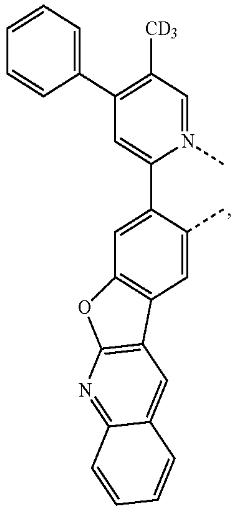

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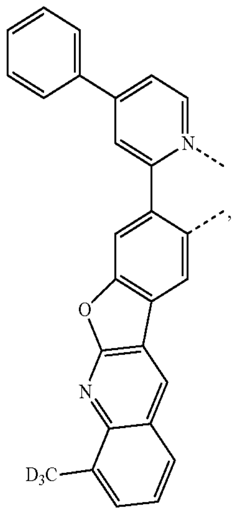

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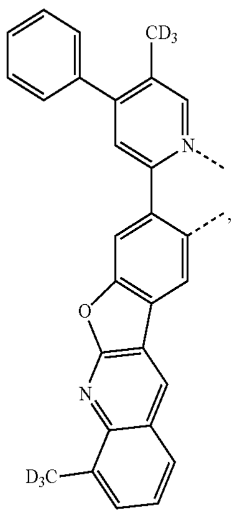

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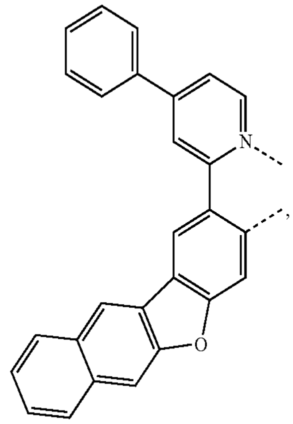

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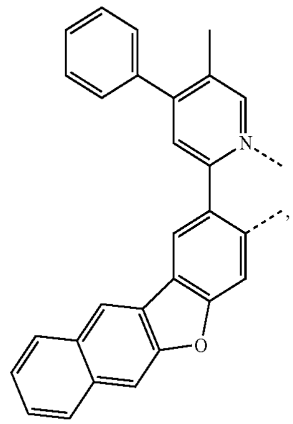

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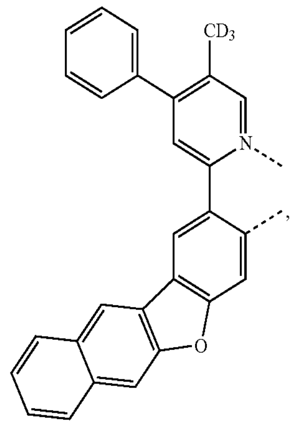

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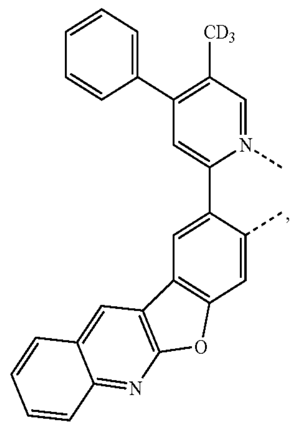

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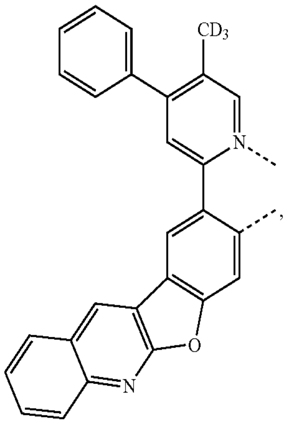

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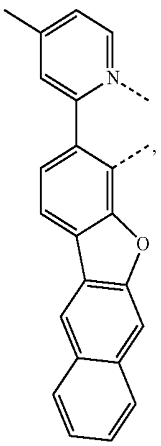

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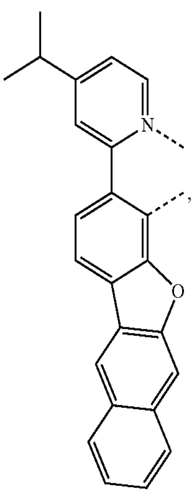

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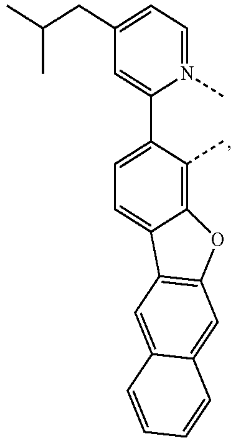

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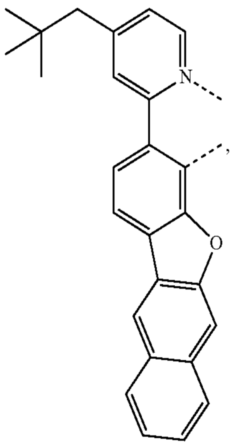

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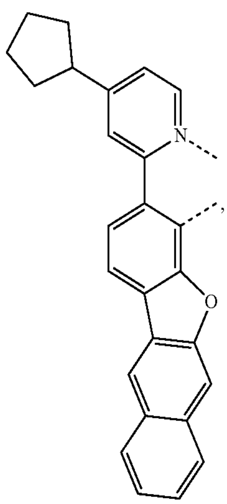

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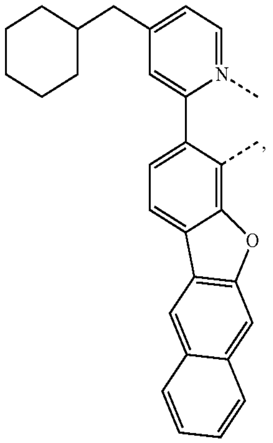

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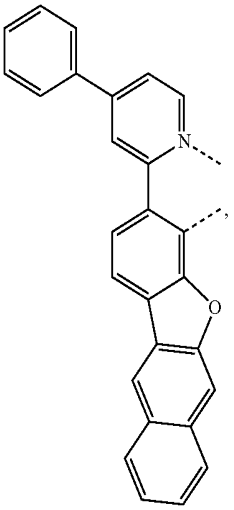

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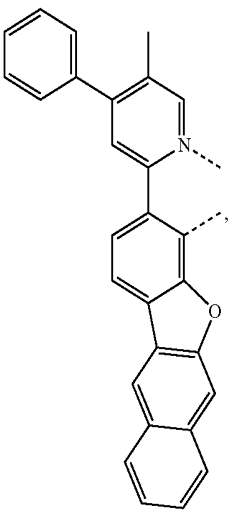

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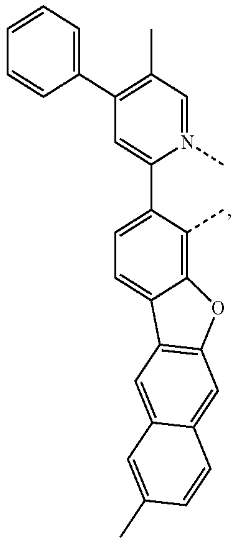

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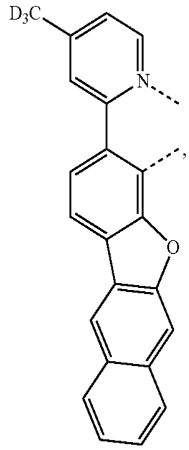

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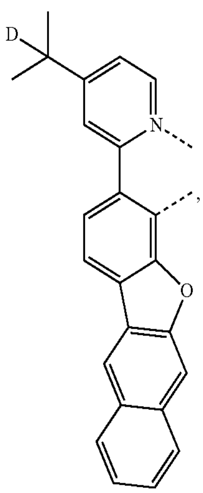

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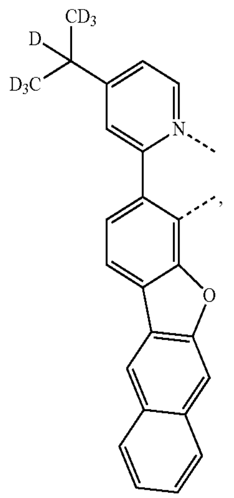

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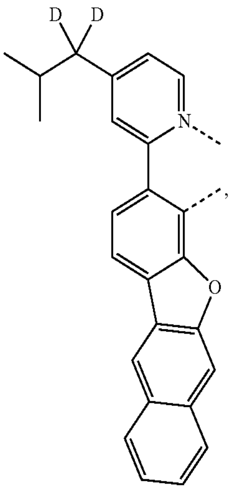

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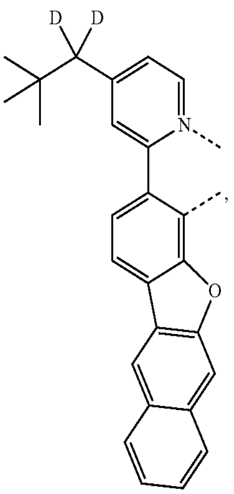

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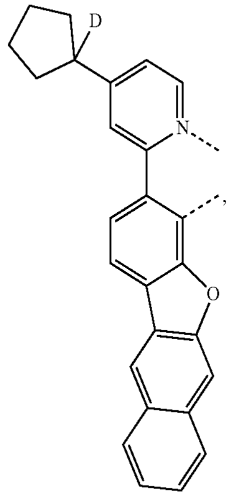

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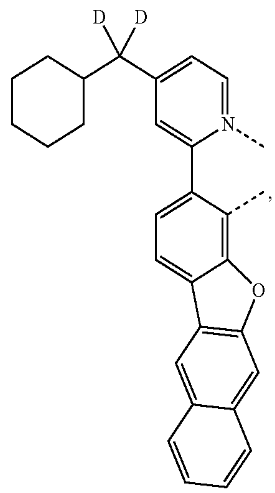

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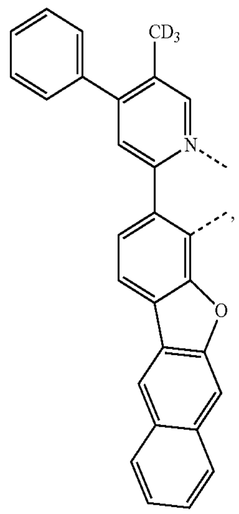

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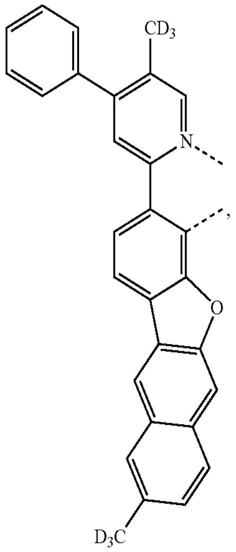

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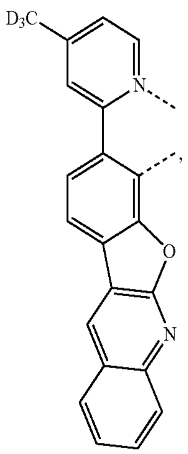

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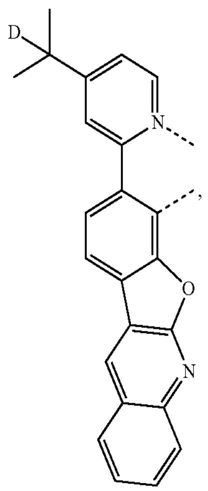

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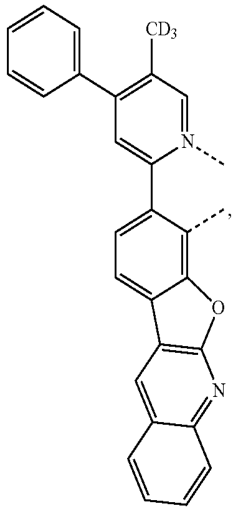

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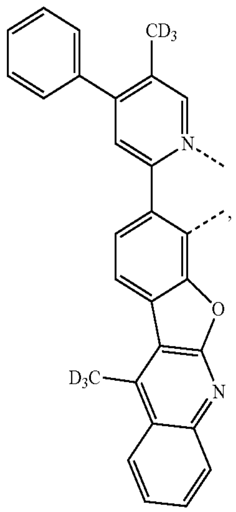

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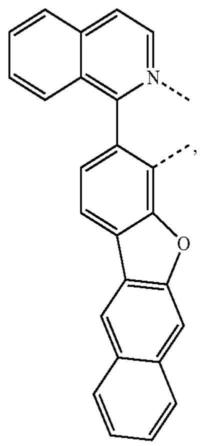

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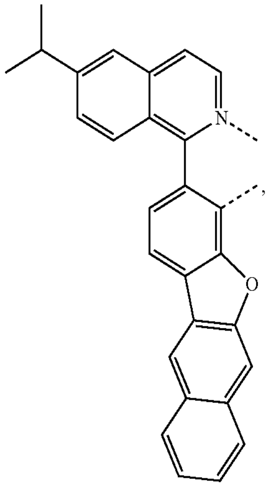

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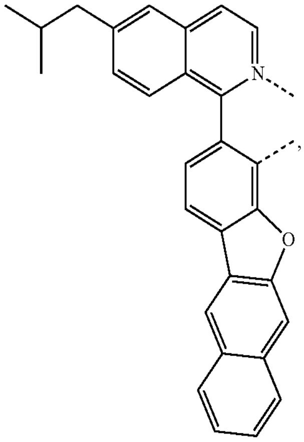

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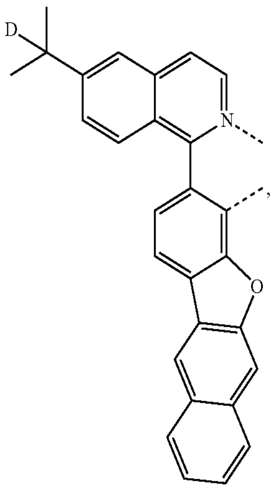

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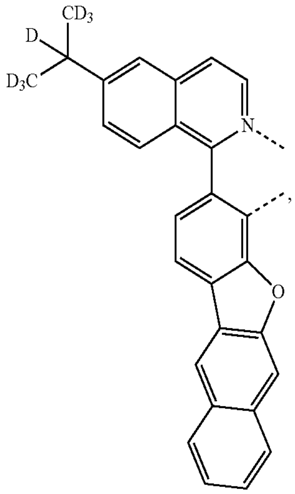

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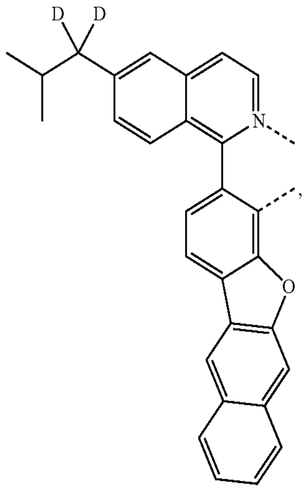

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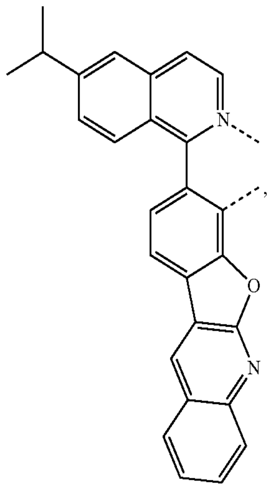

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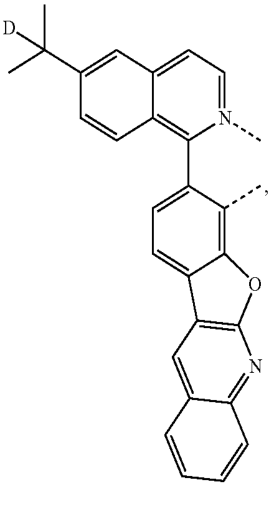

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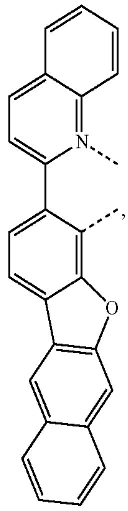

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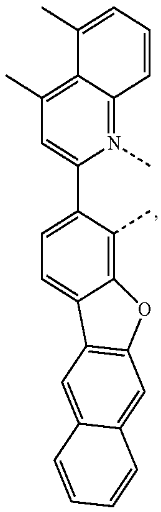

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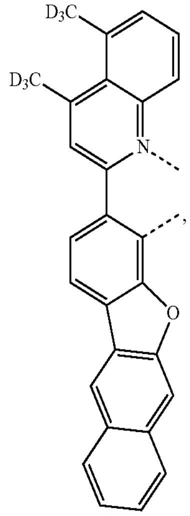

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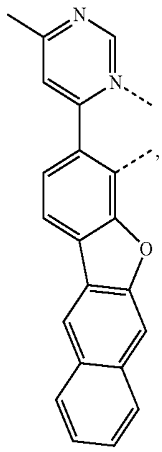

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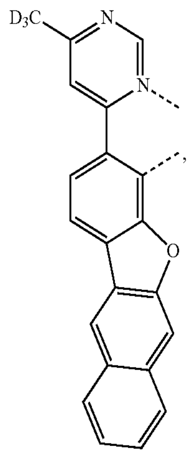

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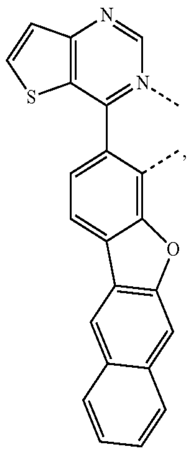

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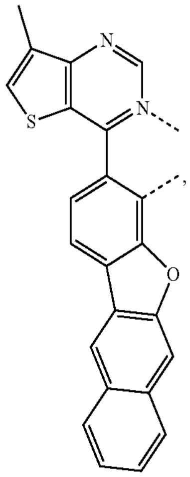

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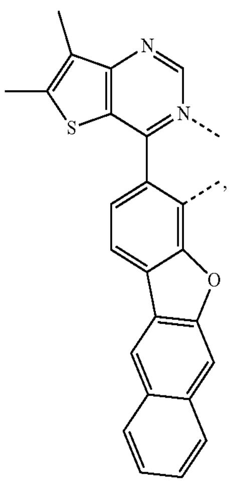

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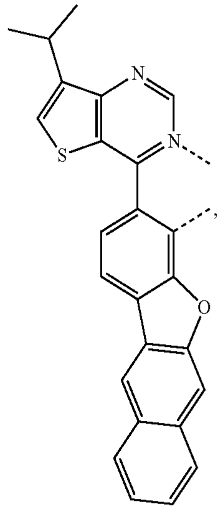

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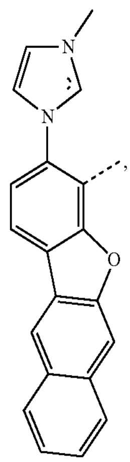

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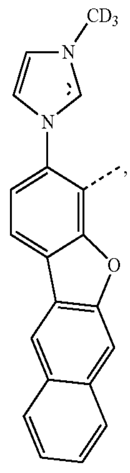

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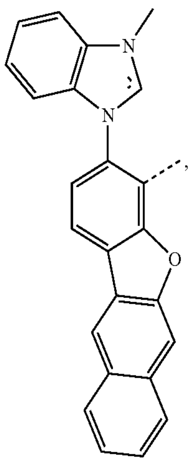

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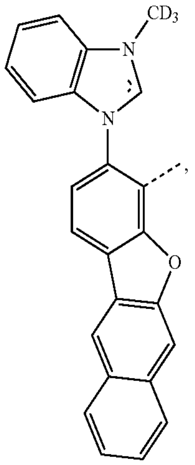

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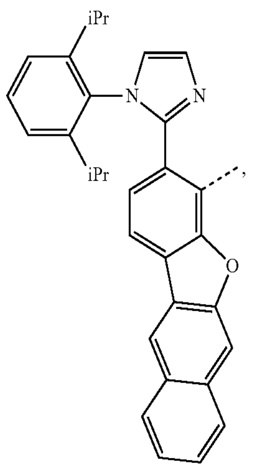

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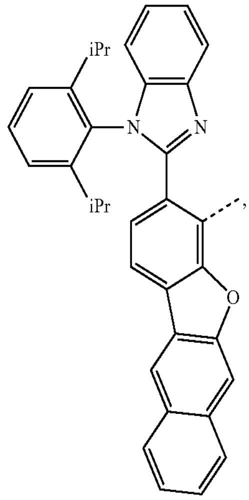

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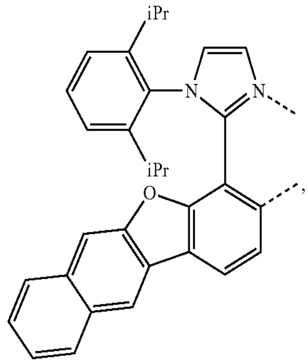

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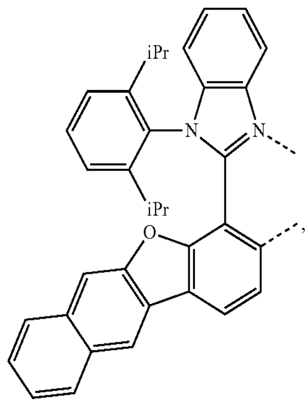

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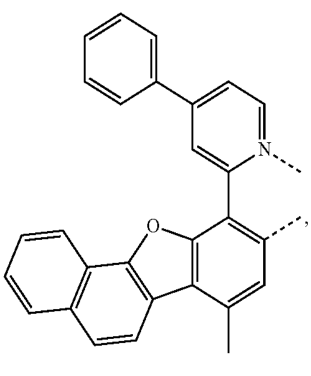

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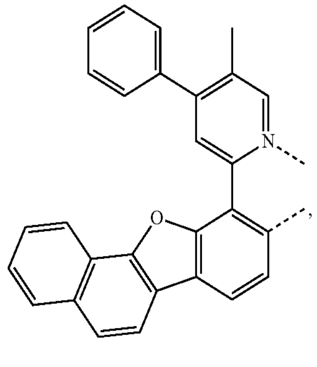

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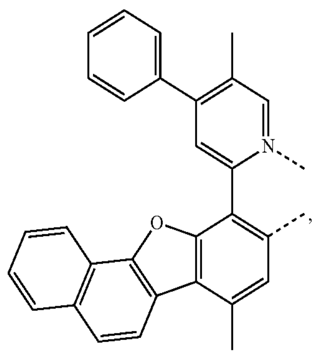

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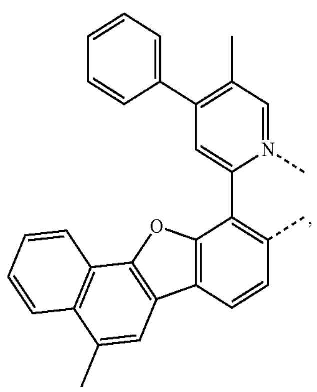

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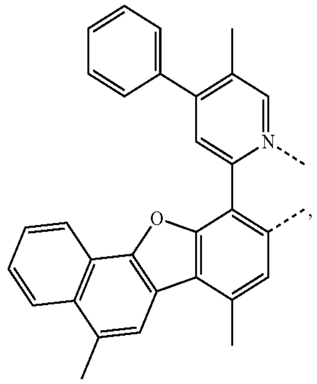

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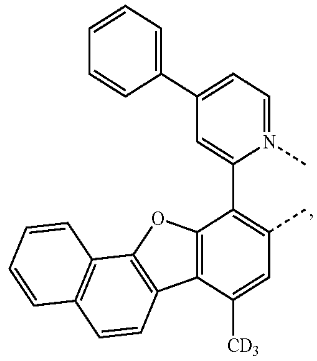

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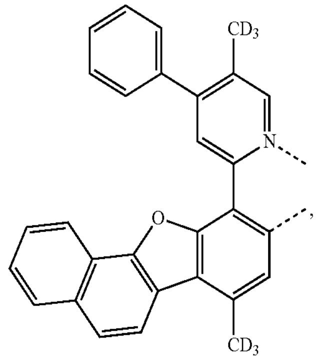

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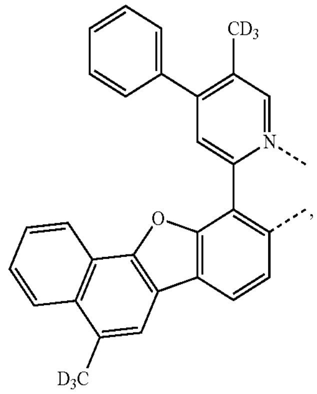

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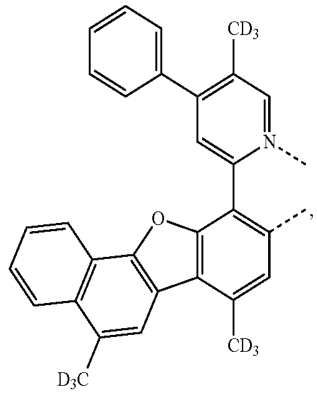

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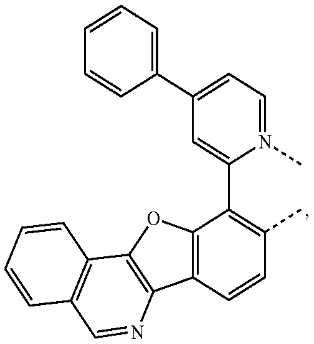

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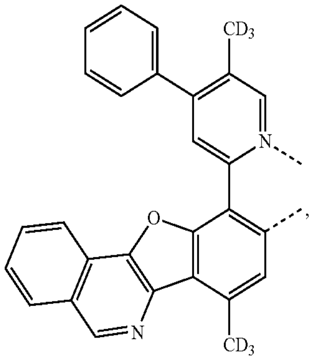

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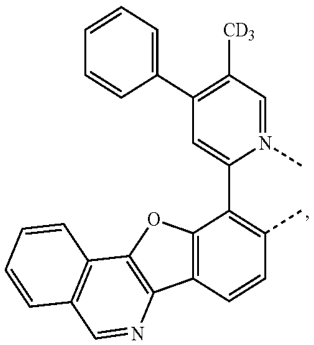

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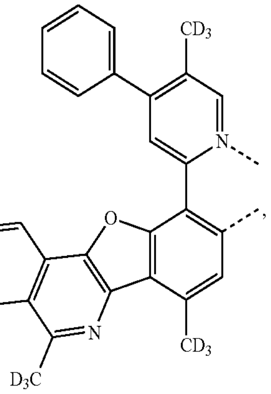

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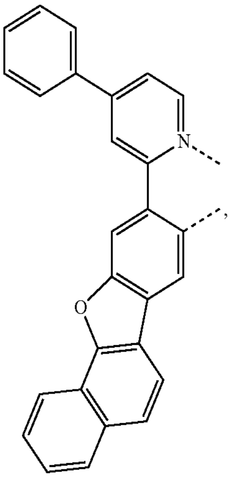

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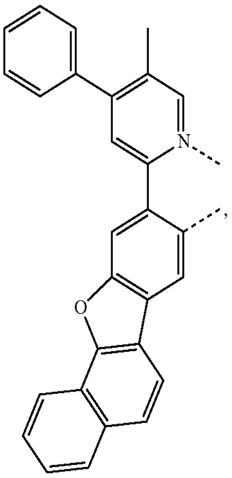

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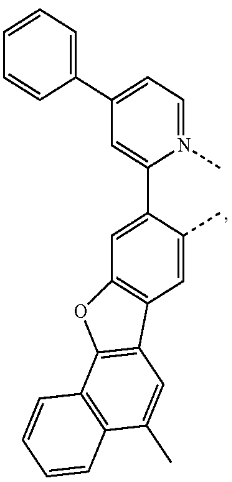

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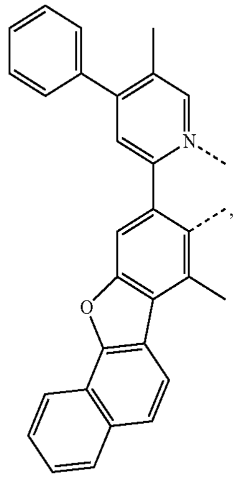

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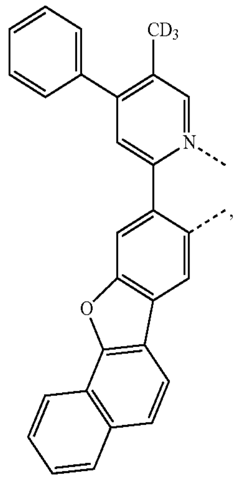

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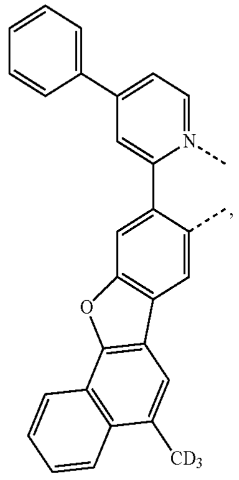

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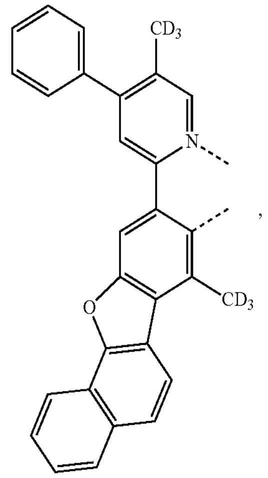

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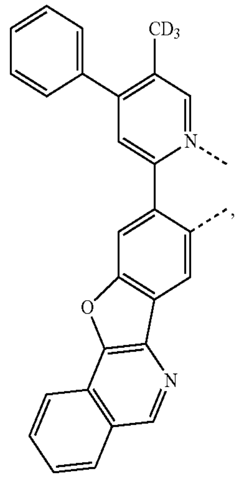

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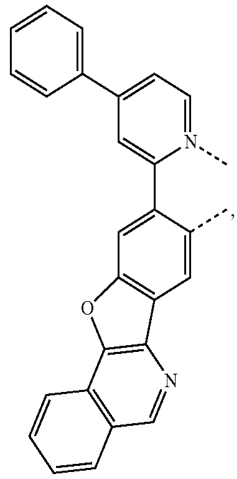

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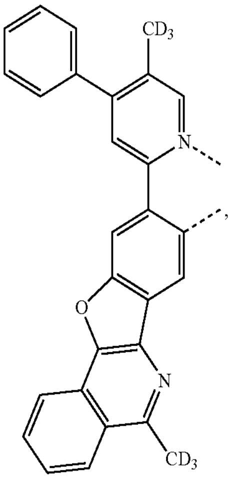

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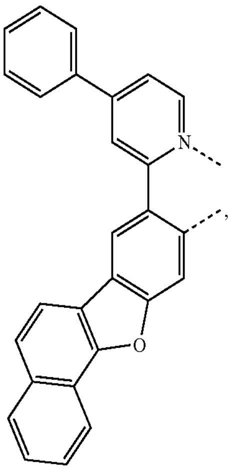

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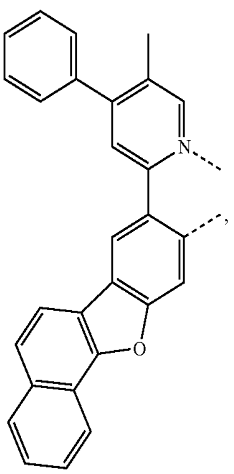

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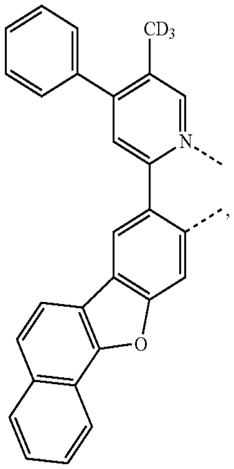

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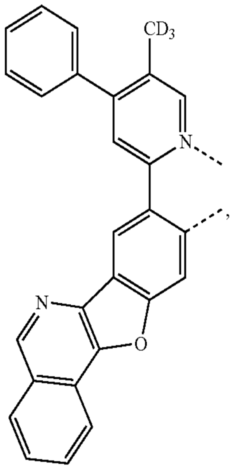

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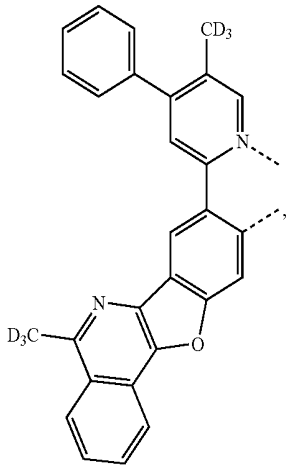

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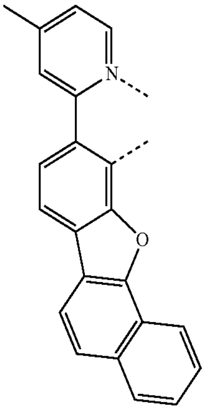

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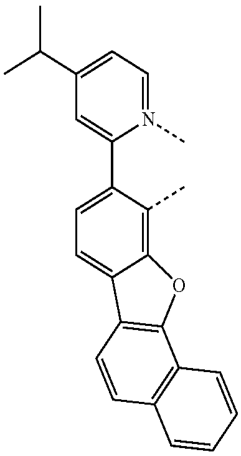

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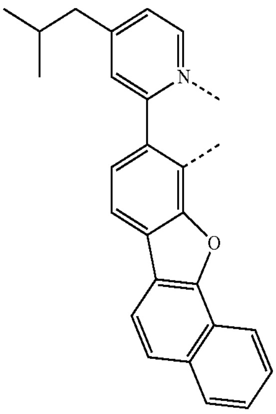

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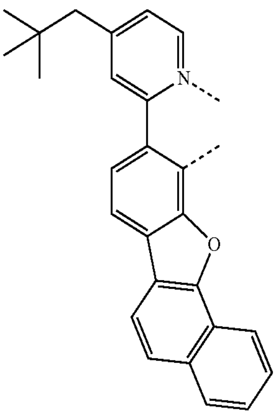

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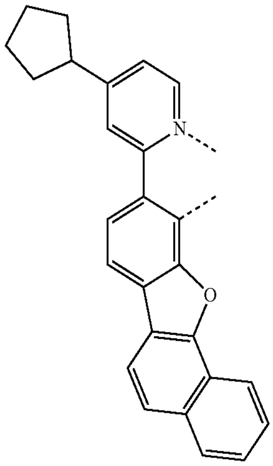

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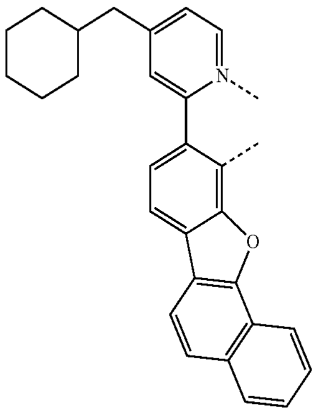

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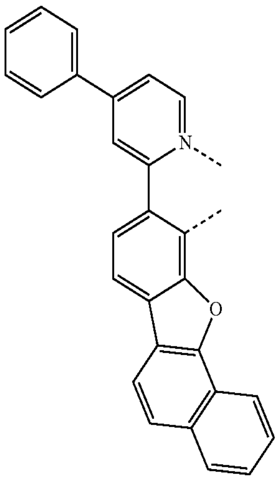

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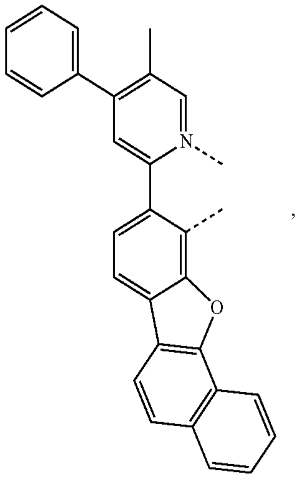

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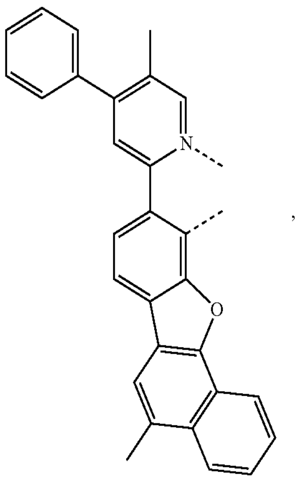

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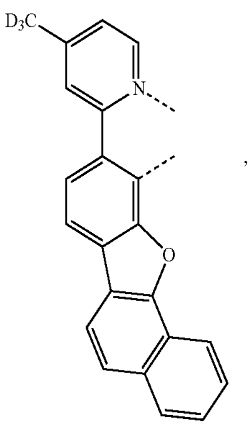

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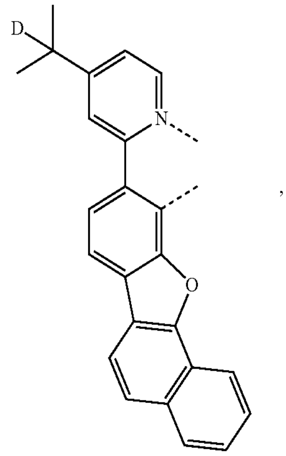

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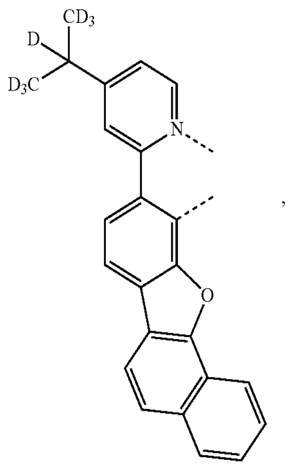

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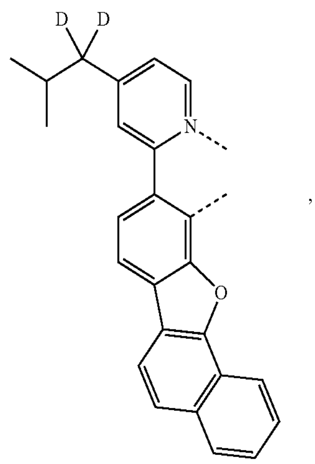

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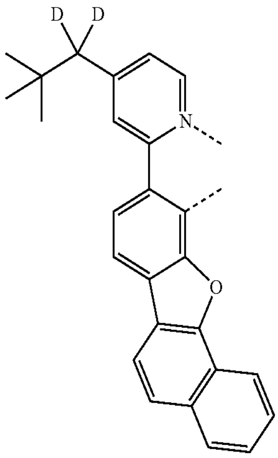

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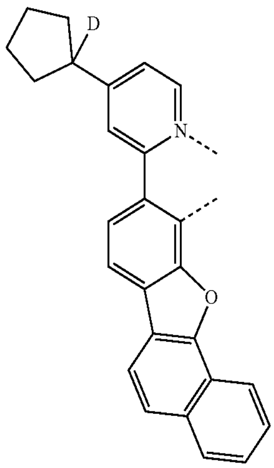

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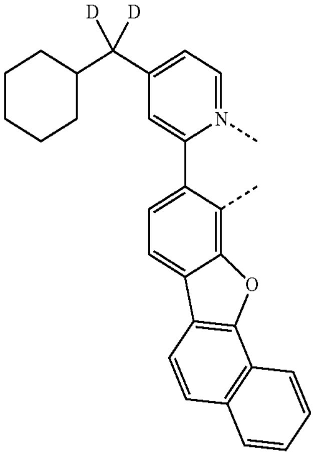

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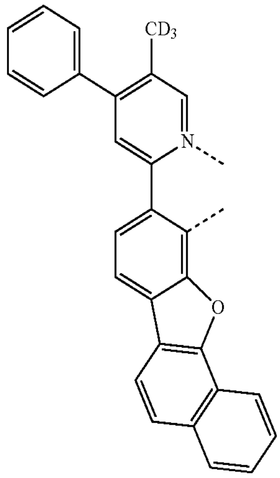

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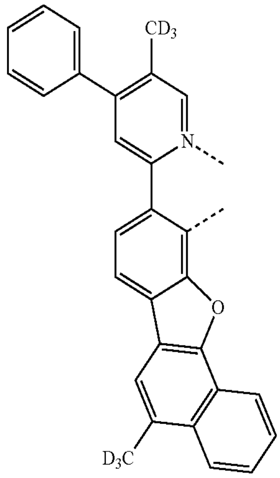

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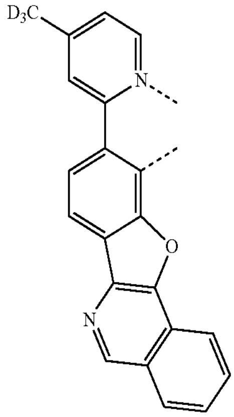

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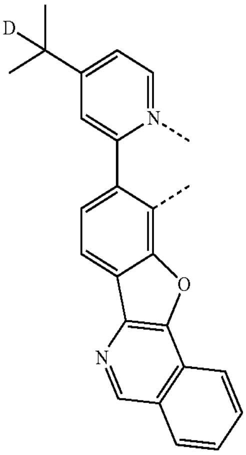

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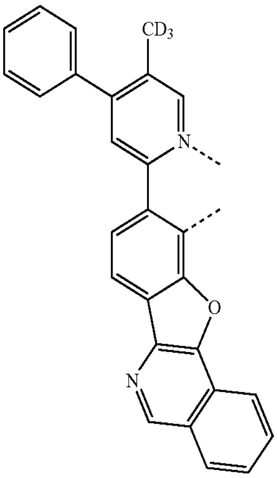

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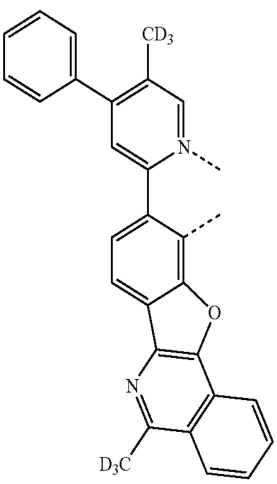

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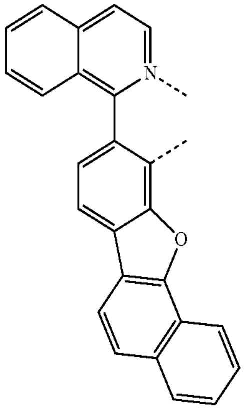

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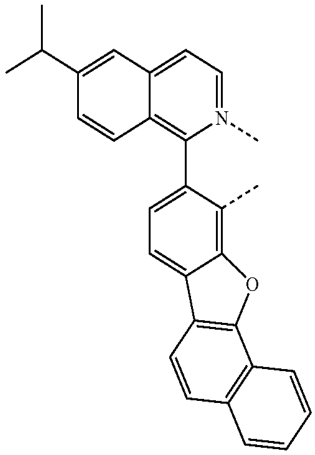

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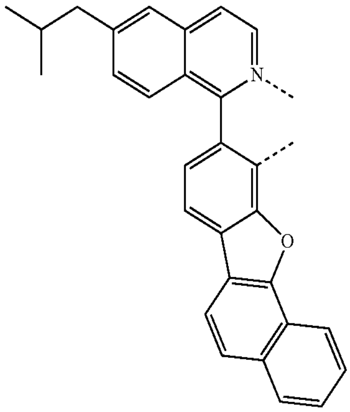

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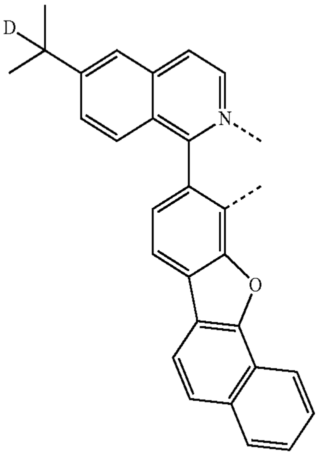
L_{A1097}



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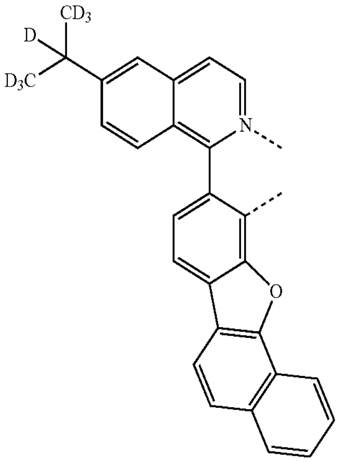

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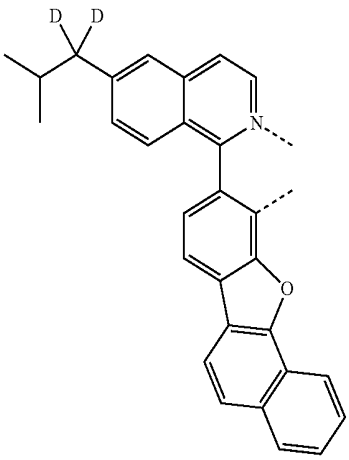

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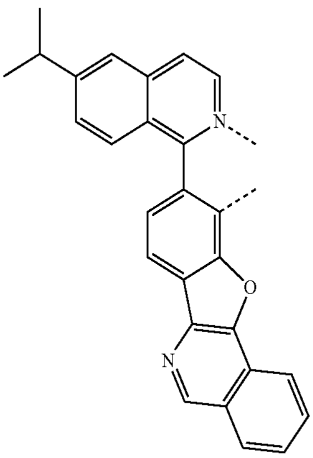

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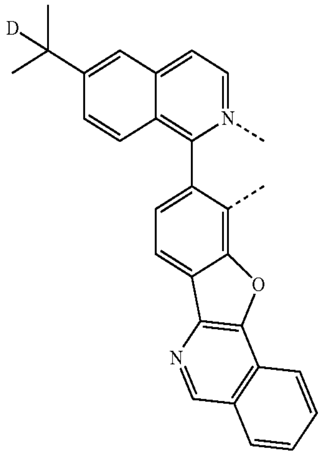

L_{A1101}

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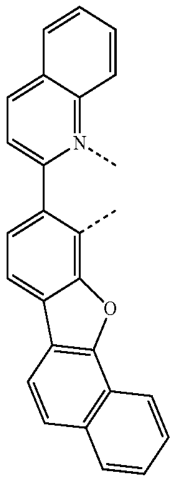

L_{A1102}

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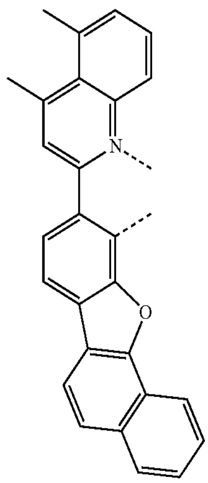

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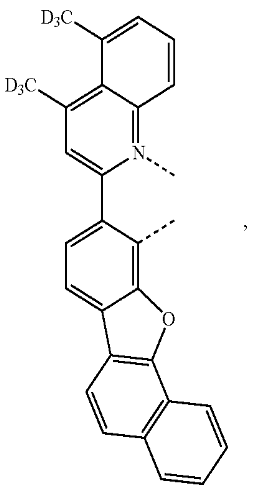

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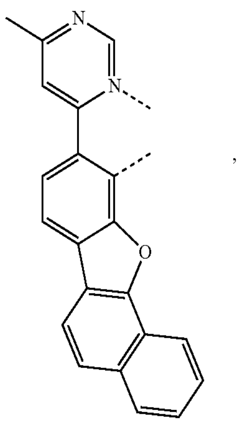
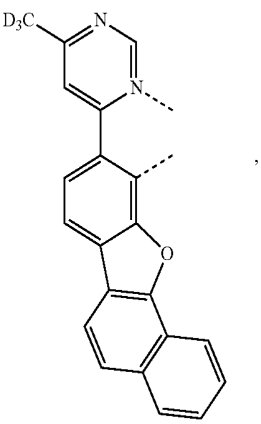


L_{A1106}



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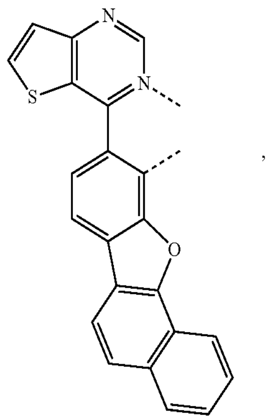

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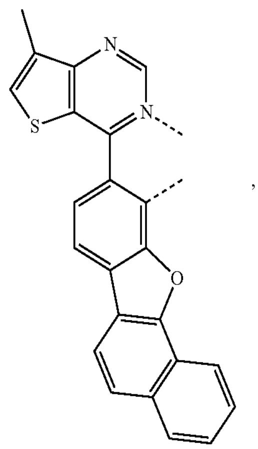

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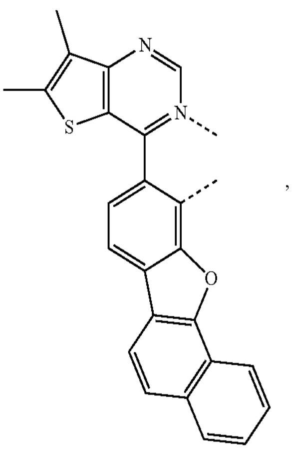

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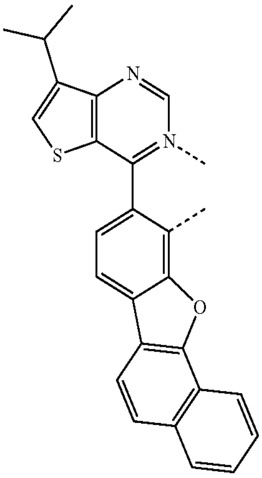

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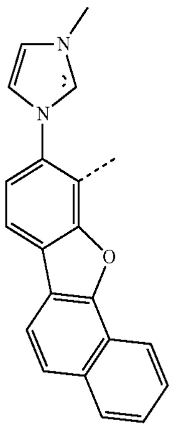
L_{A1111}



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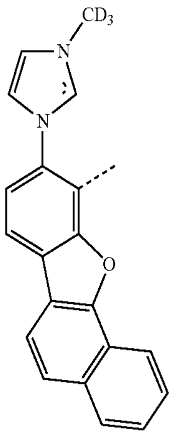

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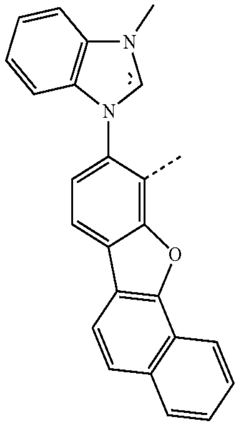

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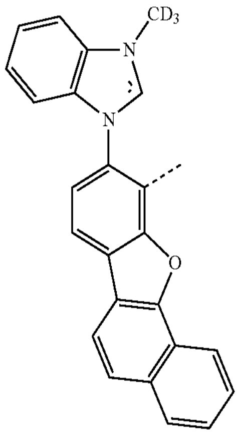

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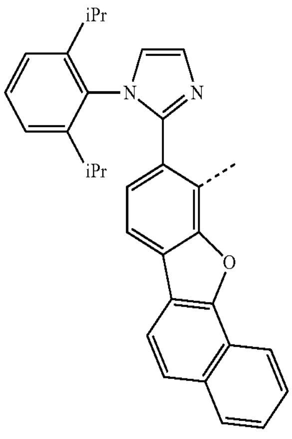
L_{A1115}



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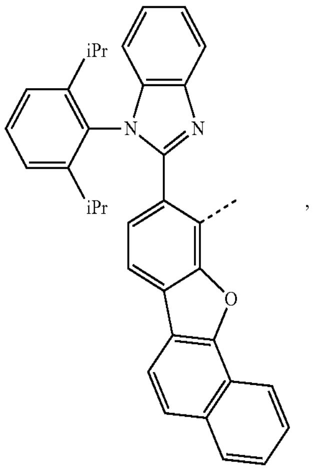
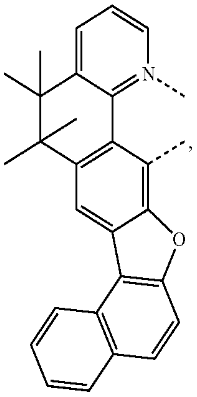
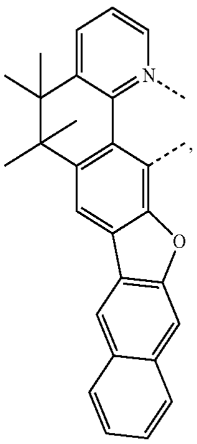


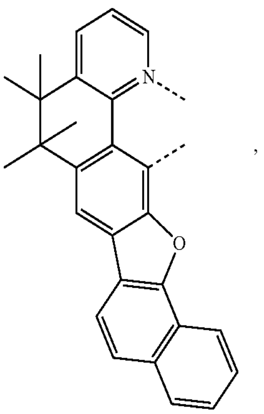
L_{A1116}



L_{A1117}



L_{A1118}



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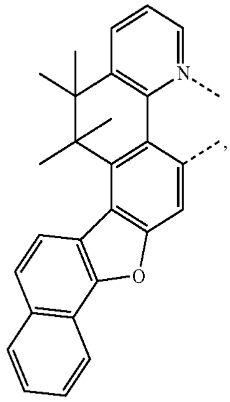
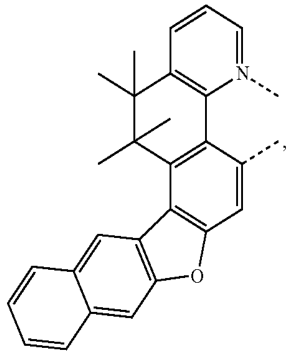
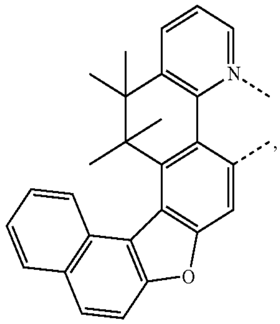


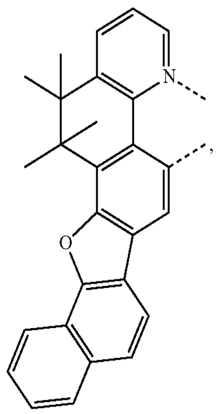
L_{A1120}



L_{A1121}



L_{A1122}



L_{A1123}

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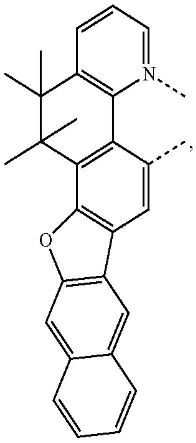
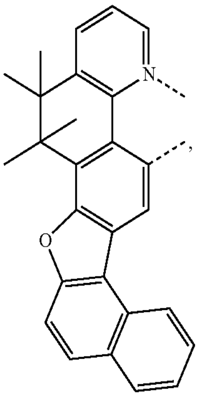


L_{A1124}



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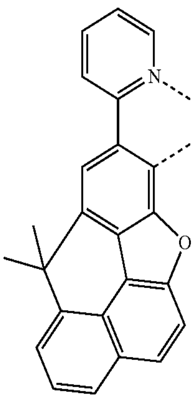
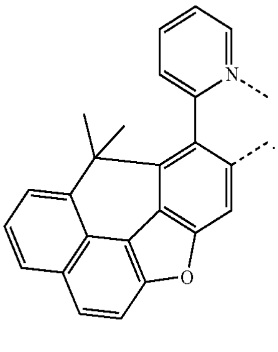


L_{A1126}

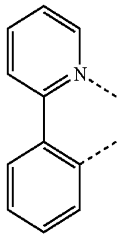
and



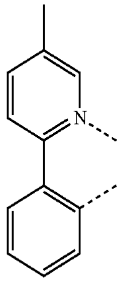
L_{A1127}

In one embodiment, the compound has the formula of $Ir(L_A)_n(L_B)_{3-n}$ or $Ir(L_A)(L_B)(L_C)$; wherein n is 1, 2, or 3.

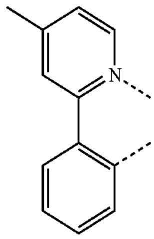
In one embodiment, the ligand L_B is selected from the group consisting of:



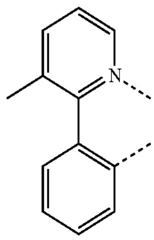
L_{B1}



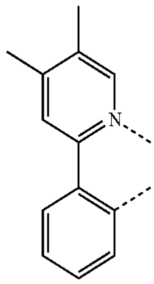
L_{B2}



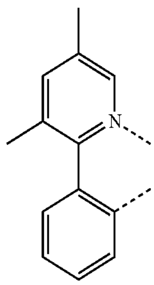
L_{B3}



L_{B4}



L_{B5}



L_{B6}

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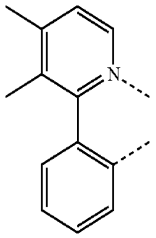
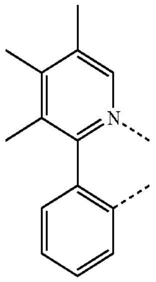
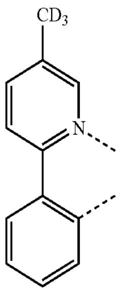
L_{B7}



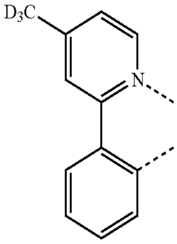
L_{B8}



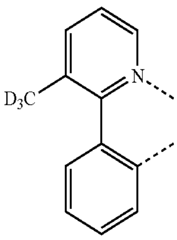
L_{B9}



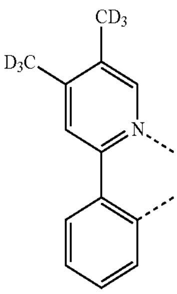
L_{B10}



L_{B11}



L_{B12}



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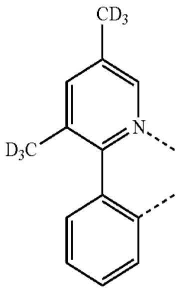
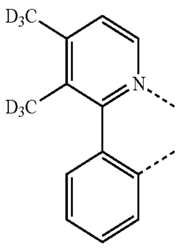
L_{B13}



L_{B14}



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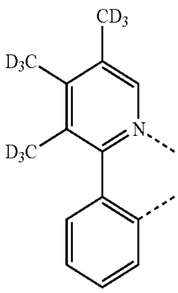

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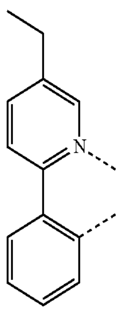
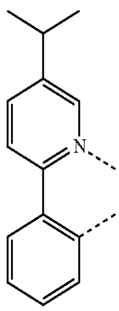
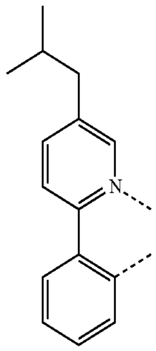


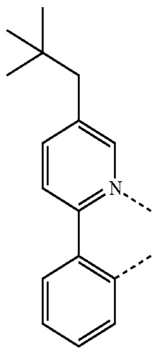
L_{B17}



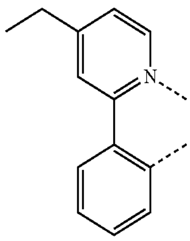
L_{B18}



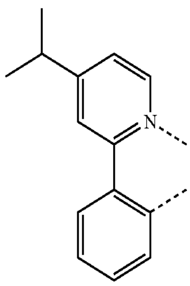
L_{B19}



L_{B20}



L_{B21}



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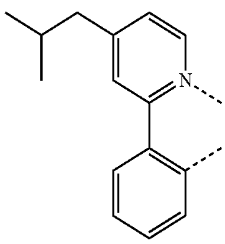
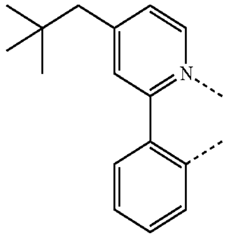
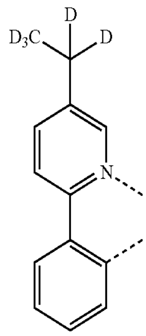


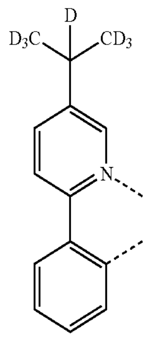
L_{B23}



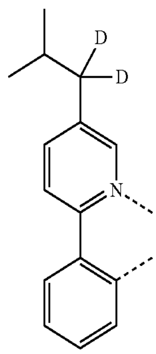
L_{B24}



L_{B25}



L_{B26}



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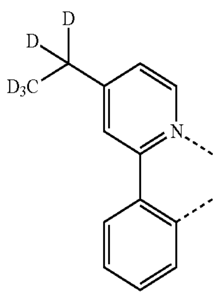

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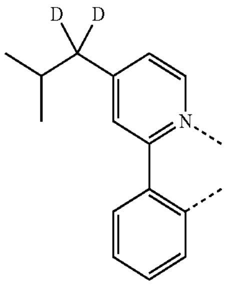

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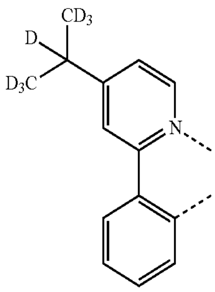

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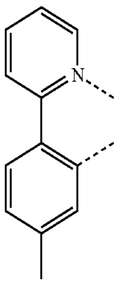

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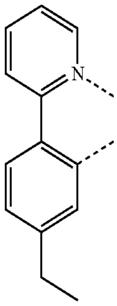

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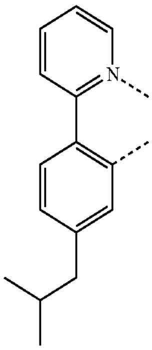

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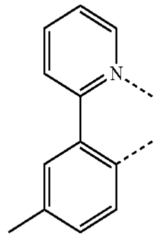

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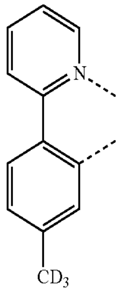
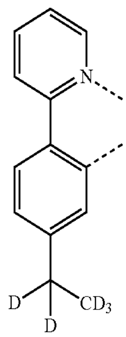


L_{B34}



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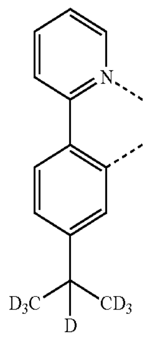
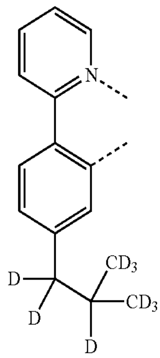


L_{B36}



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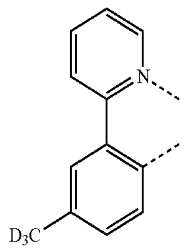
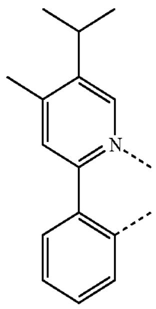
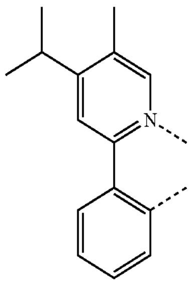
L_{B38}



L_{B39}



L_{B40}



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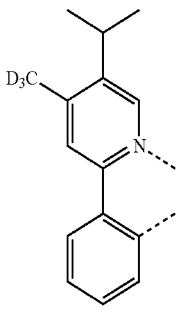

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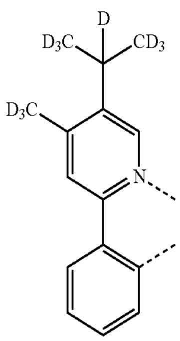

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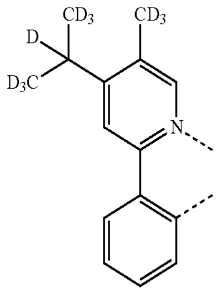

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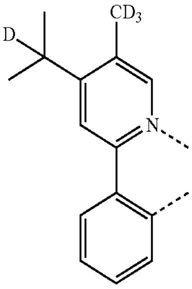

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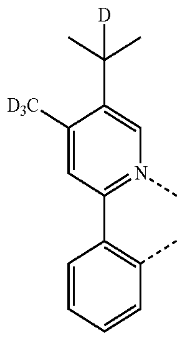

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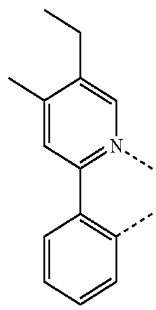

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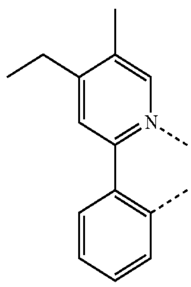

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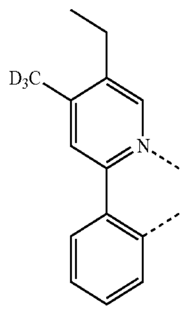

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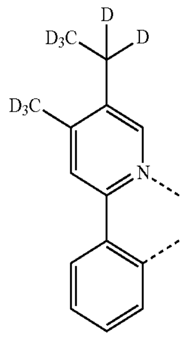

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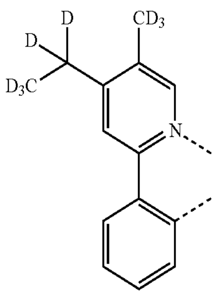

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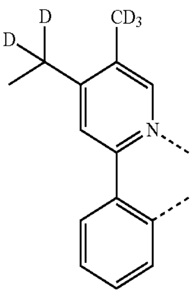

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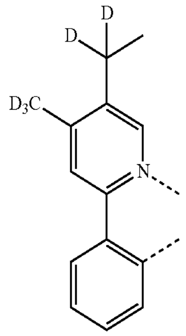

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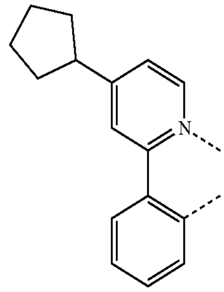

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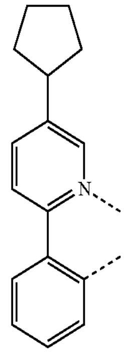

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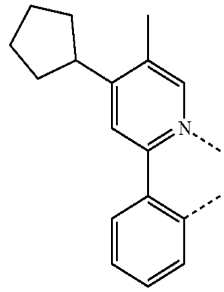

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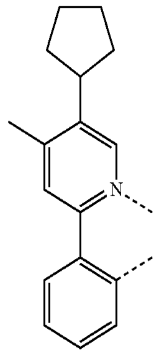

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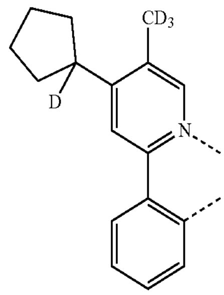

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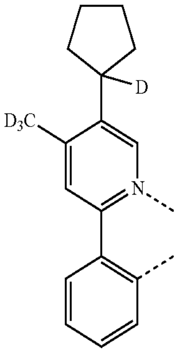

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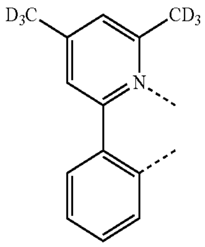

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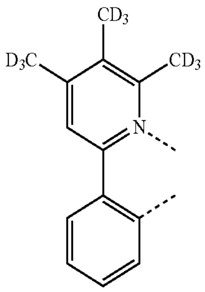

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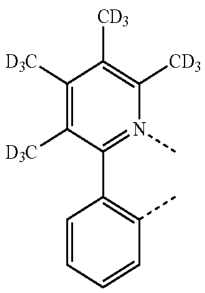

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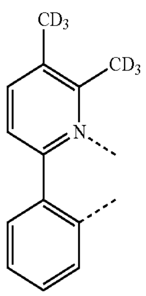

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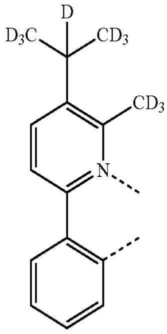

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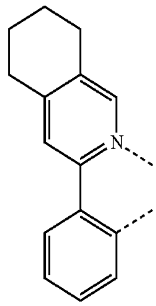

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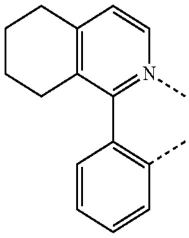

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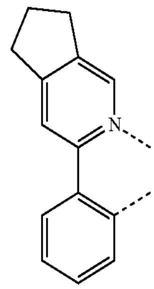

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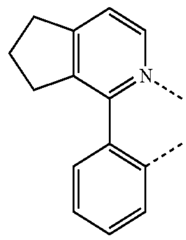

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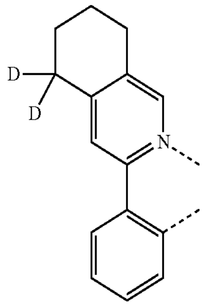

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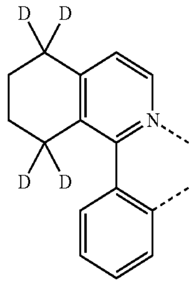

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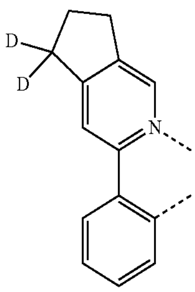

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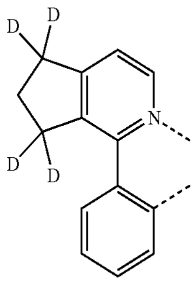

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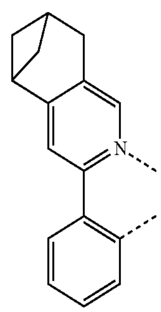

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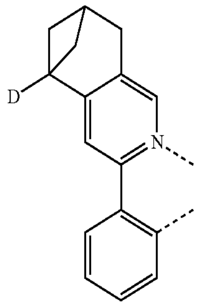

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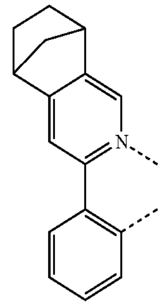

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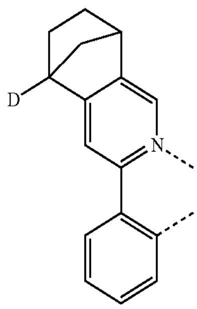

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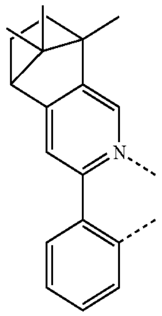

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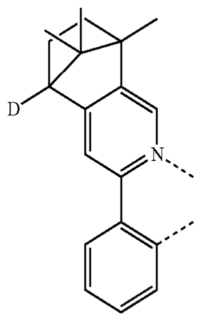

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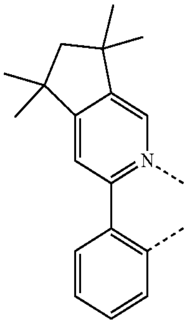
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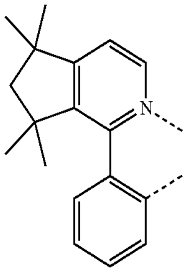
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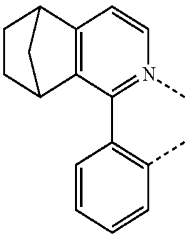
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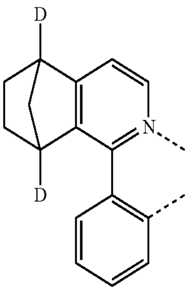
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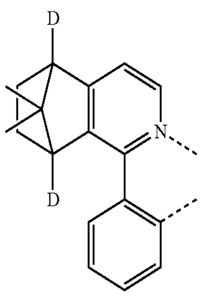
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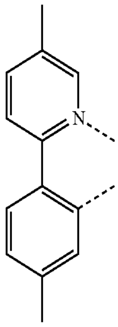
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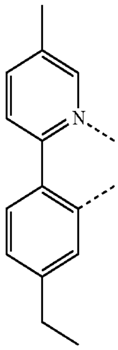
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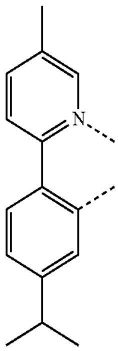
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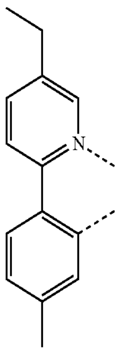
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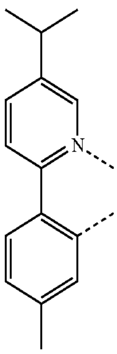

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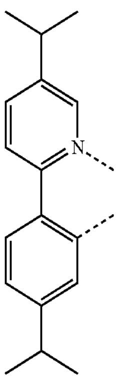

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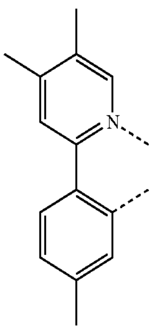

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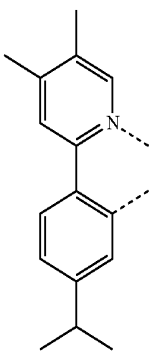

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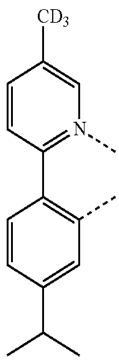

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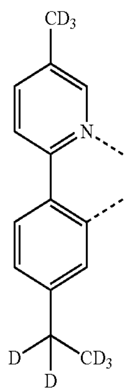

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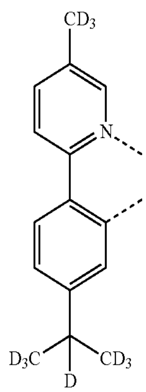

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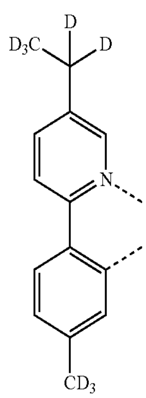

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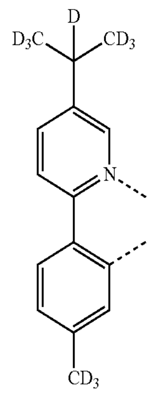

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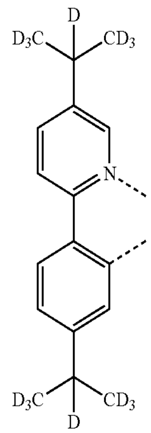

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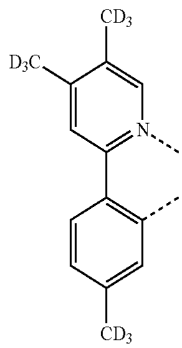

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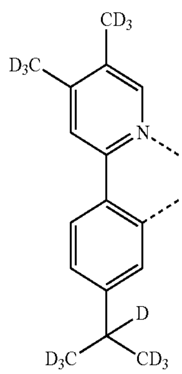

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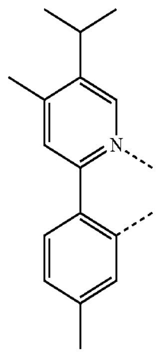

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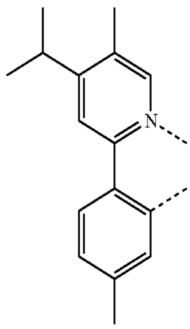

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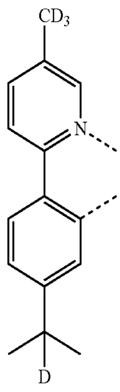

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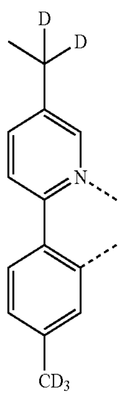

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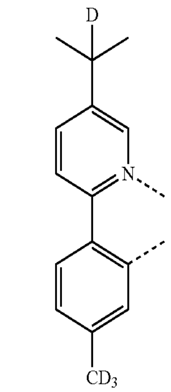

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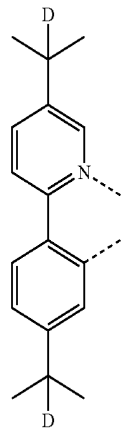

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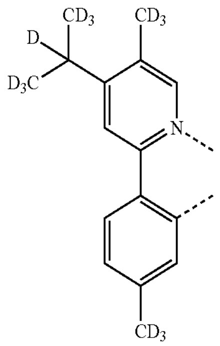

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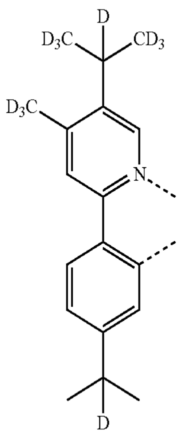

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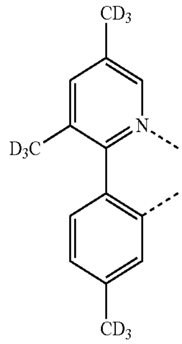

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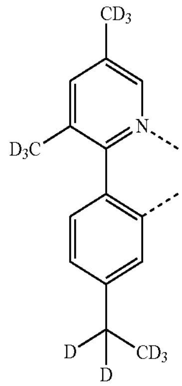

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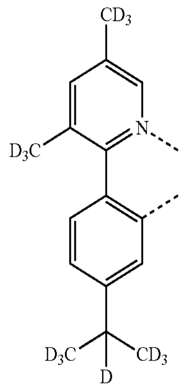

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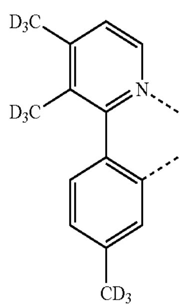

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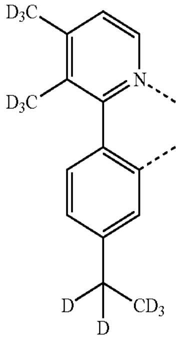

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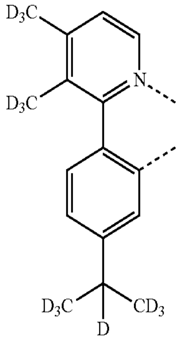

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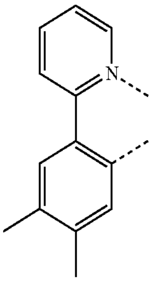

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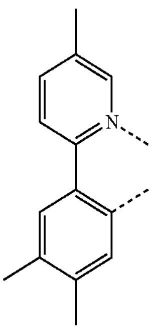

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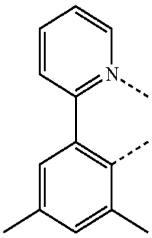

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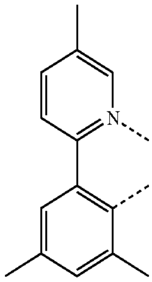

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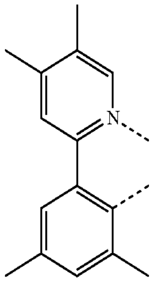

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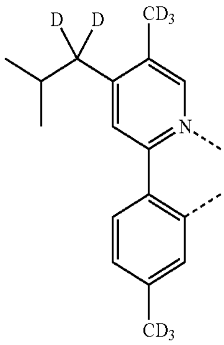

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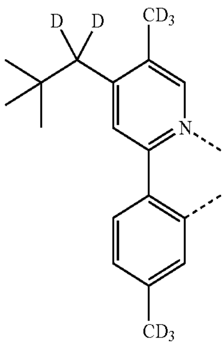

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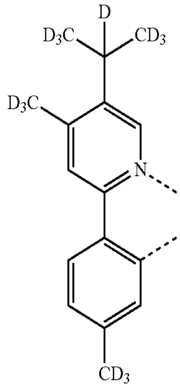

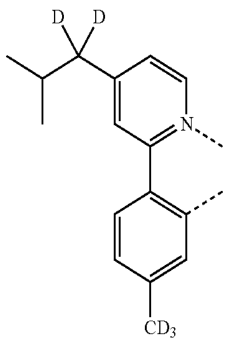
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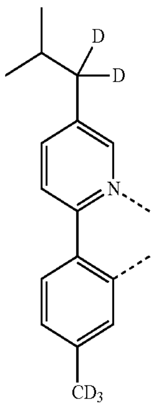
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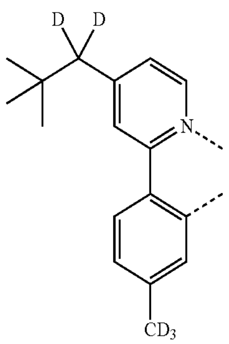
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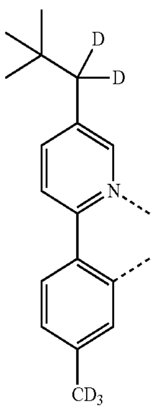
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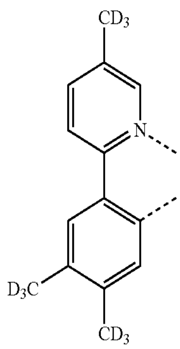
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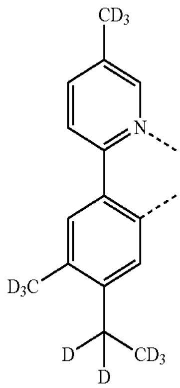
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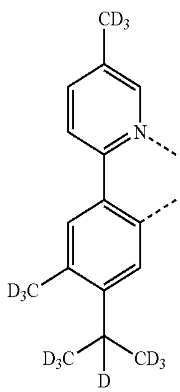
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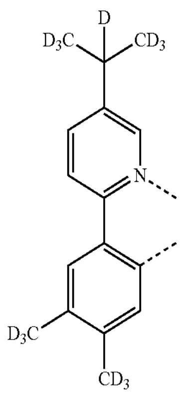
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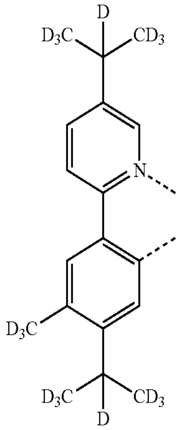

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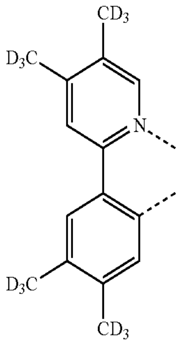

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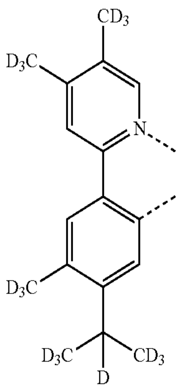

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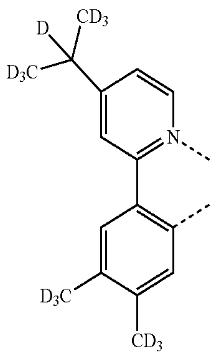

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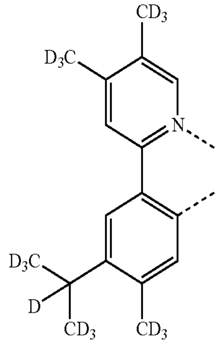

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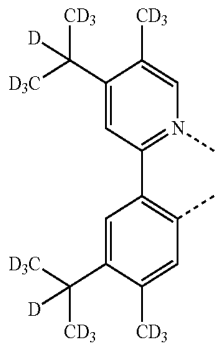

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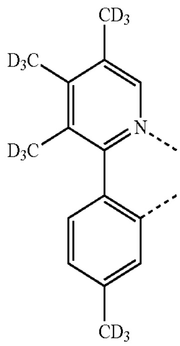

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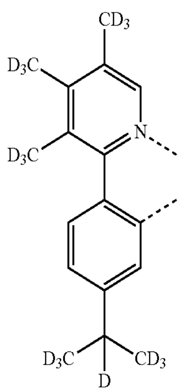

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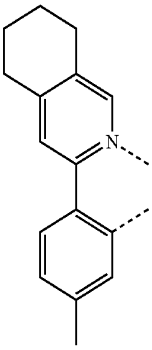

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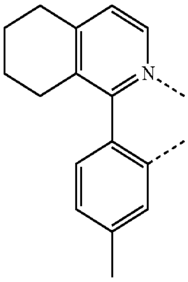

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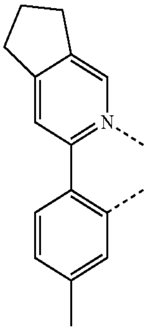

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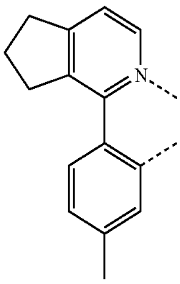

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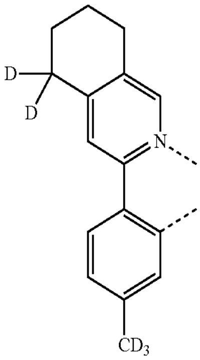

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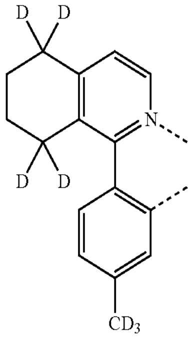

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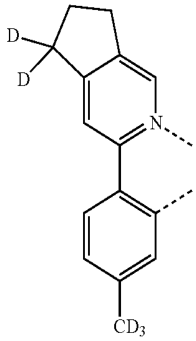

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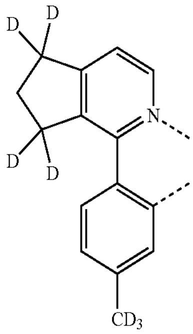

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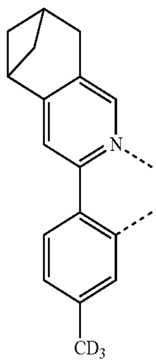

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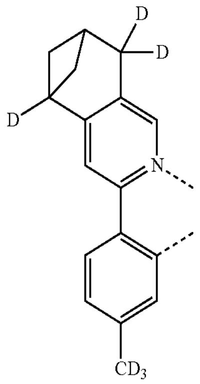

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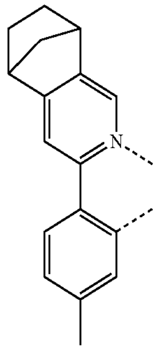

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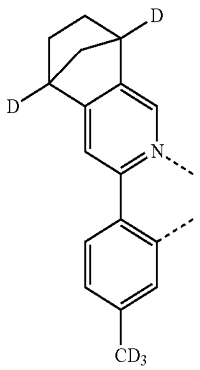

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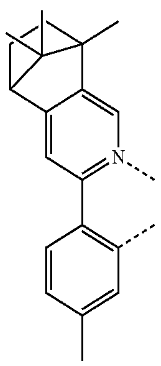

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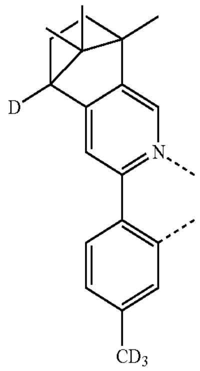

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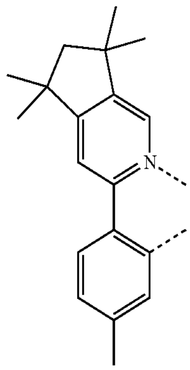

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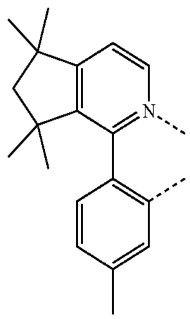

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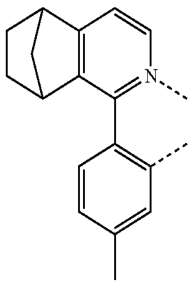

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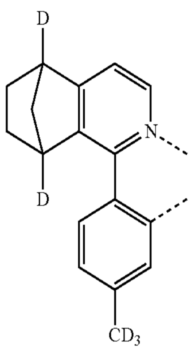

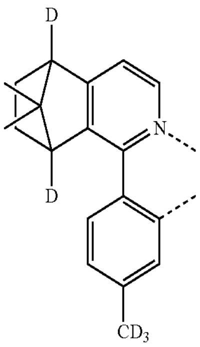

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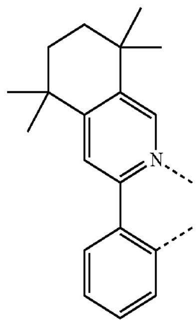

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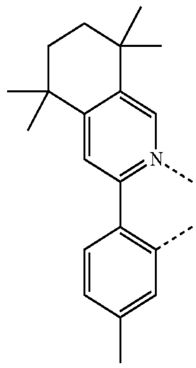

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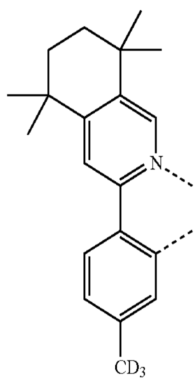

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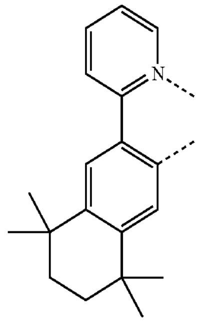

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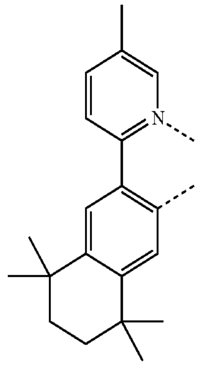

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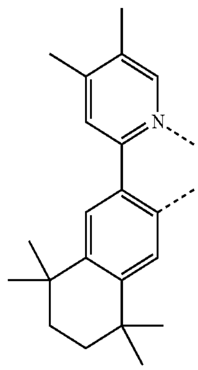

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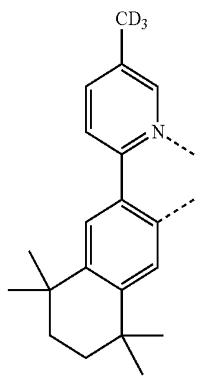

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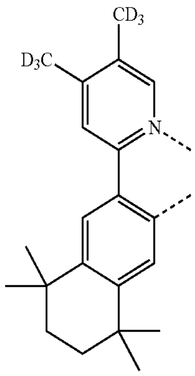

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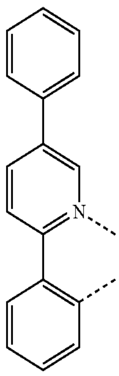

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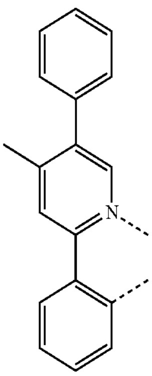

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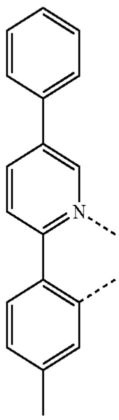

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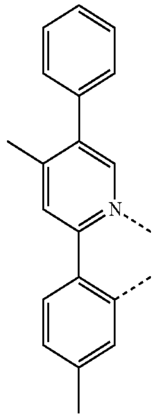

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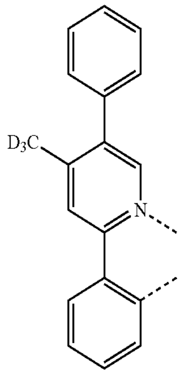

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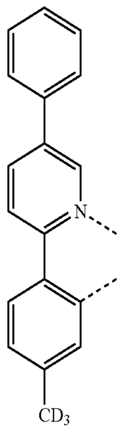

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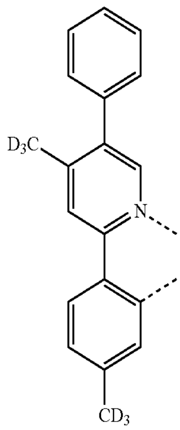

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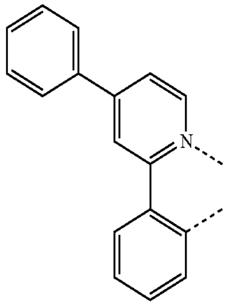

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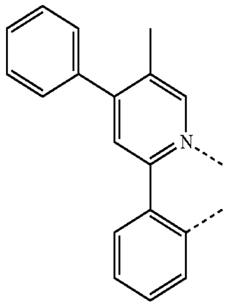

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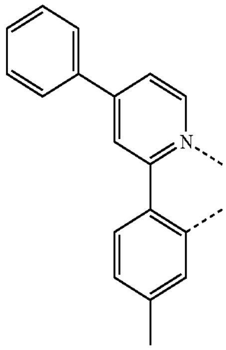

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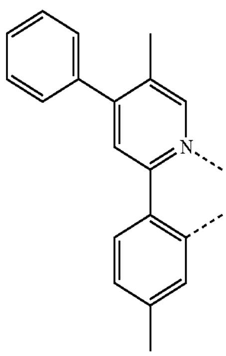

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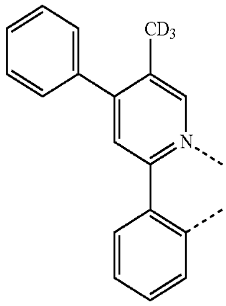

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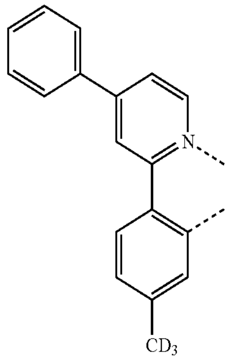

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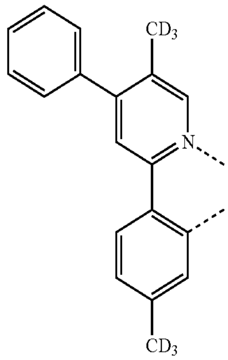

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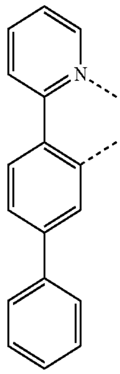

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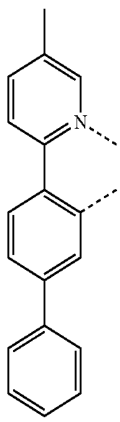

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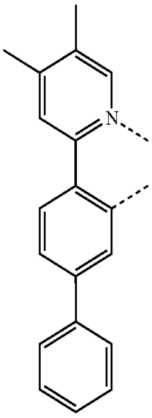

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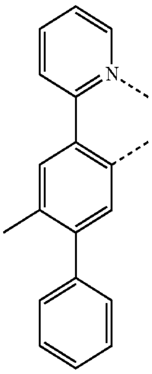

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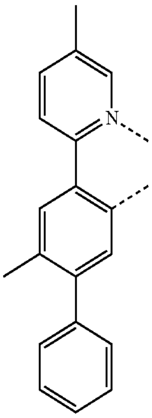

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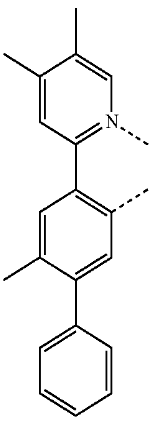

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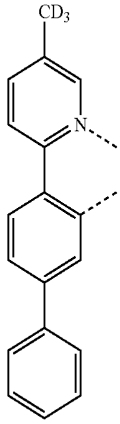

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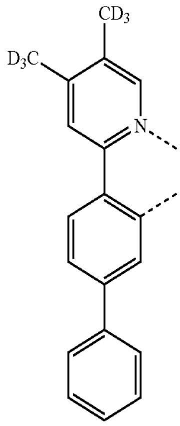

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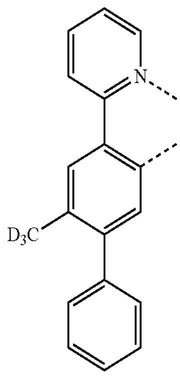

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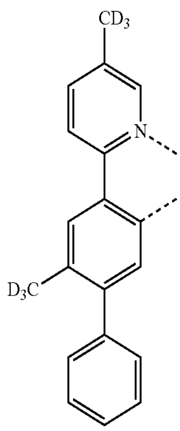

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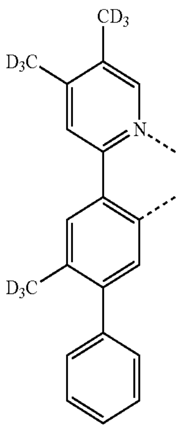

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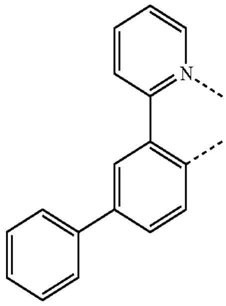

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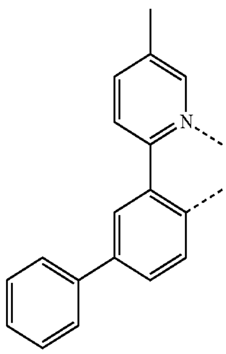

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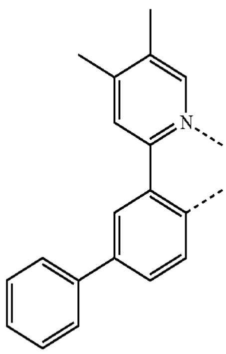

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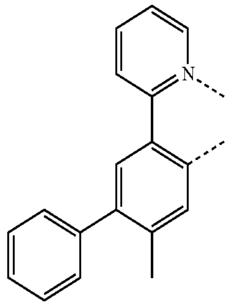

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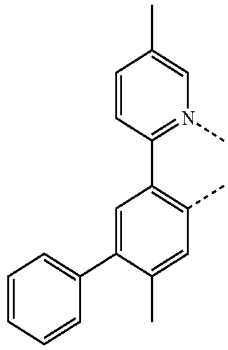

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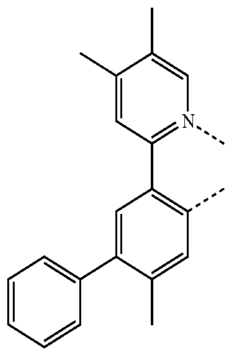

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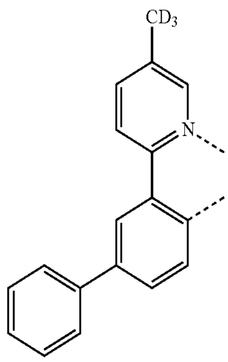

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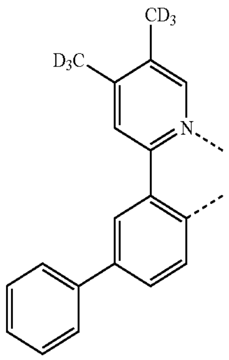

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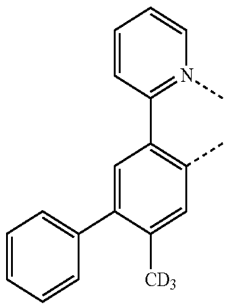

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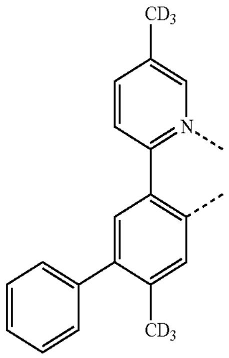

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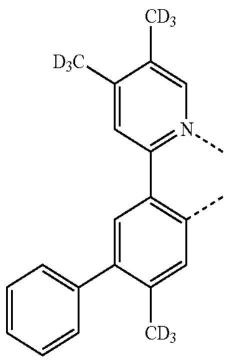

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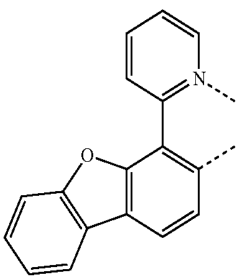

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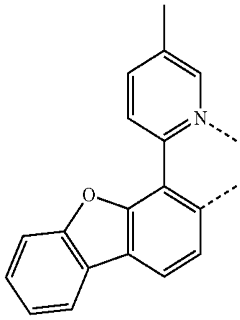

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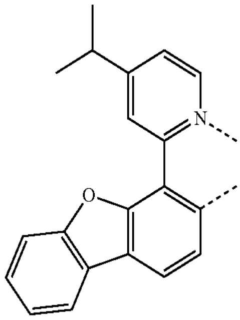

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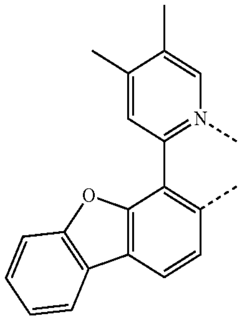

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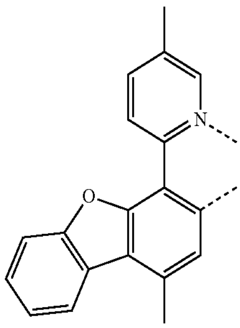

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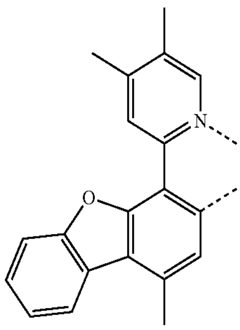

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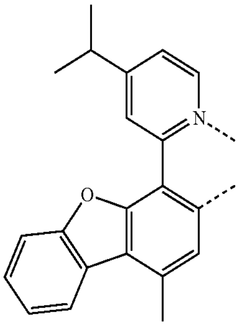

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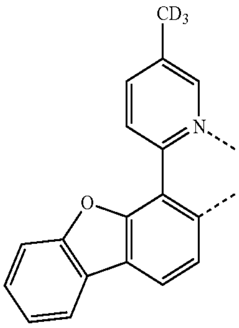

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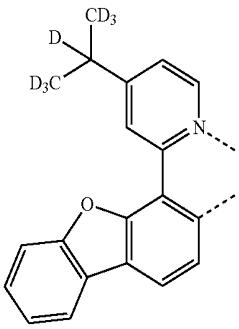

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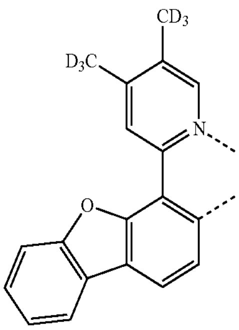

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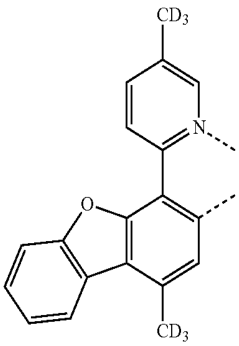

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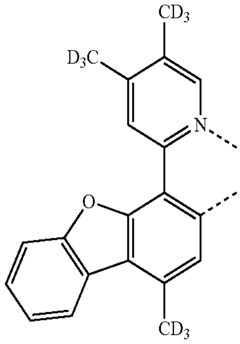

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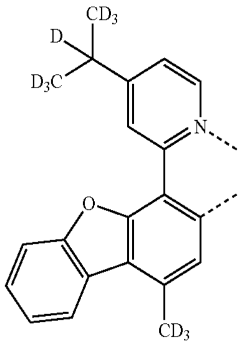

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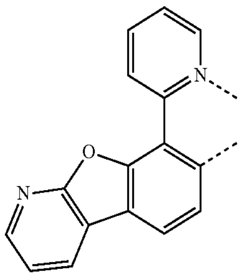

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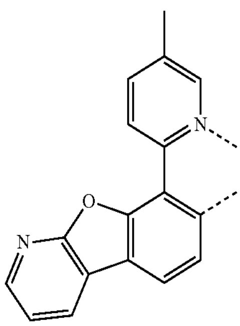

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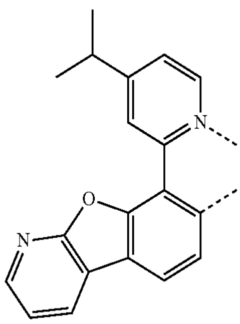

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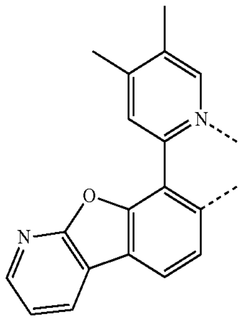

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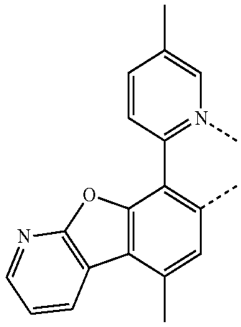

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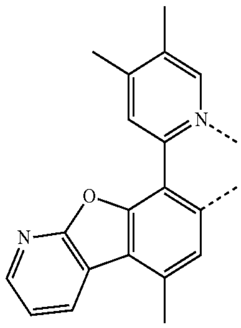

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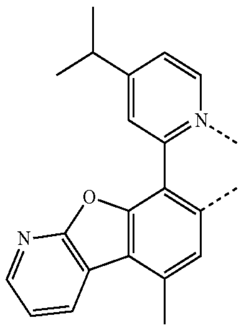

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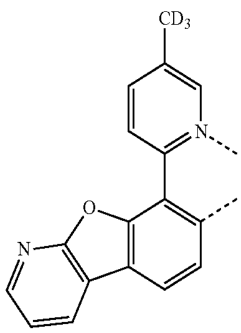

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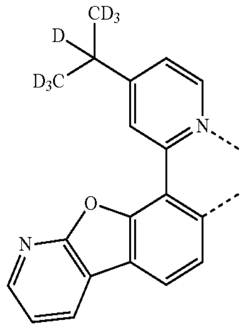

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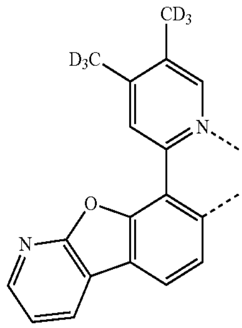

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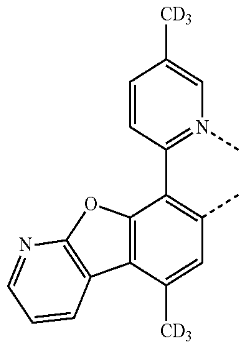

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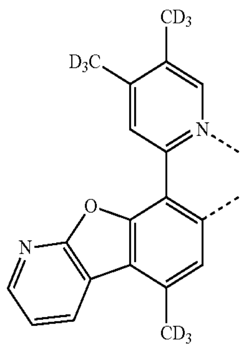

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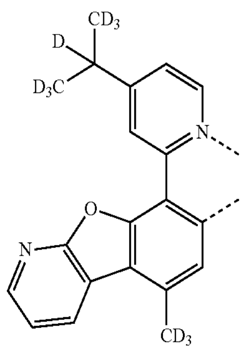

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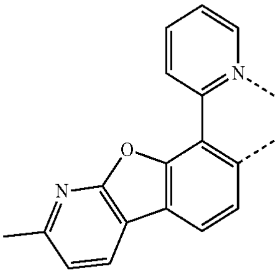

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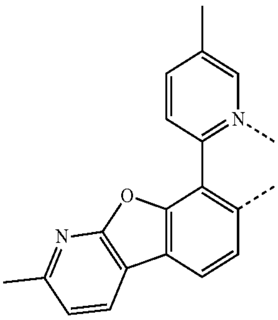

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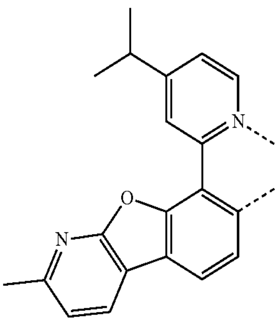

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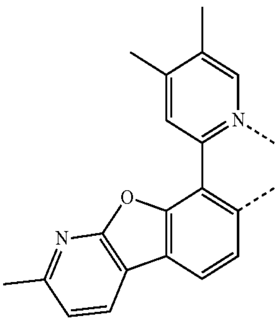

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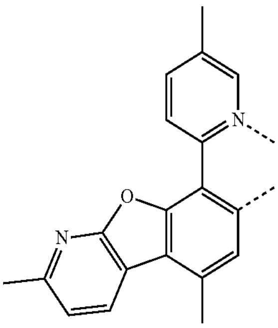

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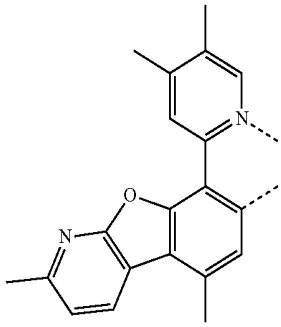

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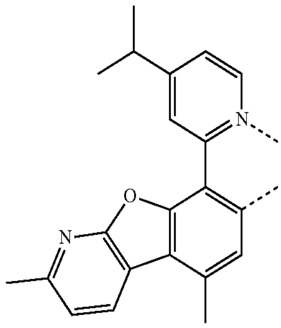

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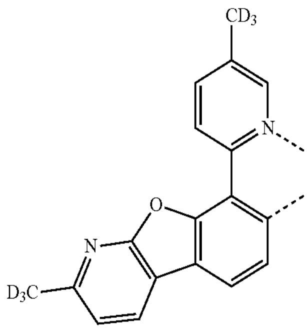

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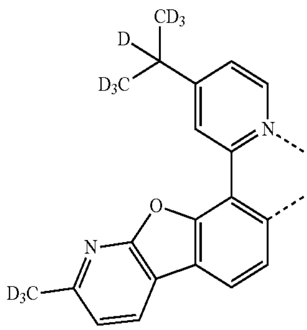

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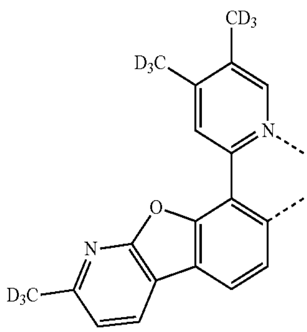

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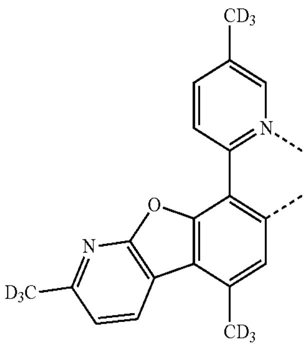

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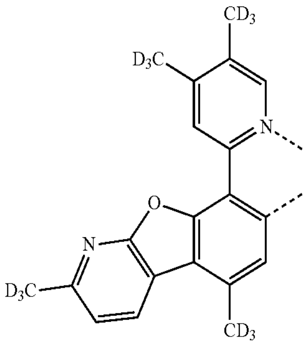

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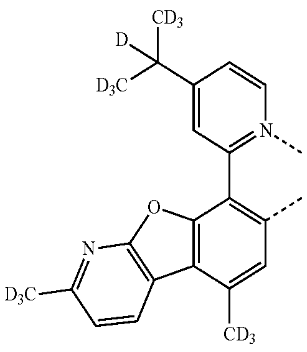

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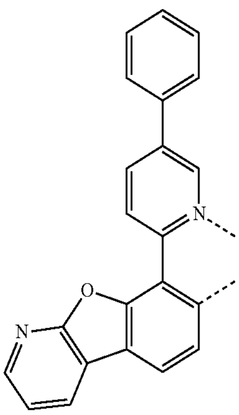

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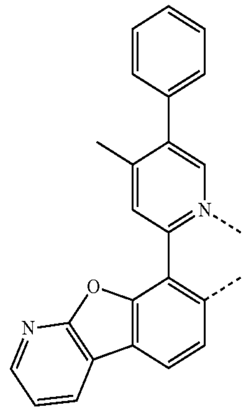

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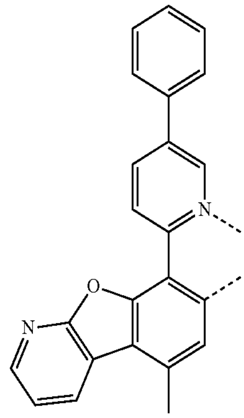

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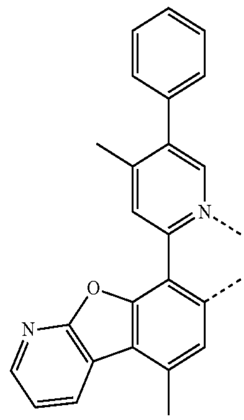

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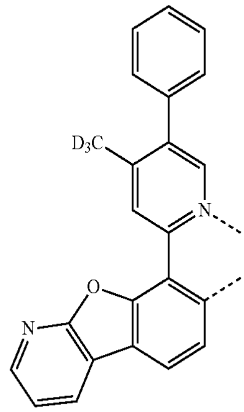

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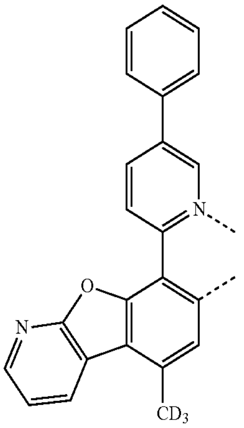

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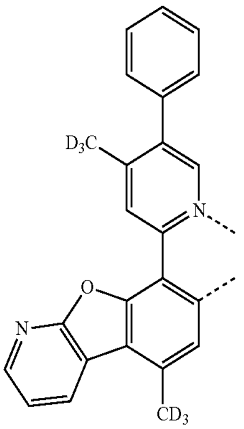

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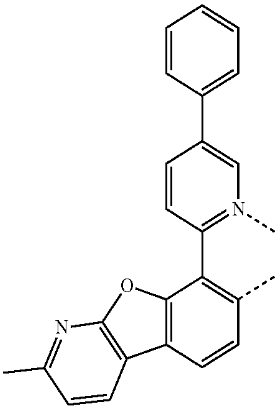

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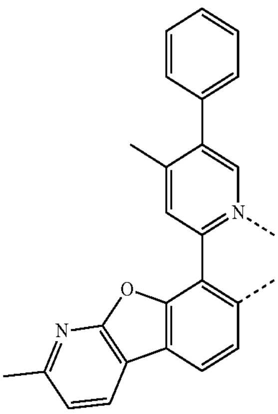

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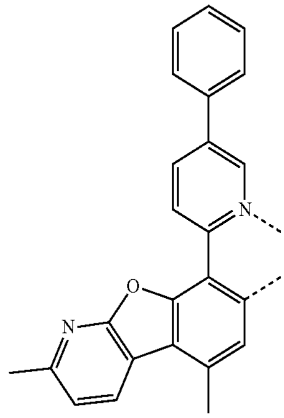

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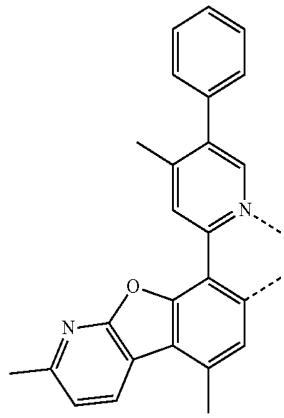

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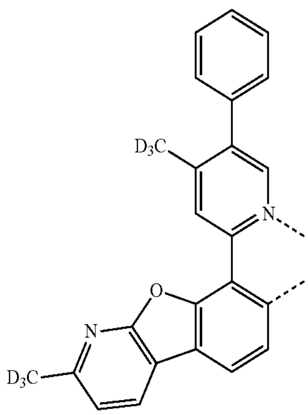

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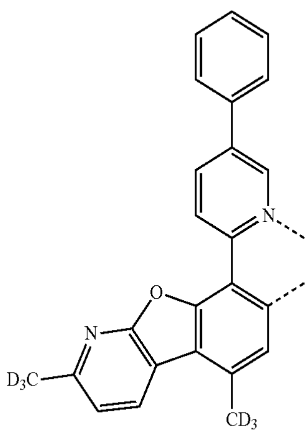

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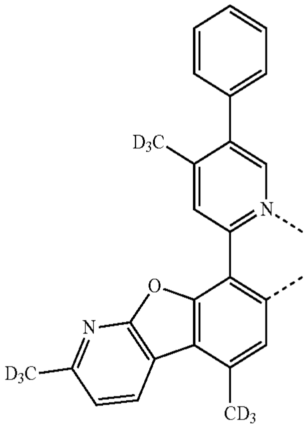

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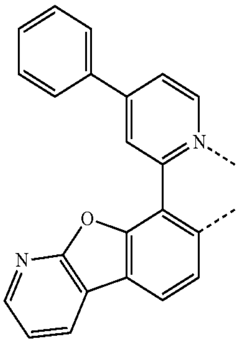

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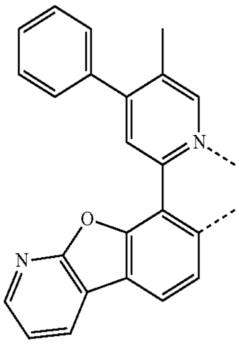

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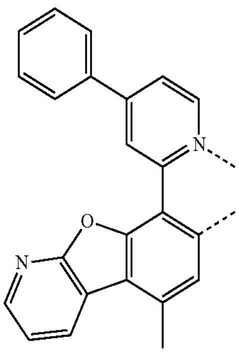

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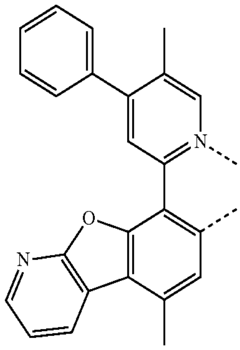

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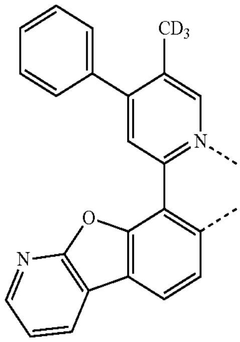
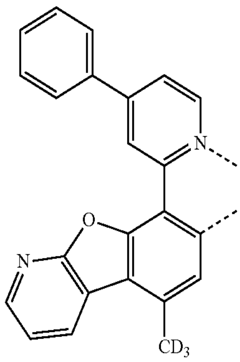


L_{B258}



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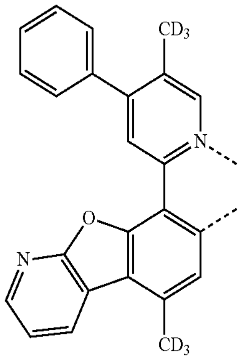

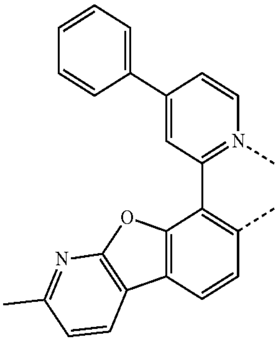

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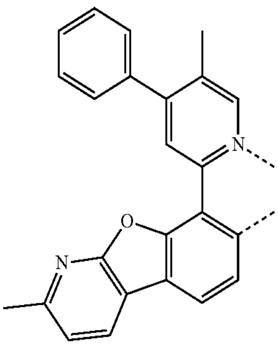

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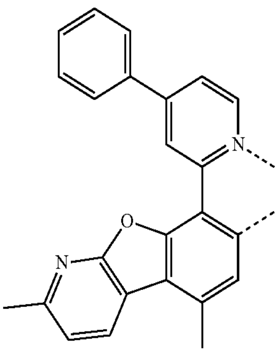

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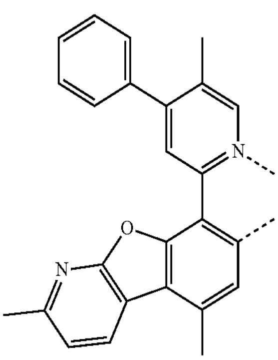

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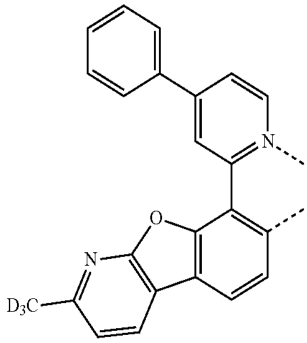

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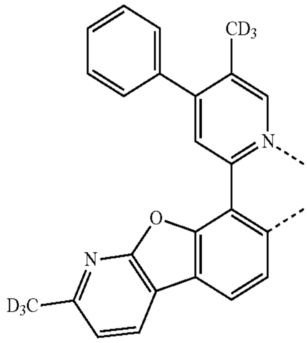

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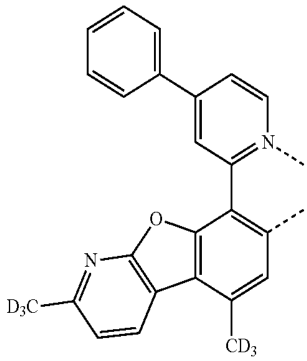

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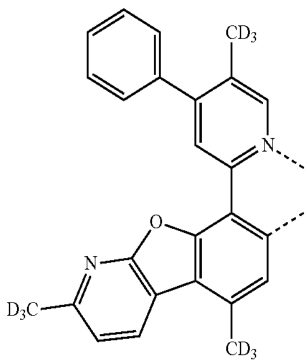

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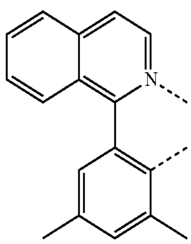

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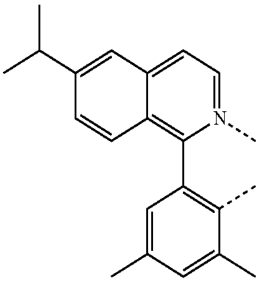
L_{B269}



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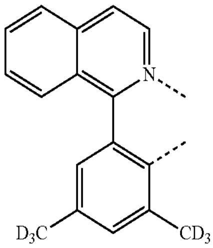

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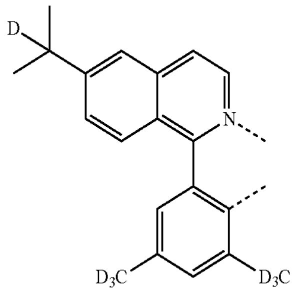

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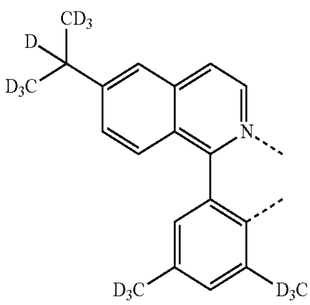

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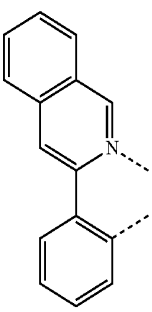

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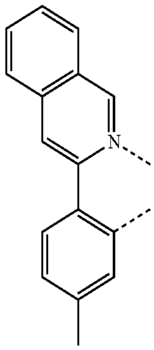

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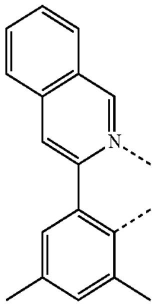

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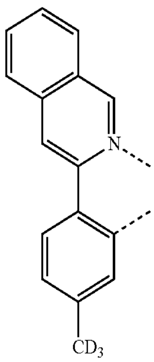

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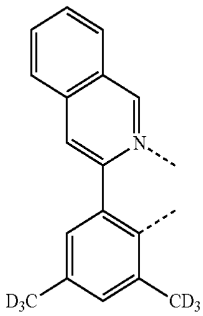

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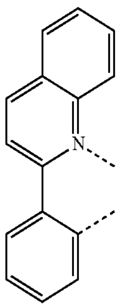

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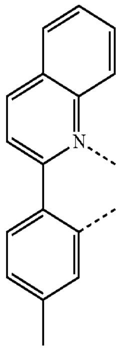

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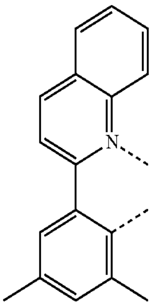

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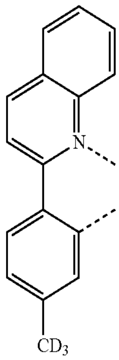

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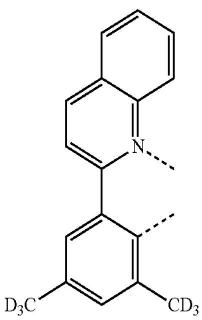

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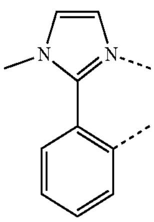

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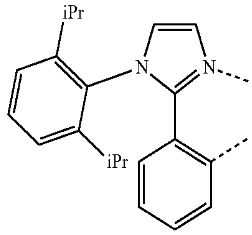

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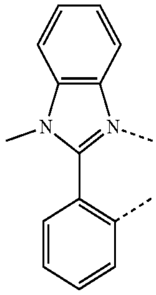

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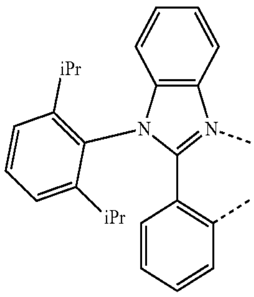

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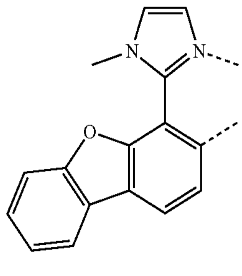

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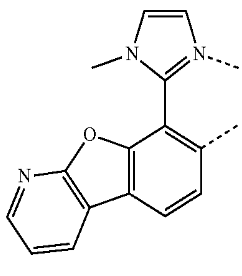

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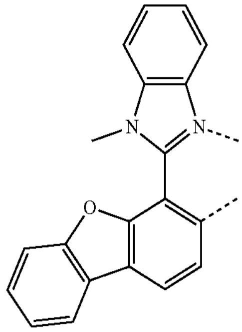
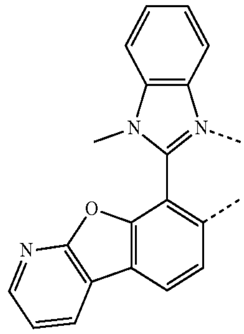


L_{B289}

L$_{B290}$



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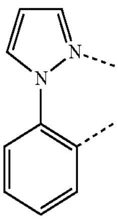

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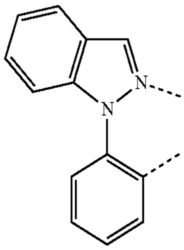

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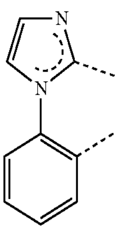
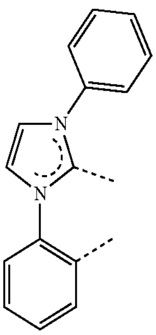
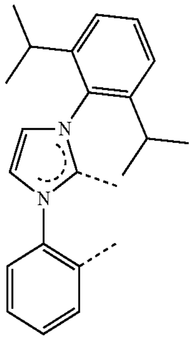


L$_{B294}$



L$_{B295}$



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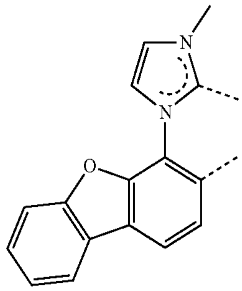

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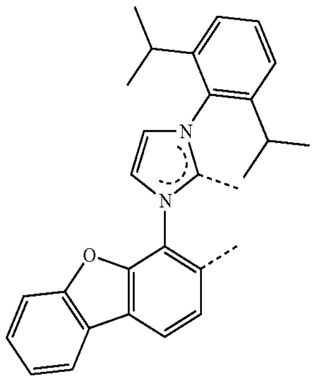

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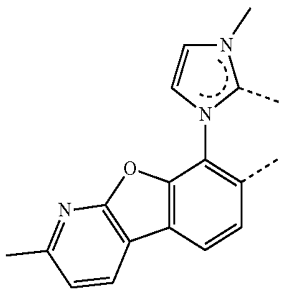
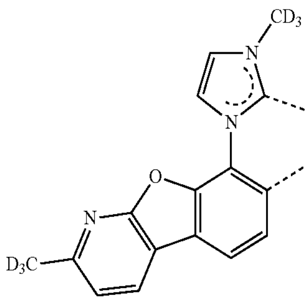


L$_{B299}$



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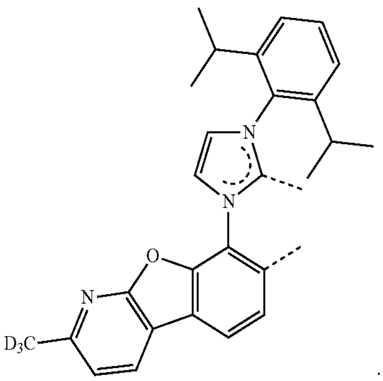
L$_{B300}$



In one embodiment, the compound is the Compound A-x having the formula $Ir(L_{Ai})(L_{Bj})_2$;

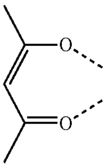
wherein x=300i+j−300; i is an integer from 1 to 1127, and j is an integer from 1 to 300.

In one embodiment, the compound is the Compound B-y having the formula $Ir(L_{Ai})_2(L_{Ck})$;

wherein y=13i+k−13; i is an integer from 1 to 1127, and k is an integer from 1 to 13; and

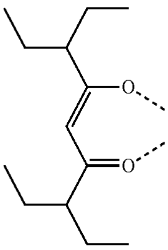
wherein L_{Ck} has the following formula:

L$_{C1}$



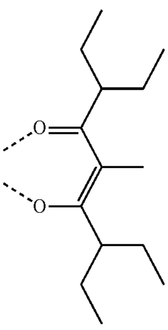
,

L$_{C2}$



,

L$_{C3}$



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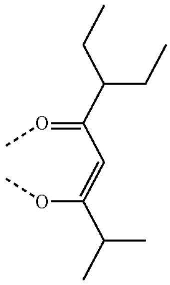
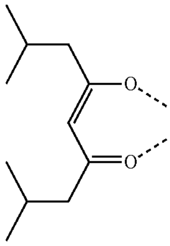
L$_{C4}$



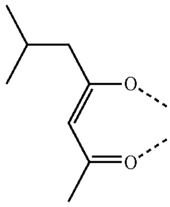
,

L$_{C5}$



,

L$_{C6}$



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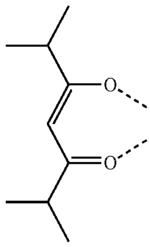
L$_{C7}$



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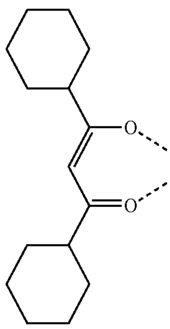
L$_{C8}$



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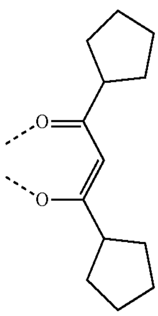
L$_{C9}$



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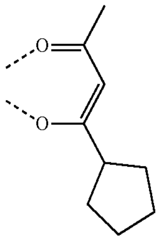
L_{C10}



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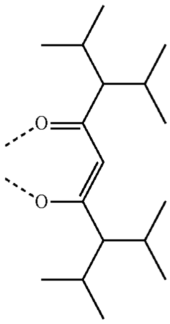
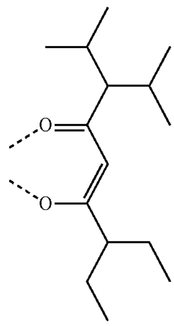
L_{C11}



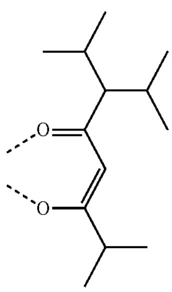
,

L_{C12}



, and

L_{C13}



.

In one embodiment, the compound has the formula of $M(L_A)_x(L_B)_y(L_C)_z$;

wherein L_B is a second ligand, and L_C is a third ligand, and L_B and L_C can be the same or different:

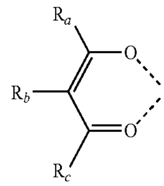
wherein x is 1, 2, or 3;

wherein y is 0, 1, or 2;

wherein z is 0, 1, or 2;

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

wherein the second ligand L_B and the third ligand L_C are each independently selected from the group consisting of:



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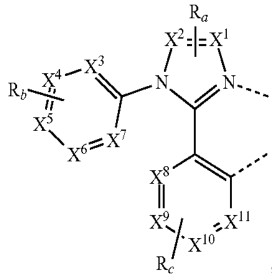

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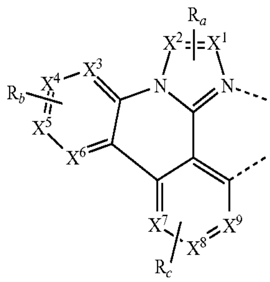

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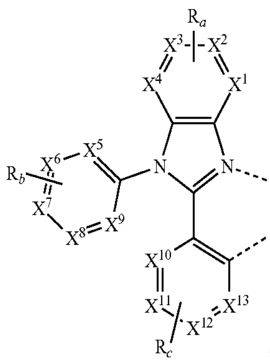

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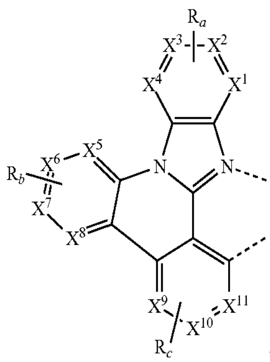

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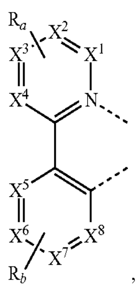

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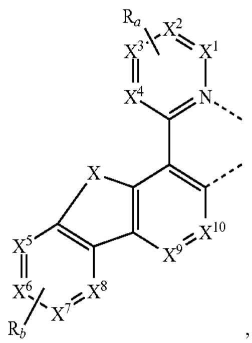

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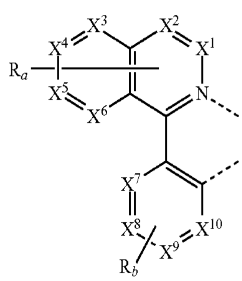

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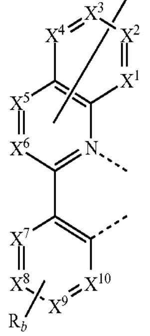

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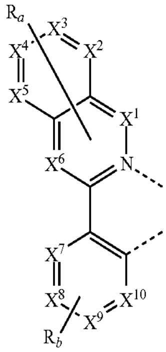

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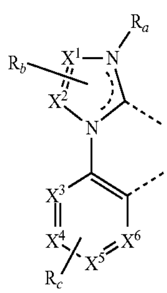

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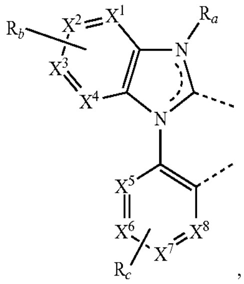
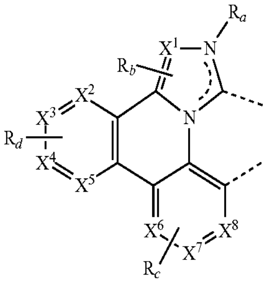
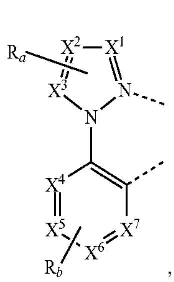
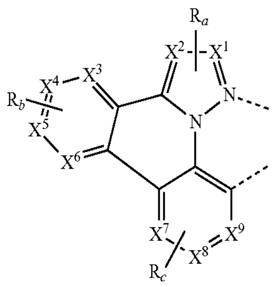
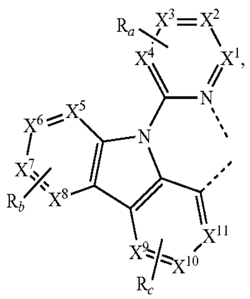
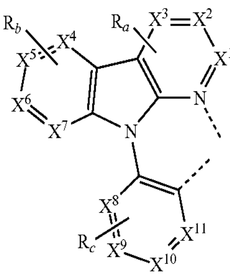
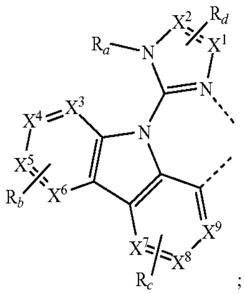
 ,
 ,

 ,
 ,

 ,
 , and

 ;

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

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

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

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

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

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

In some embodiments, the compound can be an emissive dopant. In some embodiments, the compound can produce

emissions via phosphorescence, fluorescence, thermally activated delayed fluorescence, i.e., TADF (also referred to as E-type delayed fluorescence), triplet-triplet annihilation, or combinations of these processes.

According to another aspect of the present disclosure, an OLED is also provided. The OLED includes an anode, a cathode, and an organic layer disposed between the anode and the cathode. The organic layer may include a host and a phosphorescent dopant. The organic layer can include a compound that includes a first ligand L_A having Formula I, and its variations as described herein.

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

According to another aspect of the present disclosure, a consumer product comprising an OLED is provided. The OLED may include an anode, a cathode, and an organic layer disposed between the anode and the cathode. The organic layer may include a host and one or more emitter dopants. In one embodiment, the organic layer includes a compound that includes a first ligand L_A having Formula I.

Non-limiting examples of consumer products include flat panel 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, laser printers, telephones, cell phones, tablets, phablets, personal digital assistants (PDAs), wearable device, laptop computers, digital cameras, camcorders, viewfinders, micro-displays, 3-D 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 screens, and/or signs.

The organic layer can also include a host. In some embodiments, two or more hosts are preferred. In some embodiments, the hosts used maybe a) bipolar, b) electron transporting, c) hole transporting or d) wide band gap materials that play little role in charge transport. In some embodiments, the host can include a metal complex. The host can be a triphenylene containing benzo-fused thiophene or benzo-fused furan. Any substituent in the host can be an unfused substituent independently selected from the group consisting of C_nH_{2n+1}, OC_nH_{2n+1}, OAr_1, $N(C_nH_{2n+1})_2$, $N(Ar_1)(Ar_2)$, CH═CH—C_nH_{2n+1}, C≡C—C_nH_{2n+1}, Ar_1, Ar_1—Ar_2, and C_nH_{2n}—Ar_1, or the host has no substitution. In the preceding substituents n can range from 1 to 10; and Ar_1 and Ar_2 can be independently selected from the group consisting of benzene, biphenyl, naphthalene, triphenylene, carbazole, and heteroaromatic analogs thereof. The host can be an inorganic compound. For example, a Zn containing inorganic material e.g. ZnS.

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

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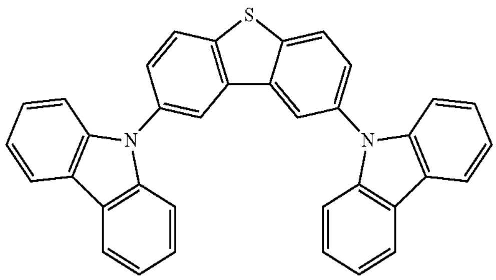

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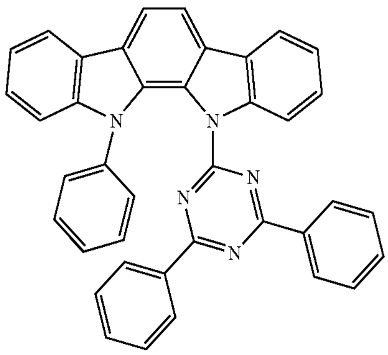

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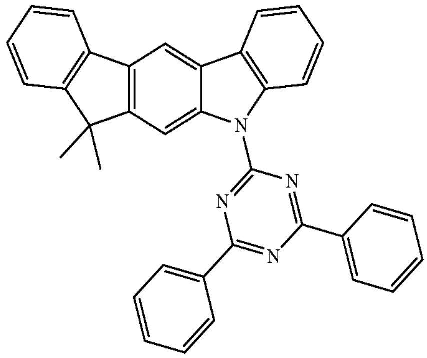

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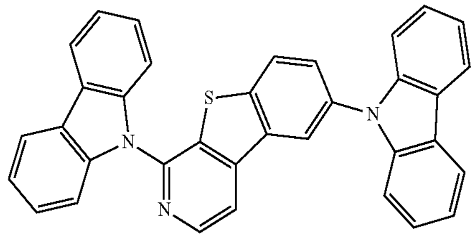

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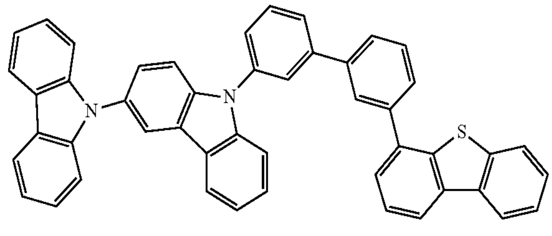

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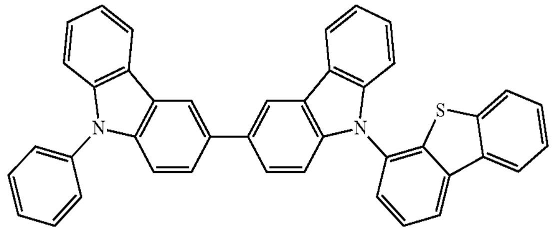

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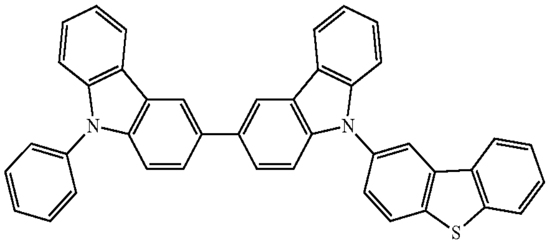

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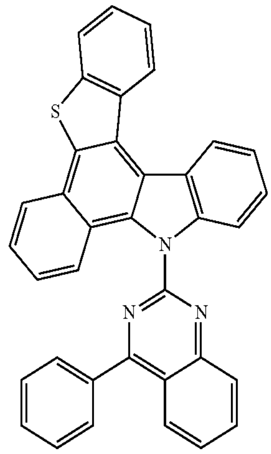

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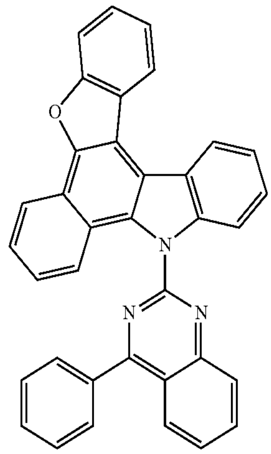

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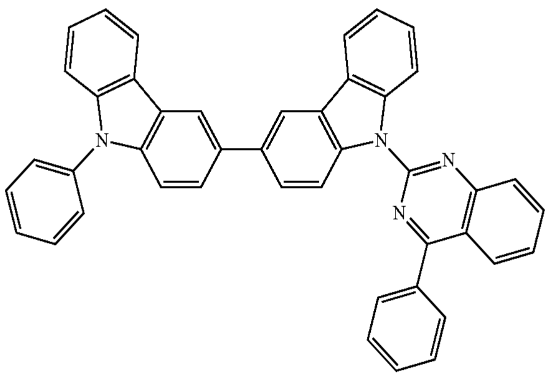

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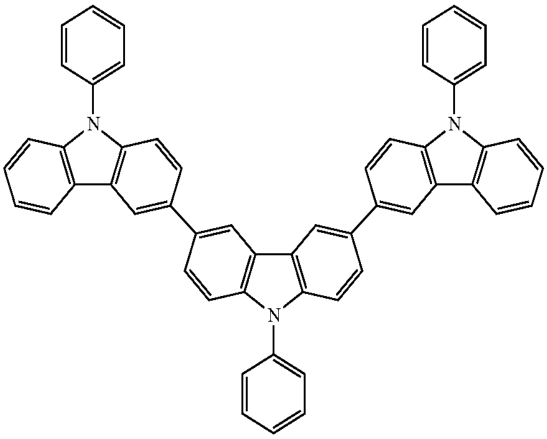
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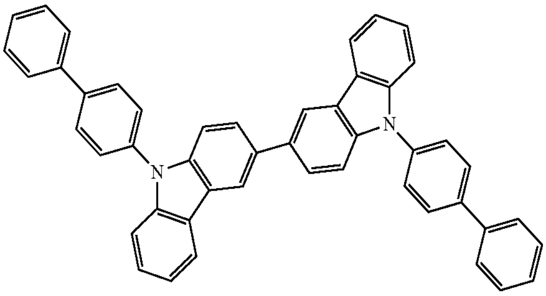
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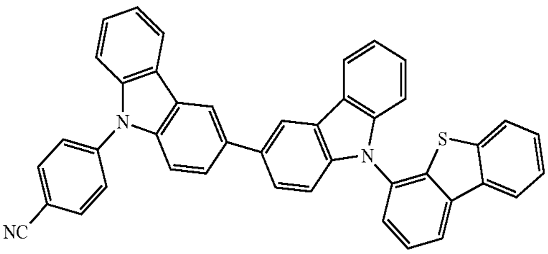
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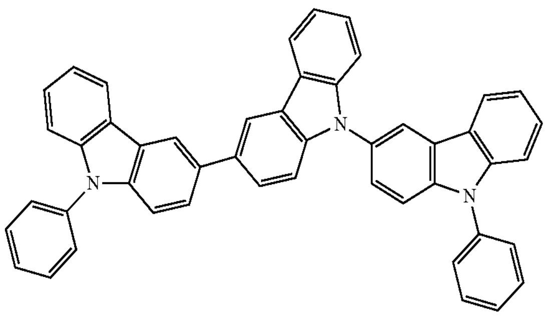
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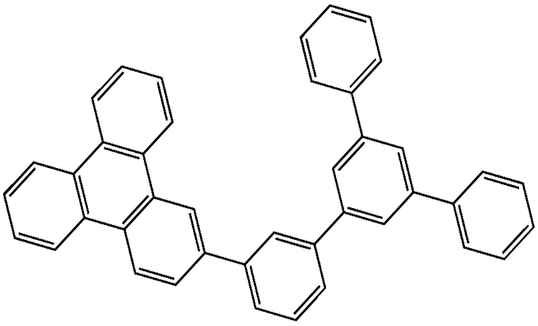
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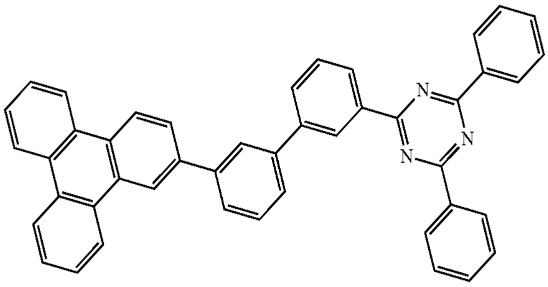
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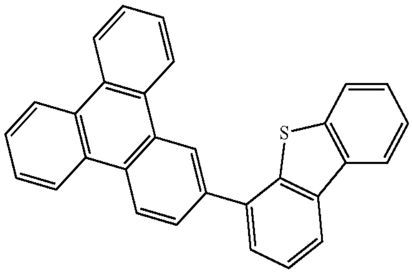
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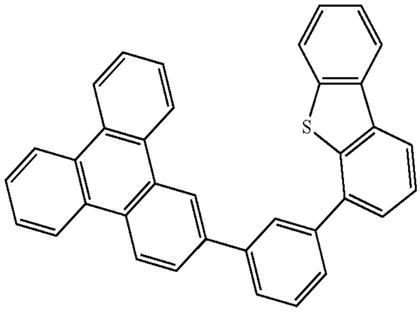
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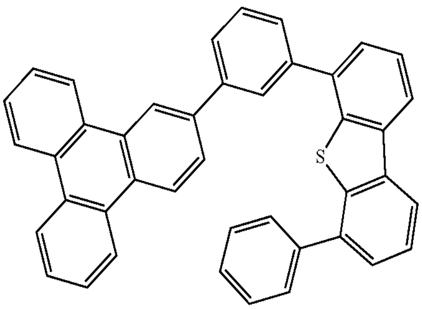
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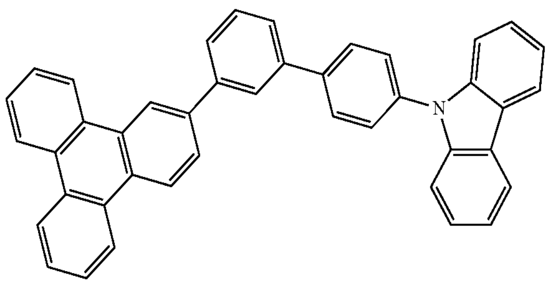
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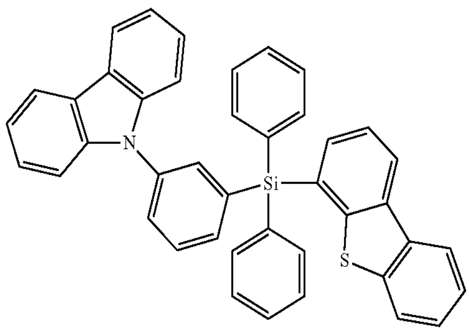
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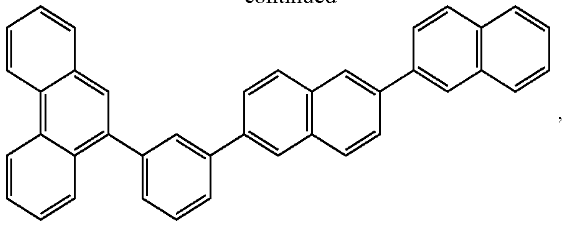


and combinations thereof.

Additional information on possible hosts is provided below.

In yet another aspect of the present disclosure, a formulation that comprises a compound that includes a first ligand L_A having Formula I is described. The formulation can include one or more components selected from the group consisting of a solvent, a host, a hole injection material, hole transport material, and an electron transport layer material, disclosed herein.

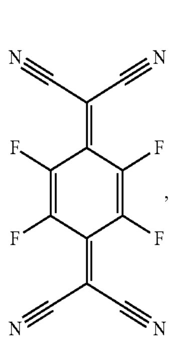
Combination with Other Materials

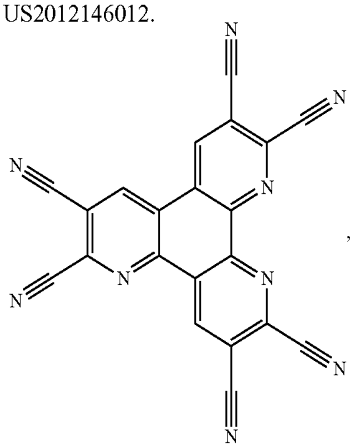
The materials described herein as useful for a particular layer in an organic light emitting device may be used in combination with a wide variety of other materials present in the device. For example, emissive dopants disclosed herein may be used in conjunction with a wide variety of hosts, transport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

Conductivity Dopants:

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.

Non-limiting examples of the conductivity dopants that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: EP01617493, EP01968131, EP2020694, EP2684932, US20050139810, US20070160905, US20090167167, US2010288362, WO06081780, WO2009003455, WO2009008277, WO2009011327, WO2014009310, US2007252140, US2015060804 and US2012146012.





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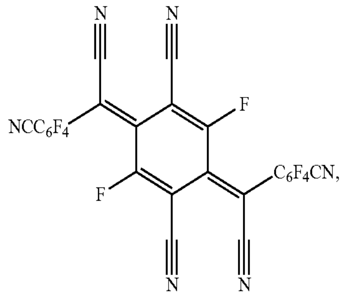

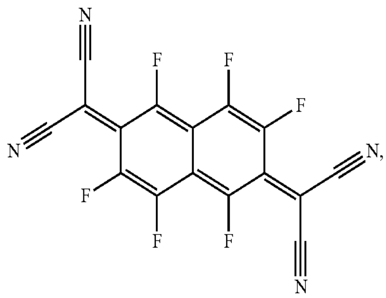

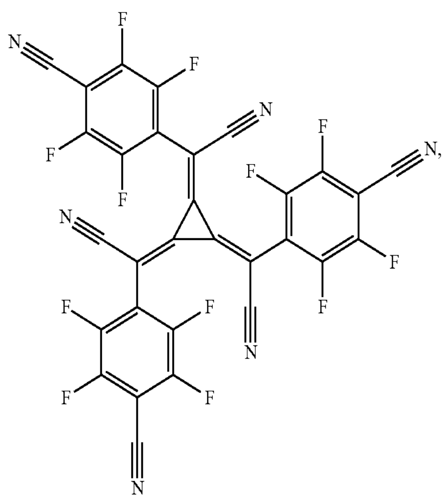

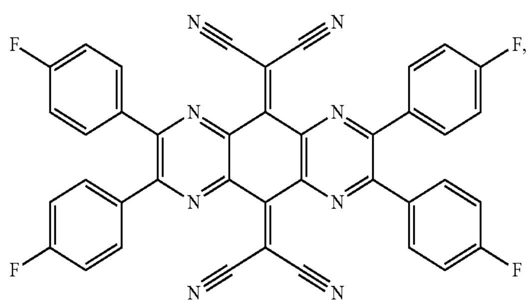

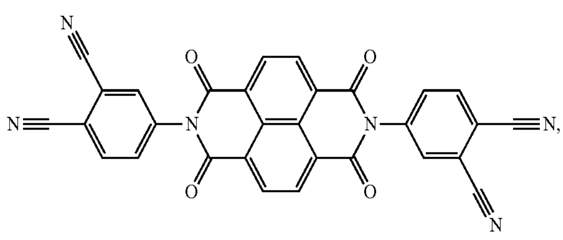

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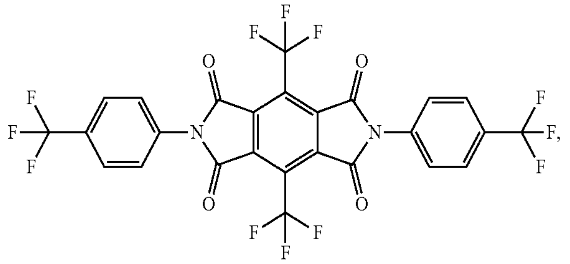

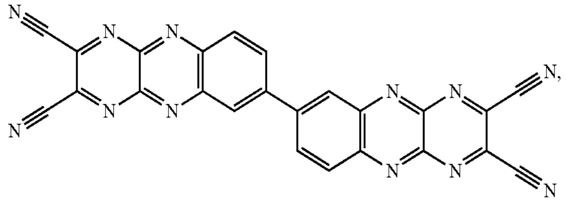

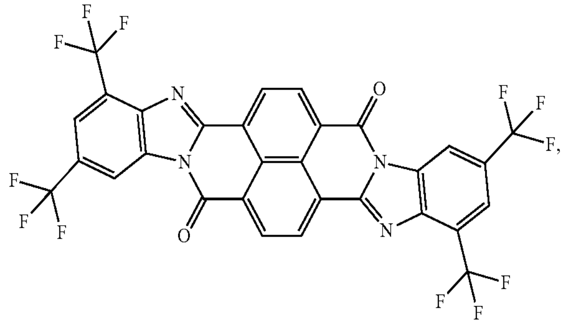

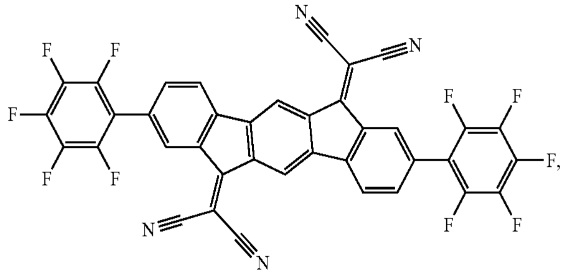

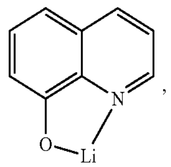

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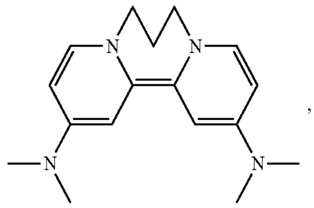
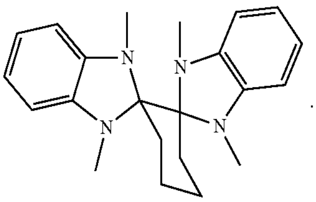
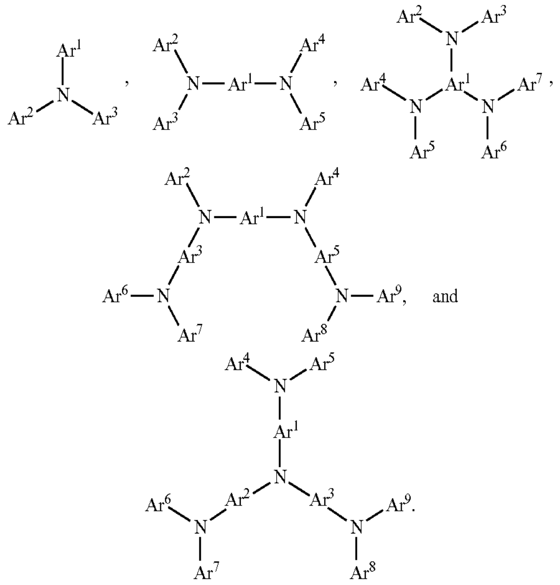




HIL/HTL:

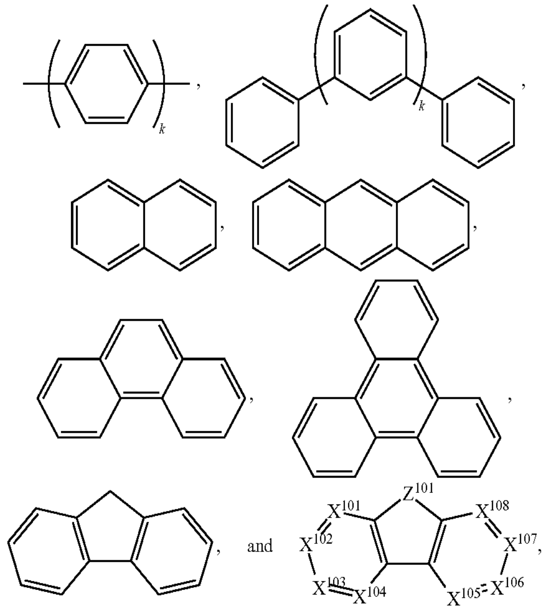
A hole injecting/transporting material to be used in the present invention is not particularly limited, and any compound may be used as long as the compound is typically used as a hole injecting/transporting material. Examples of the material include, but are not limited to: a phthalocyanine or porphyrin 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 phosphoric 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.

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



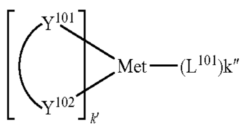
Each of Ar^1 to Ar^9 is selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene; the group consisting of aromatic heterocyclic compounds 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 Ar may be unsubstituted or may be substituted by a substituent selected from the group consisting of deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

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



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

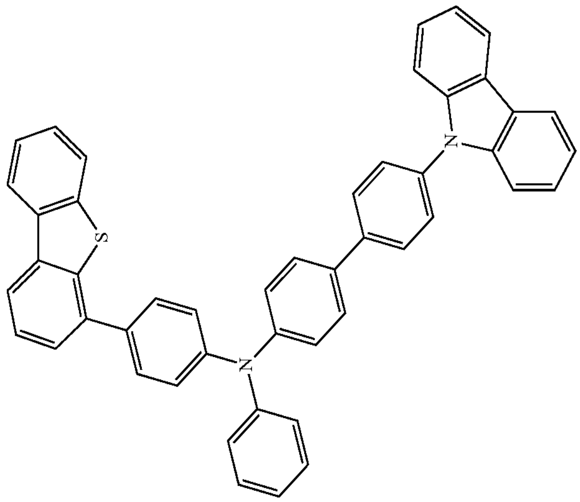
Examples of metal complexes used in HIL or HTL include, but are not limited to the following general formula:

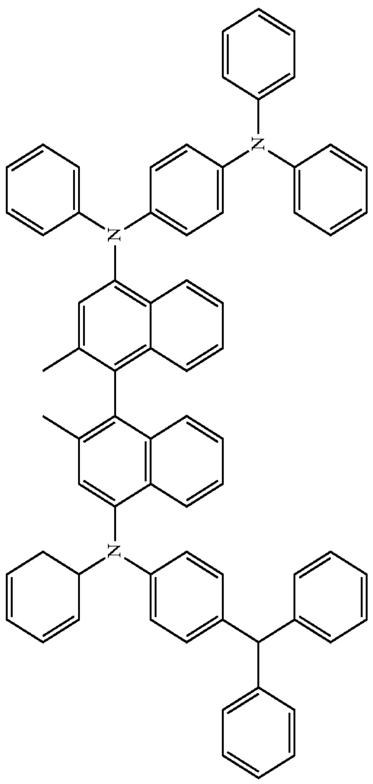


wherein Met is a metal, which can have an atomic weight greater than 40; (Y^{101}-Y^{102}) is a bidentate ligand, Y^{101} and Y^{102} are independently selected from C, N, O, P, and S; L^{101} is an ancillary ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached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

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

Non-limiting examples of the HIL and HTL materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: CN102702075, DE102012005215, EP01624500, EP01698613, EP01806334, EP01930964, EP01972613, EP01997799, EP02011790, EP02055700, EP02055701, EP1725079, EP2085382, EP2660300, EP650955, JP07-073529, JP2005112765, JP2007091719, JP2008021687, JP2014-009196, KR20110088898, KR20130077473, TW201139402, U.S. Ser. No. 06/517,957, US20020158242, US20030162053, US20050123751, US20060182993, US20060240279, US20070145888, US20070181874, US20070278938, US20080014464, US20080091025, US20080106190, US20080124572, US20080145707, US20080220265, US20080233434, US20080303417, US2008107919, US20090115320, US20090167161, US2009066235, US2011007385, US20110163302, US2011240968, US2011278551, US2012205642, US2013241401, US20140117329, US2014183517, U.S. Pat. Nos. 5,061,569, 5,639,914, WO05075451, WO07125714, WO08023550, WO08023759, WO2009145016, WO2010061824, WO2011075644, WO2012177006, WO2013018530, WO2013039073, WO2013087142, WO2013118812, WO2013120577, WO2013157367, WO2013175747, WO2014002873, WO2014015935, WO2014015937, WO2014030872, WO2014030921, WO2014034791, WO2014104514, WO2014157018.





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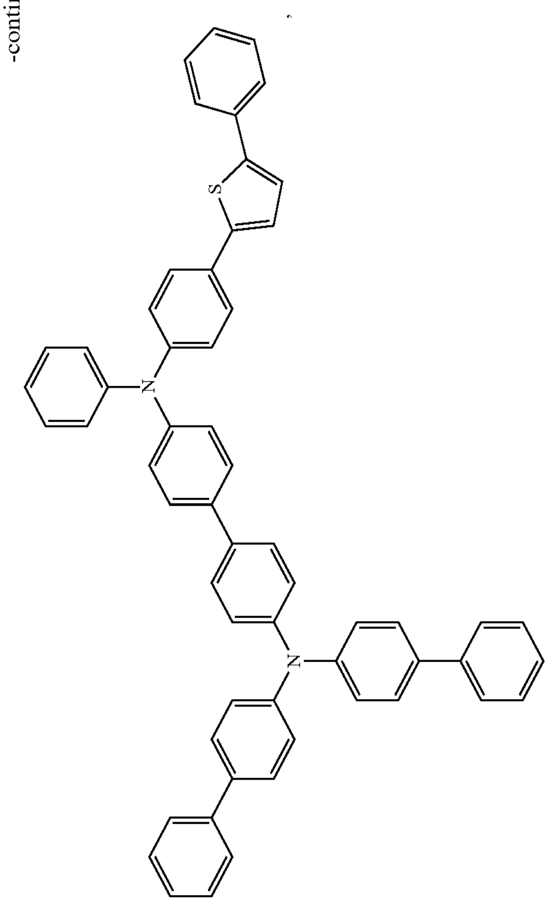

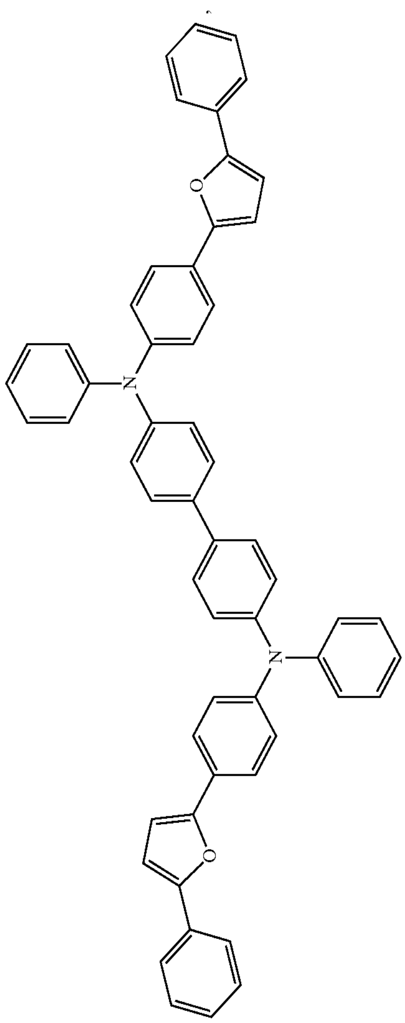

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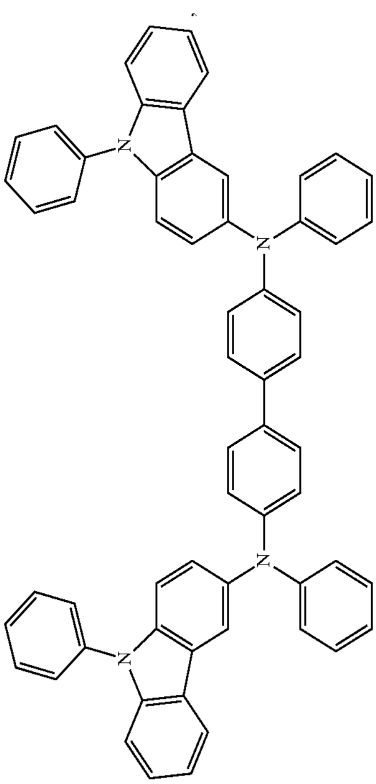

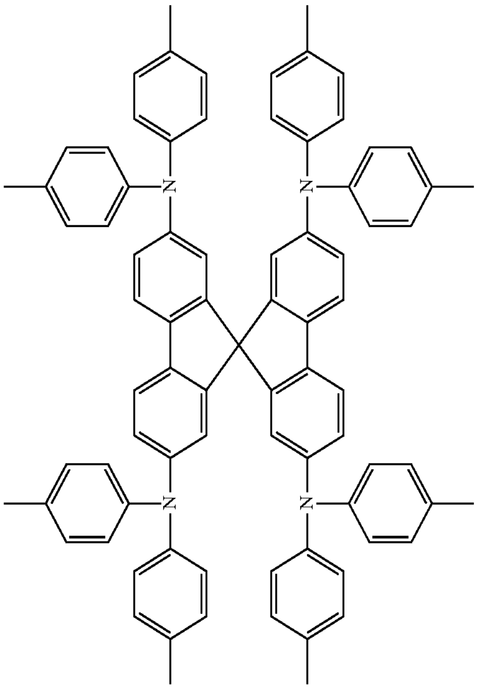

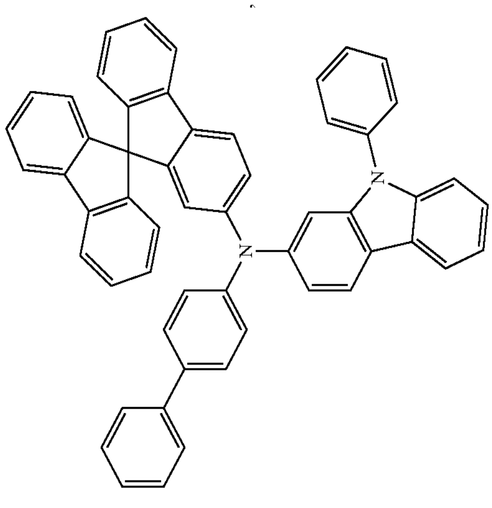

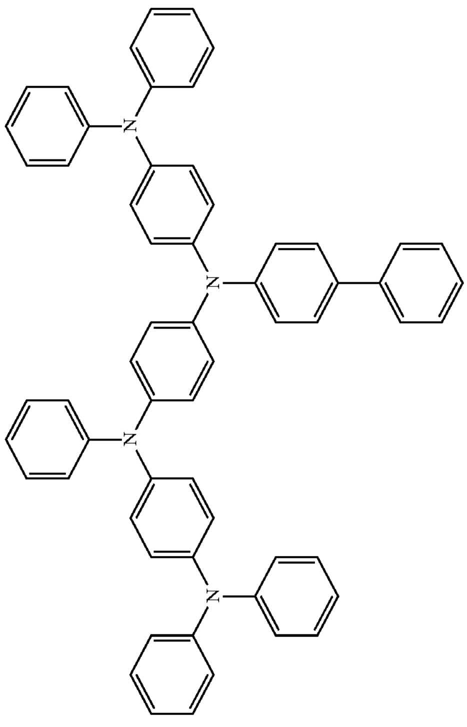

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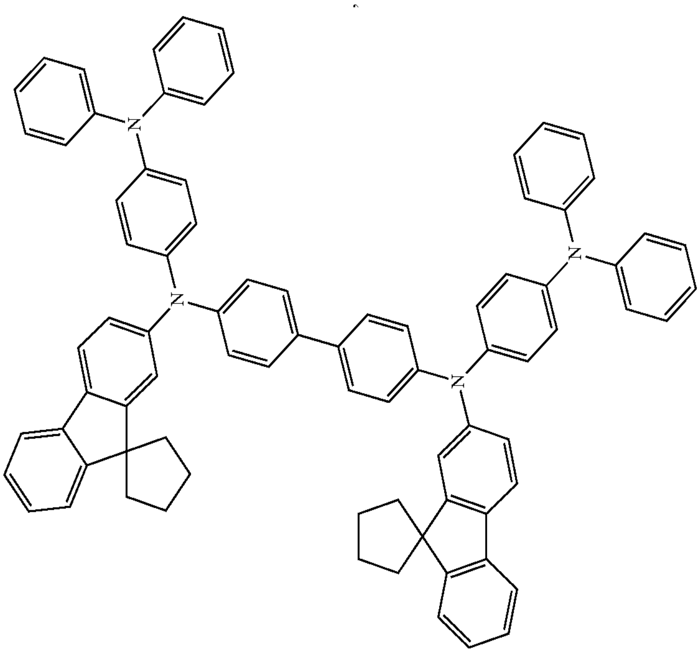

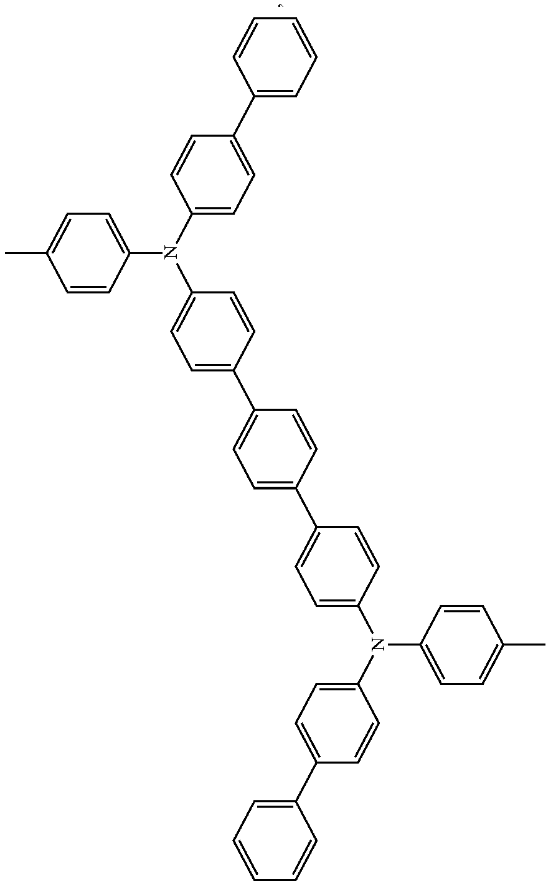

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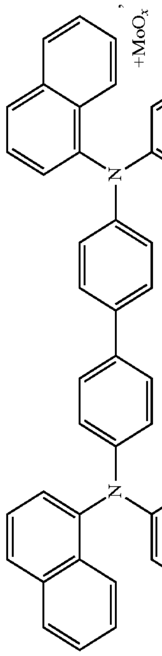

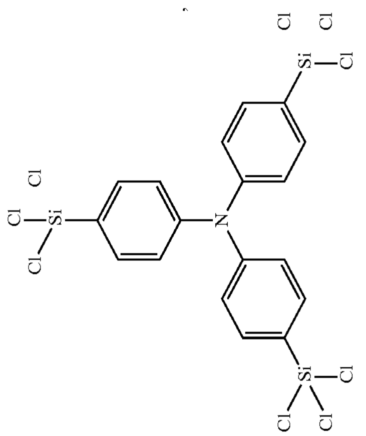

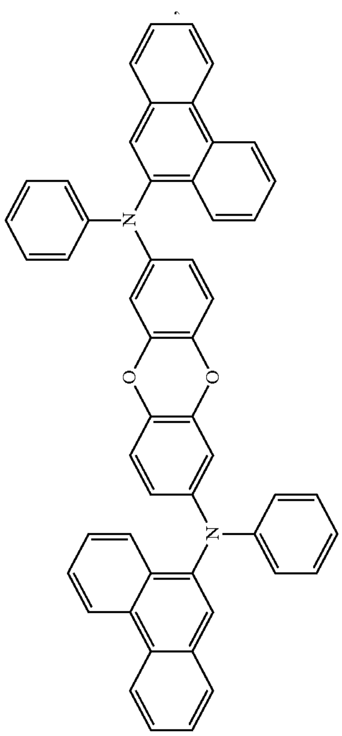

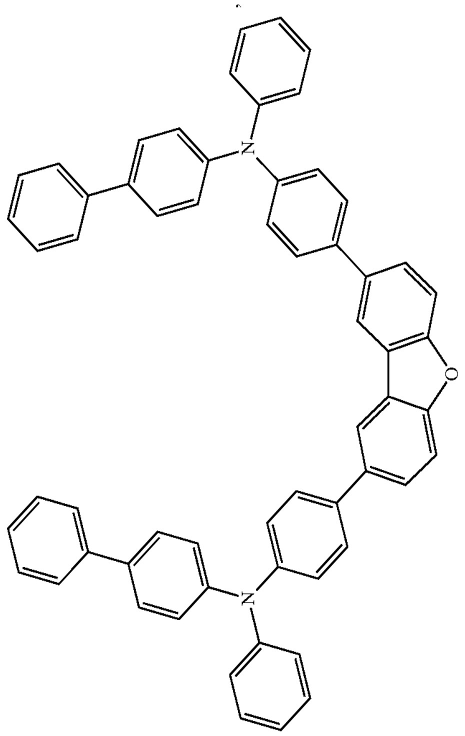

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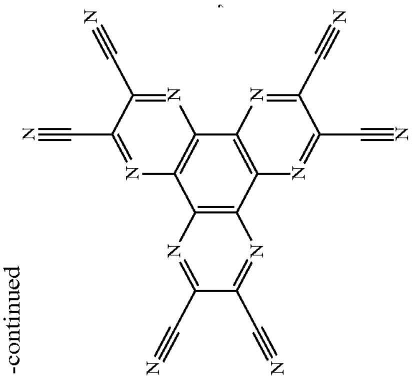

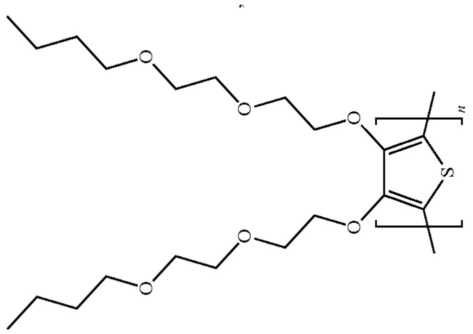

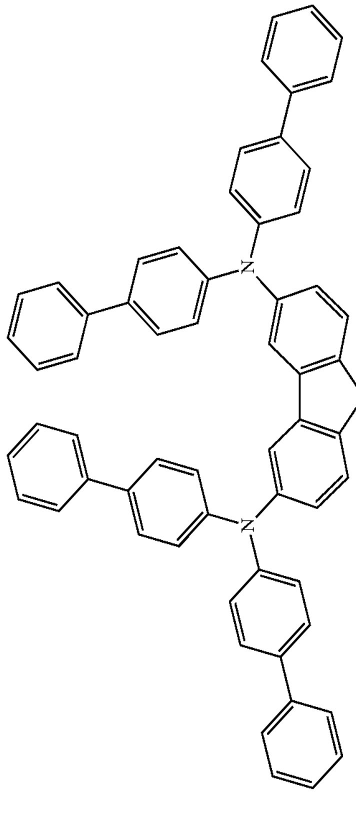

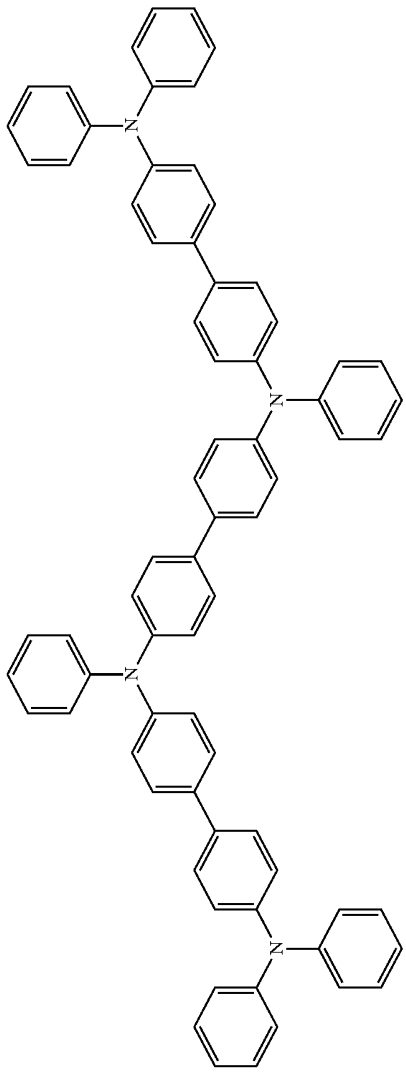

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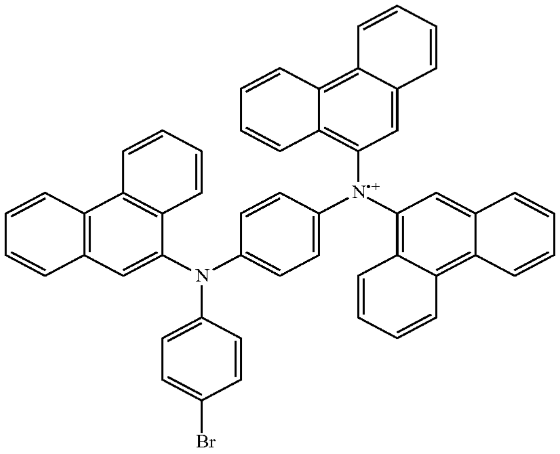

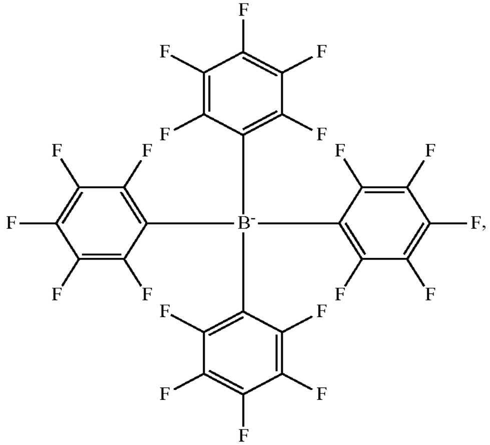

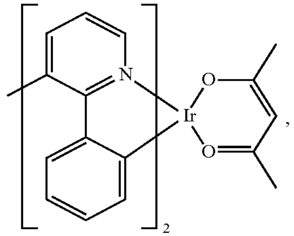

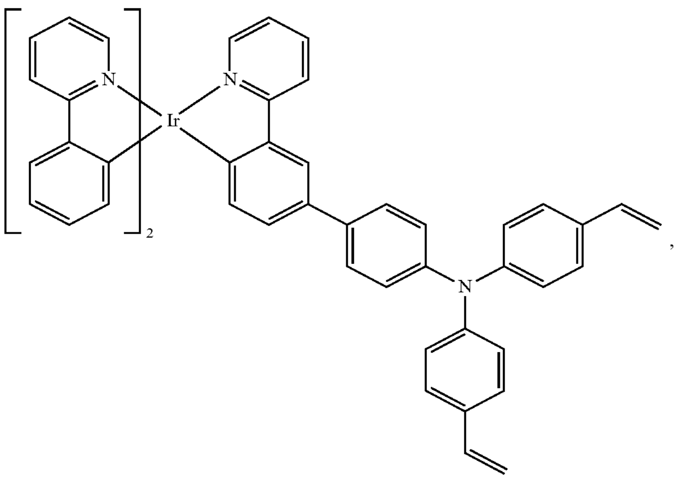

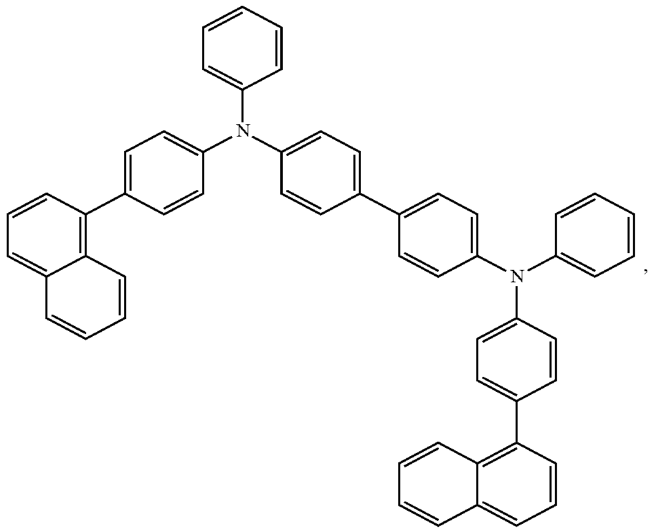

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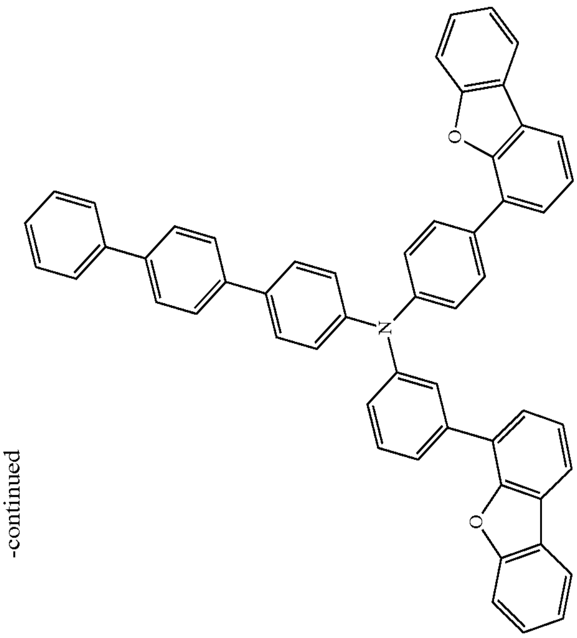

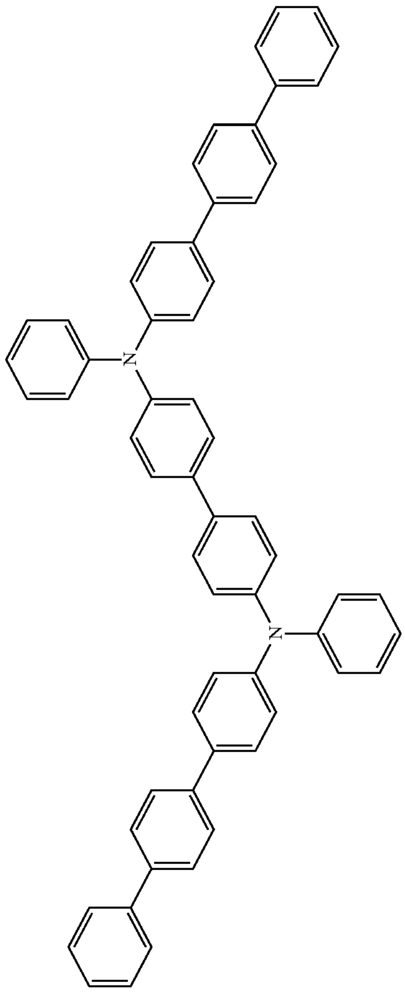

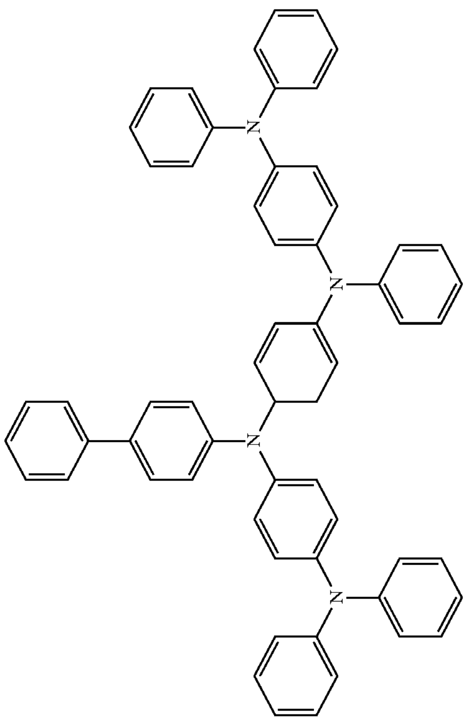

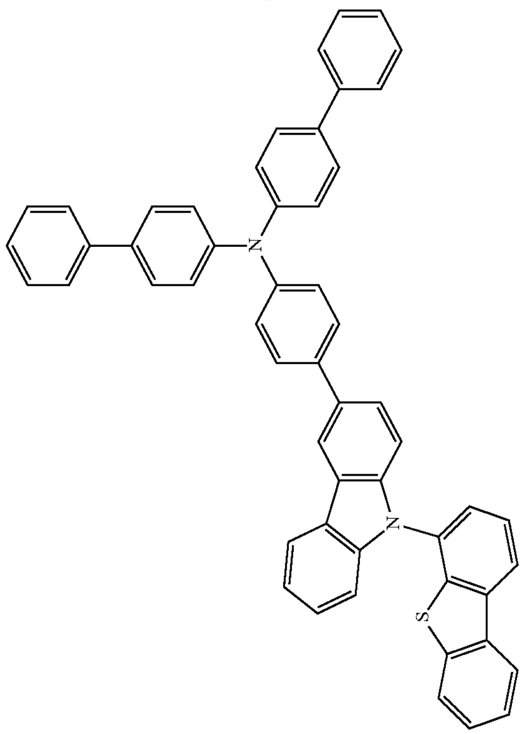

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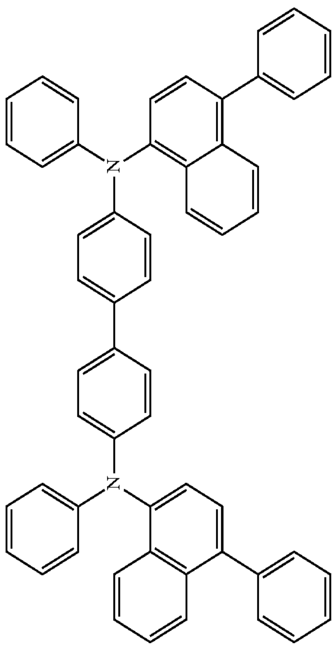

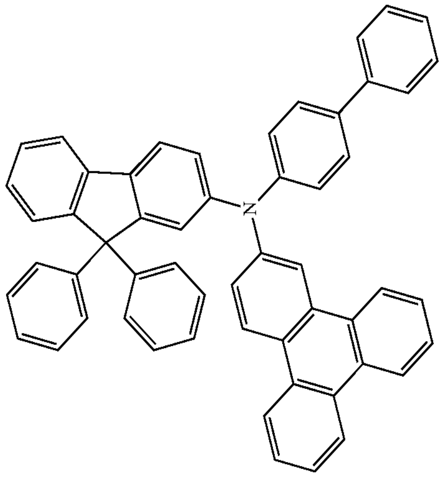

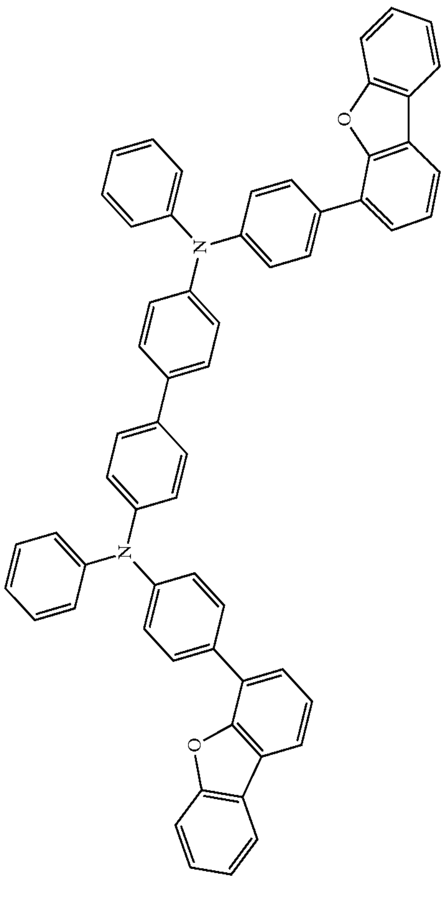

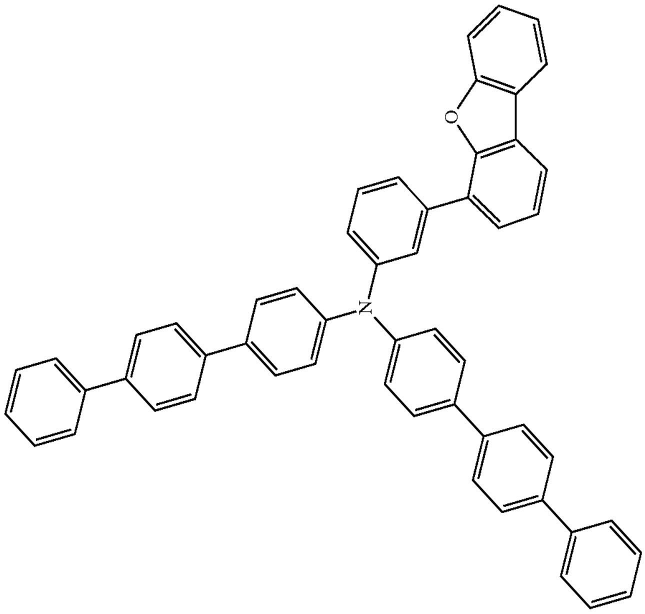

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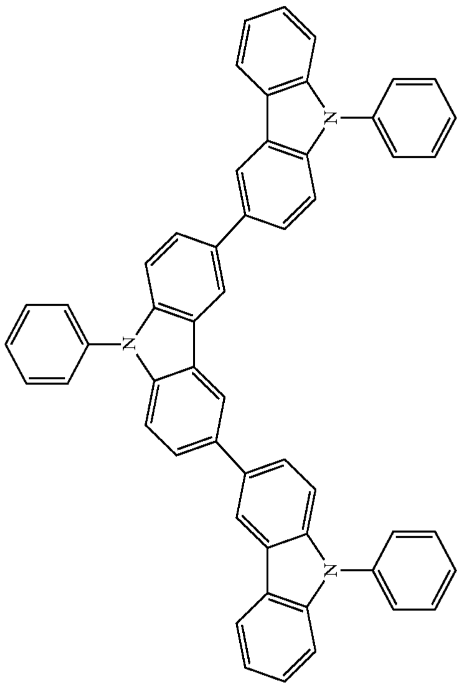

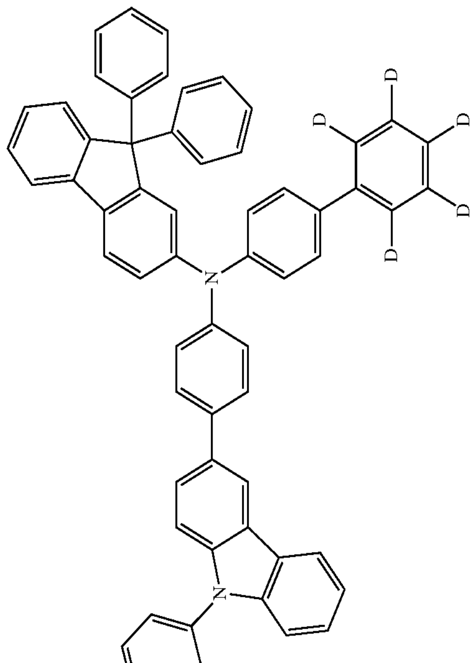

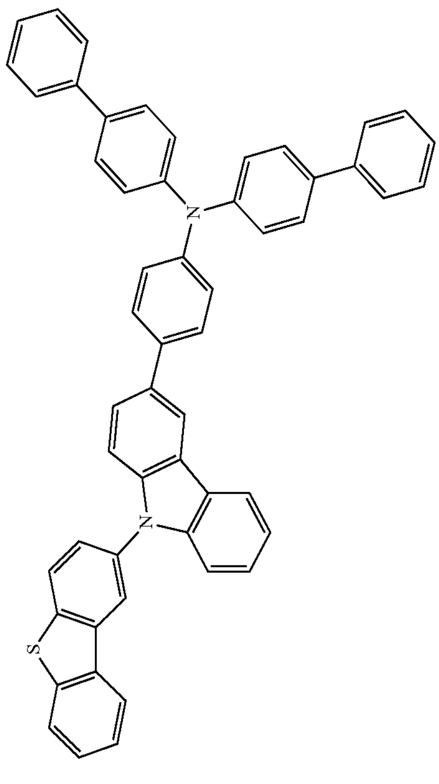

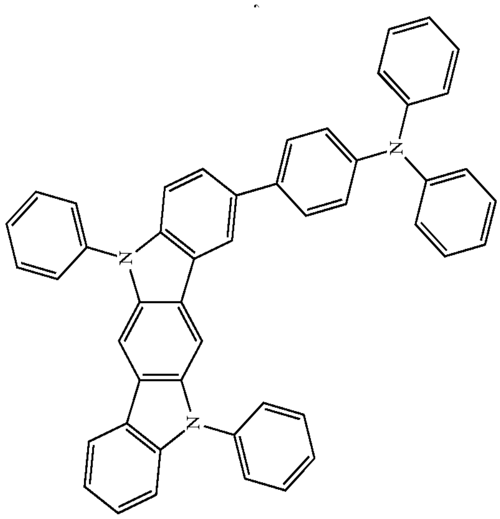

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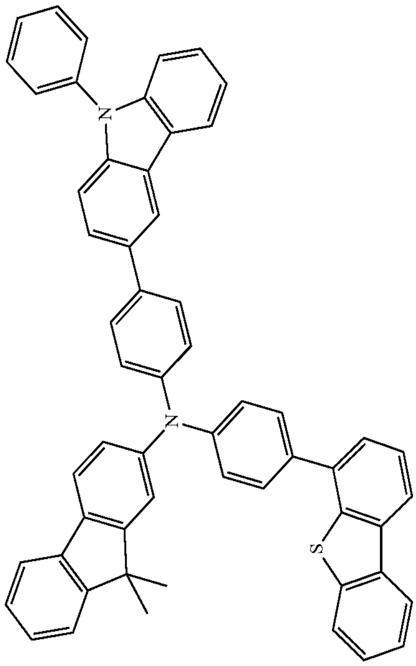

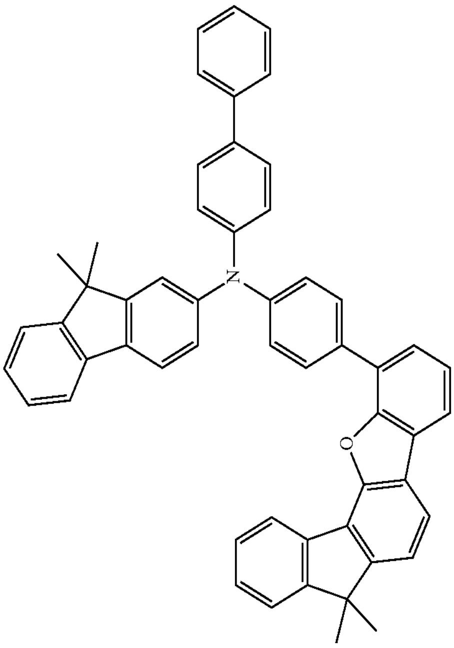

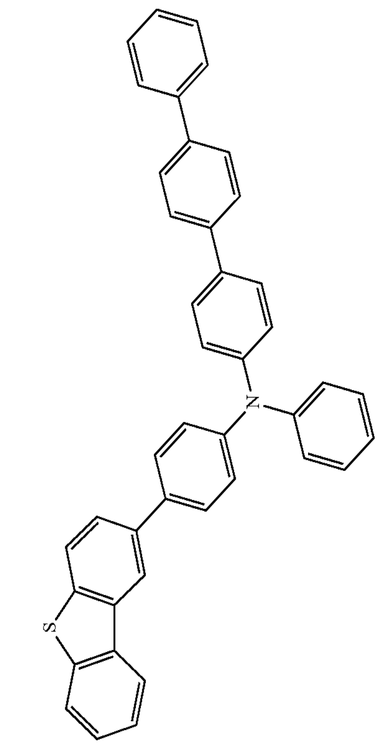

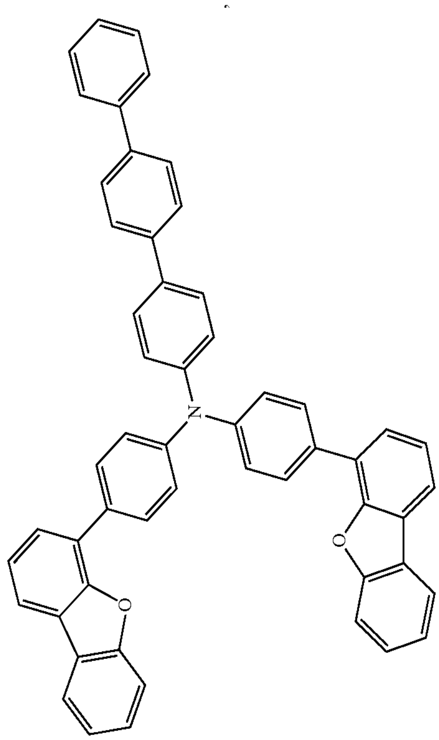

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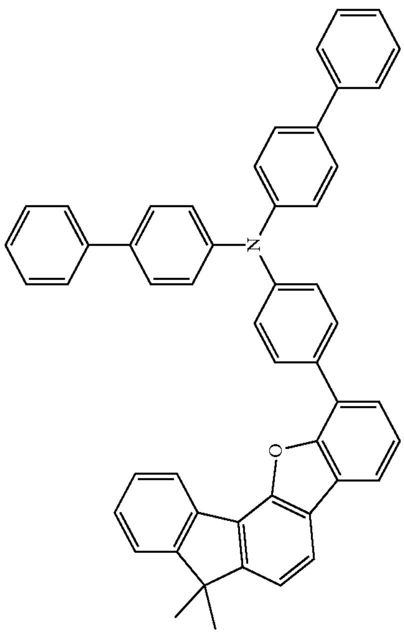

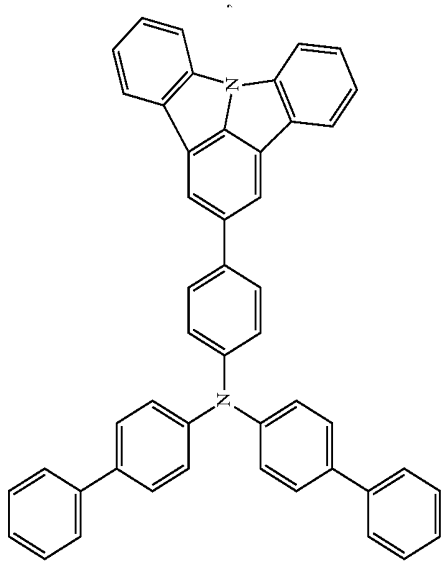

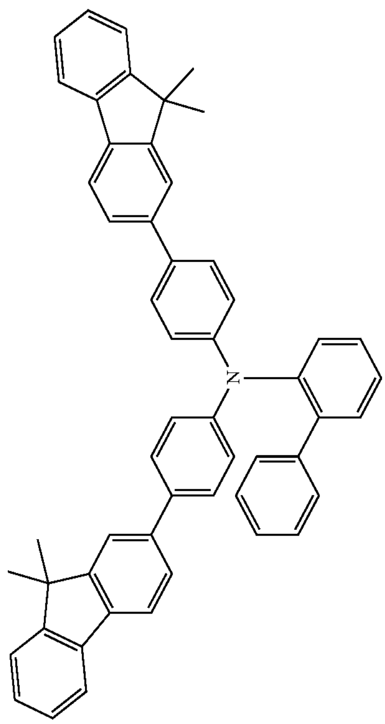

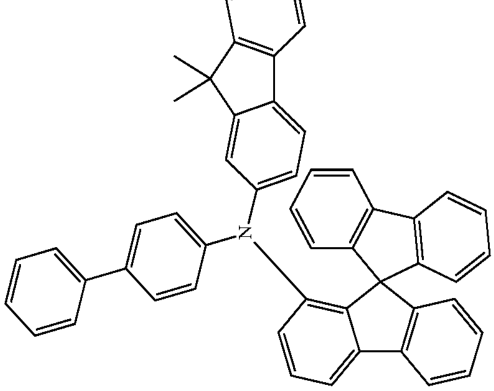

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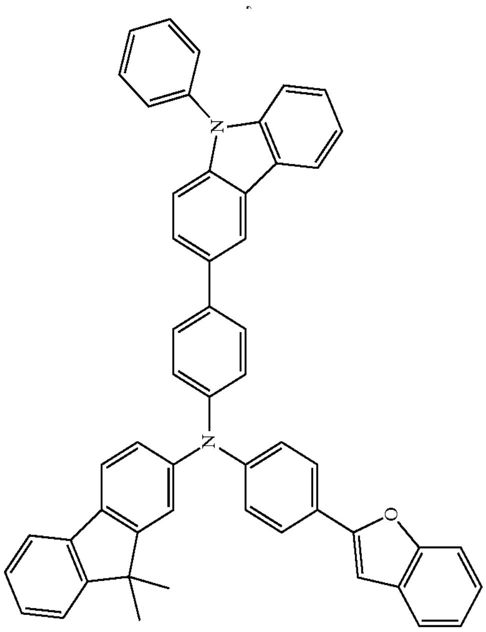

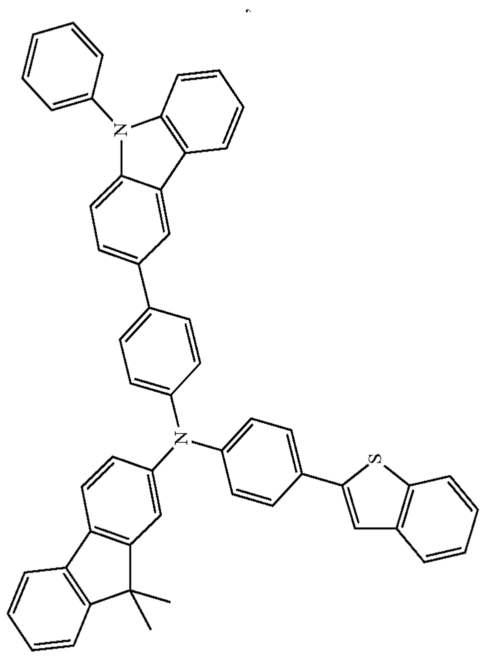

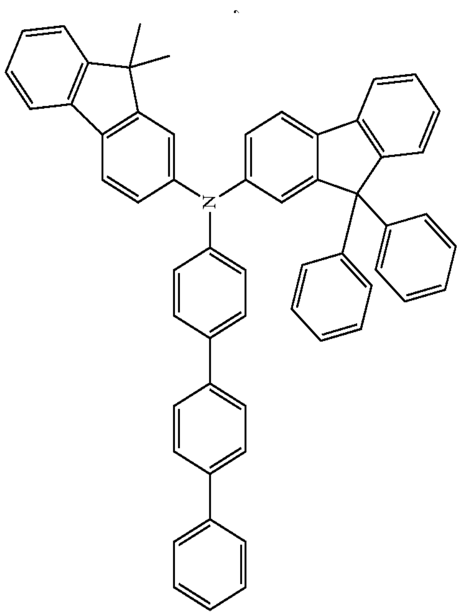

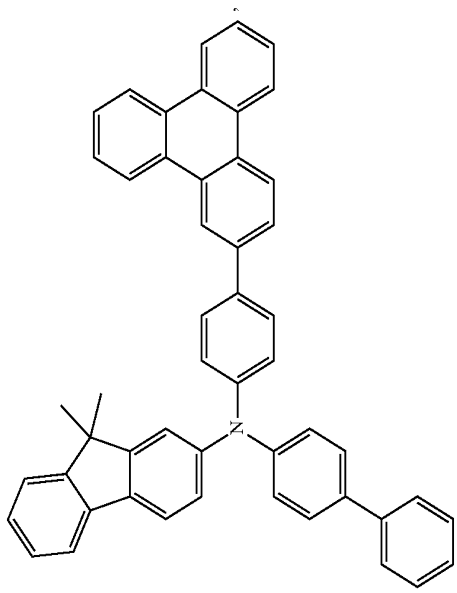

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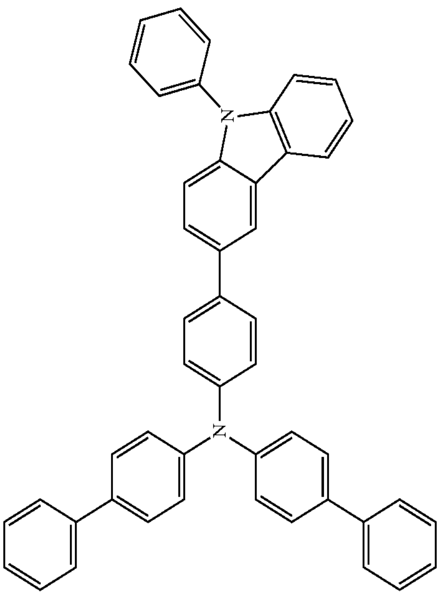

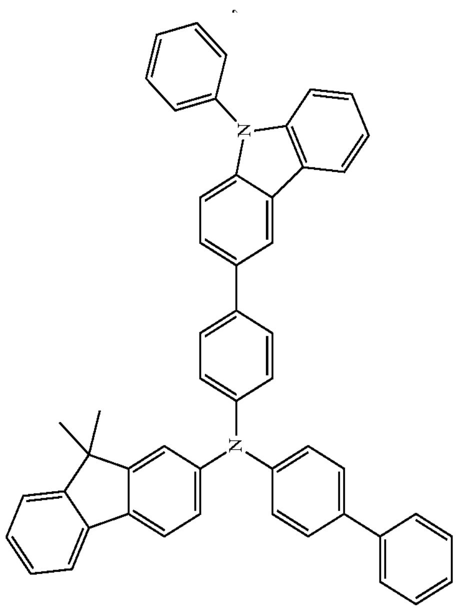

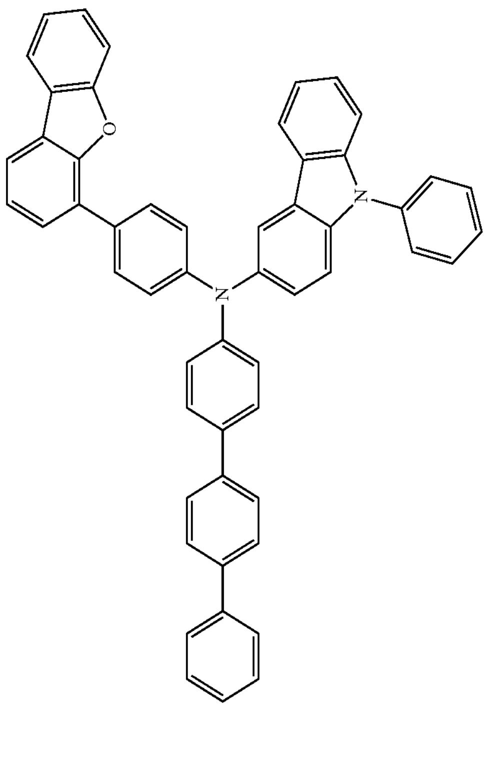

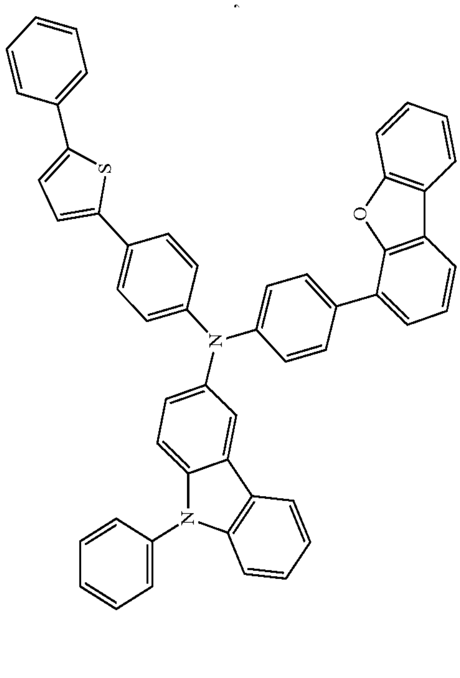

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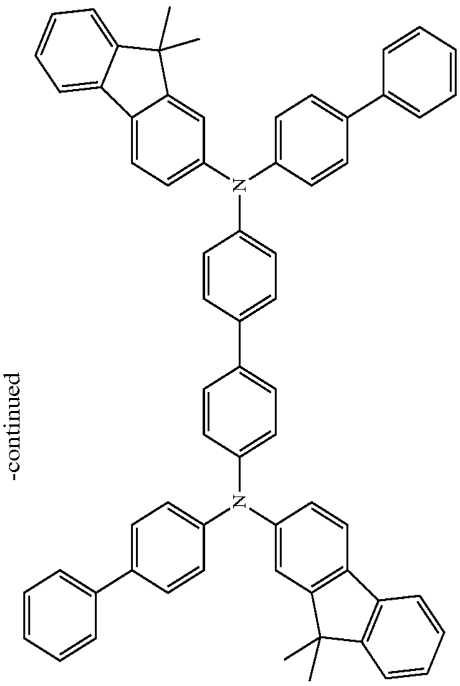

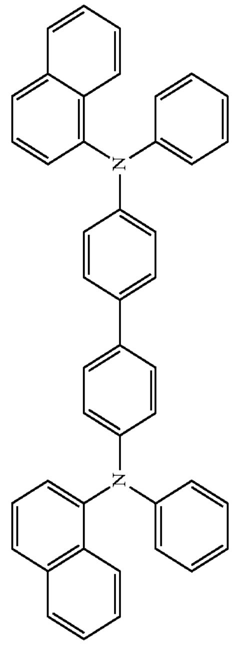

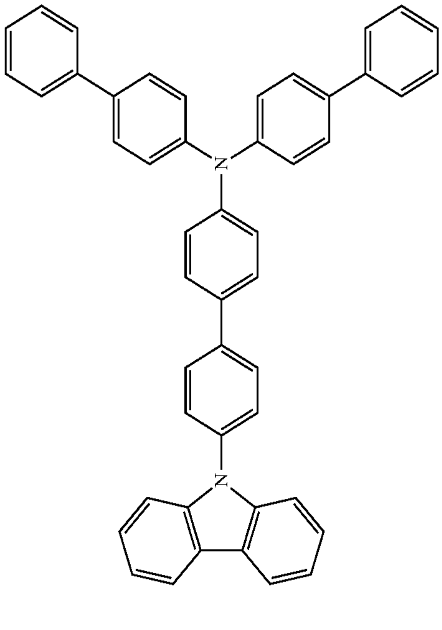

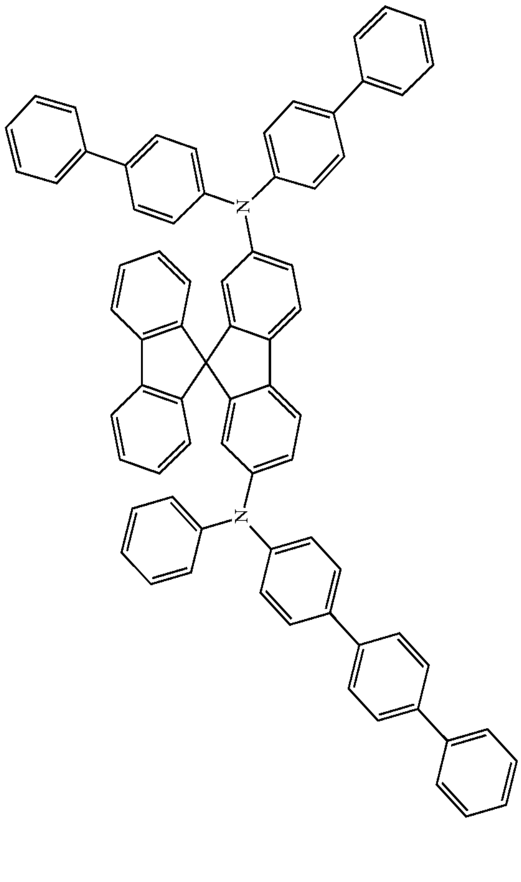

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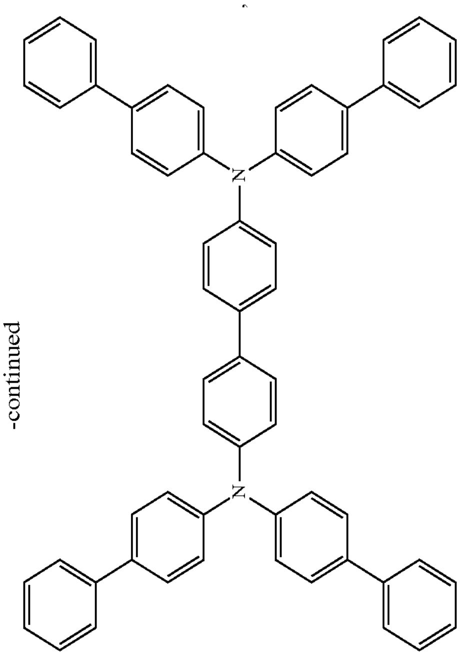

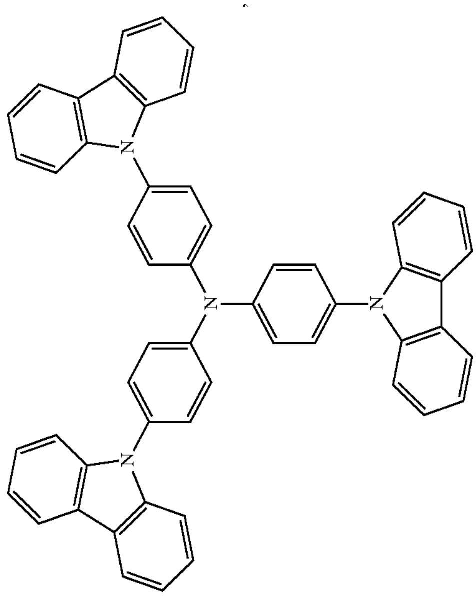

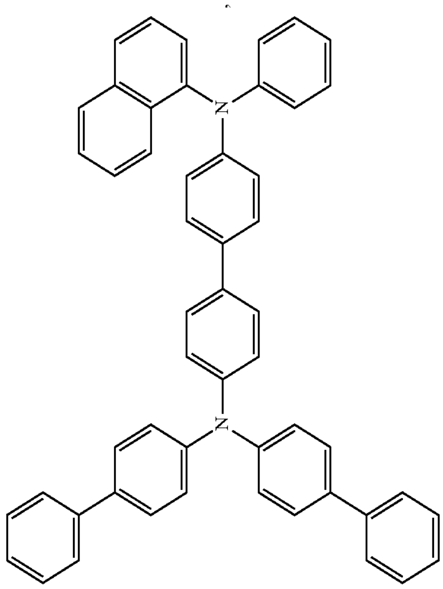

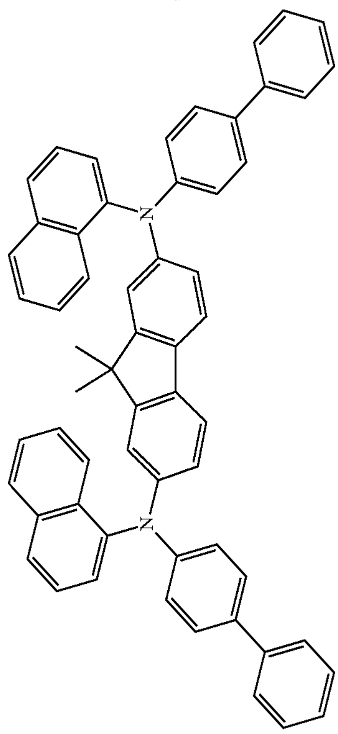

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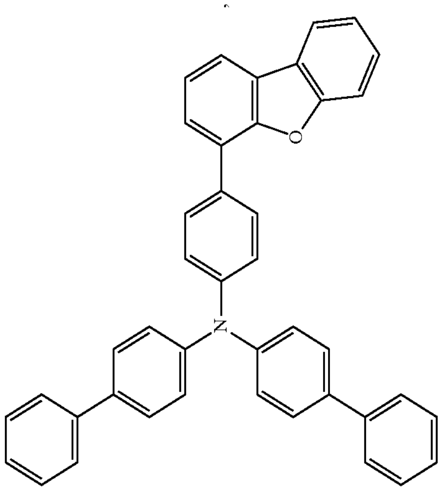

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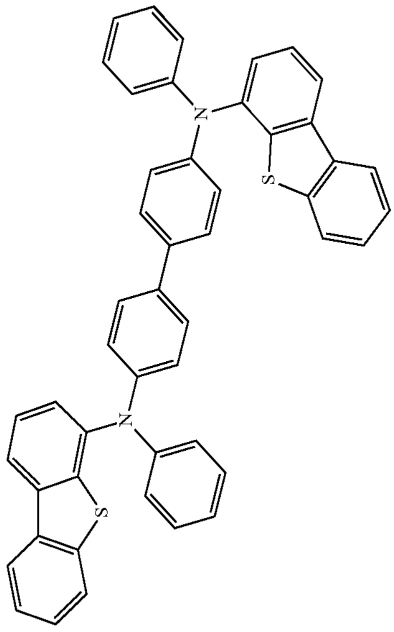

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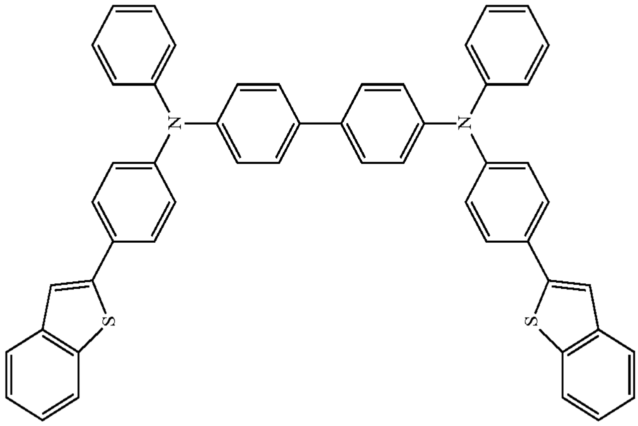

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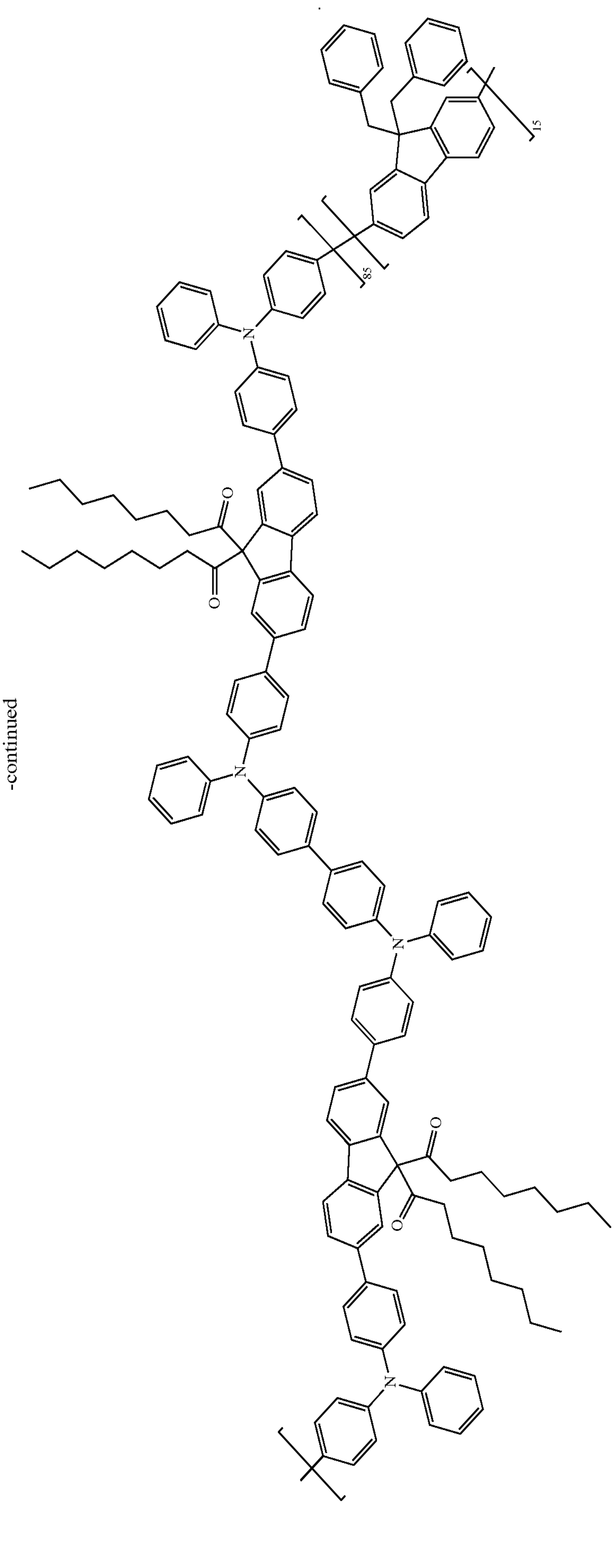


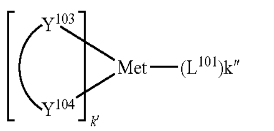
EBL:

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

Host:

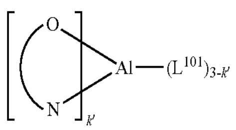
The light emitting layer of the organic EL device of the present invention preferably contains at least a metal complex as light emitting material, and may contain a host material using the metal complex as a dopant material. Examples of the host material are not particularly limited, and any metal complexes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

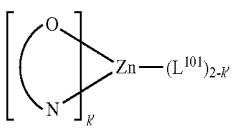
Examples of metal complexes used as host are preferred to have the following general formula:



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

In one aspect, the metal complexes are:



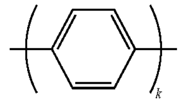


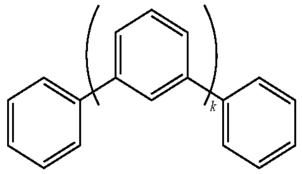
wherein (O—N) is a bidentate ligand, having metal coordinated to atoms O and N.

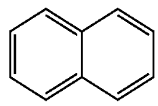
In another aspect, Met is selected from Ir and Pt. In a further aspect, (Y^{103}-Y^{104}) is a carbene ligand.

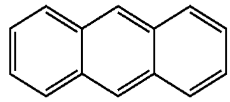
Examples of other organic compounds used as host are selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, tetraphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene; the group consisting of aromatic heterocyclic compounds such as dibenzothiophene, dibenzofuran, dibenzoselenophene, furan, thiophene, benzofuran, benzothiophene, benzoselenophene, carbazole, indolocarbazole, pyridylindole, 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 option within each group may be unsubstituted or may be substituted by a substituent selected from the group consisting of deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

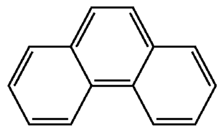
In one aspect, the host compound contains at least one of the following groups in the molecule:

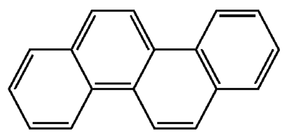
,

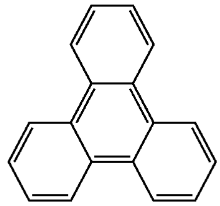
,

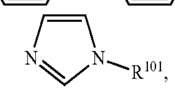
,

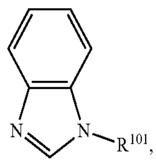
,

,

,

,





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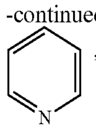

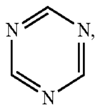

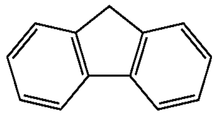

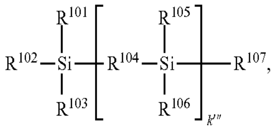

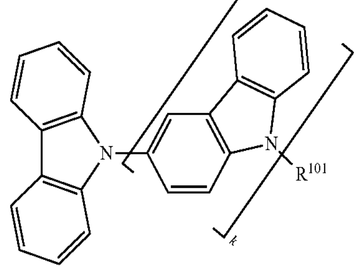

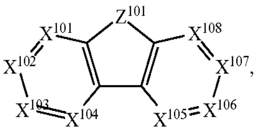

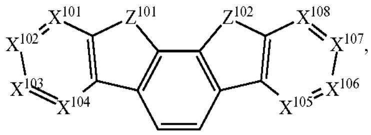

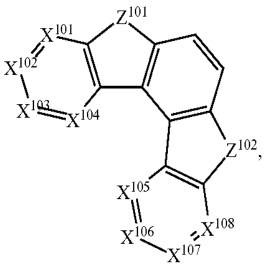

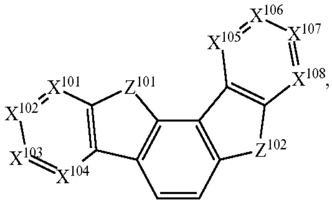

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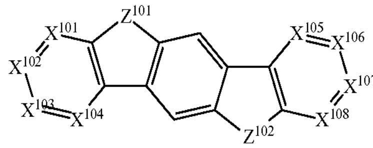
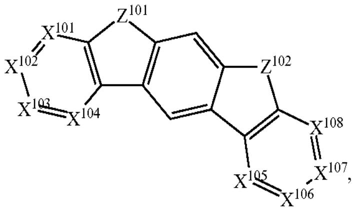
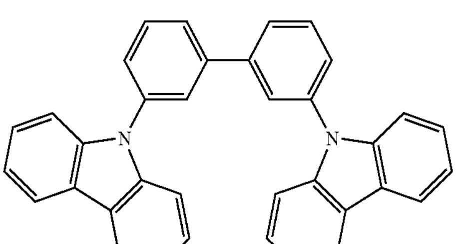
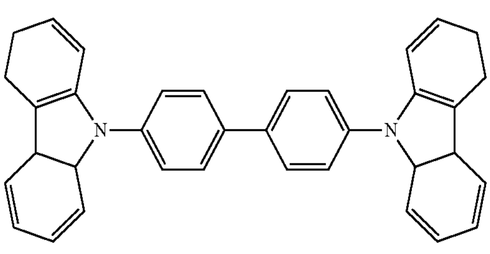




wherein each of R^{101} to R^{107} is independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof, and when it is aryl or heteroaryl, it has the similar definition as Ar's mentioned above. k is an integer from 0 to 20 or 1 to 20; k''' is an integer from 0 to 20. X^{101} to X^{108} is selected from C (including CH) or N. Z^{101} and Z^{102} is selected from NR^{101}, O, or S.

Non-limiting examples of the host materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: EP2034538, EP2034538A, EP2757608, JP2007254297, KR20100079458, KR20120088644, KR20120129733, KR20130115564, TW201329200, US20030175553, US20050238919, US20060280965, US20090017330, US20090030202, US20090167162, US20090302743, US20090309488, US20100012931, US20100084966, US20100187984, US2010187984, US2012075273, US2012126221, US2013009543, US2013105787, US2013175519, US2014001446, US20140183503, US20140225088, US2014034914, U.S. Pat. No. 7,154,114, WO2001039234, WO2004093207, WO2005014551, WO2005089025, WO2006072002, WO2006114966, WO2007063754, WO2008056746, WO2009003898, WO2009021126, WO2009063833, WO2009066778, WO2009066779, WO2009086028, WO2010056066, WO2010107244, WO2011081423, WO2011081431, WO2011086863, WO2012128298, WO2012133644, WO2012133649, WO2013024872, WO2013035275, WO2013081315, WO2013191404, WO2014142472,





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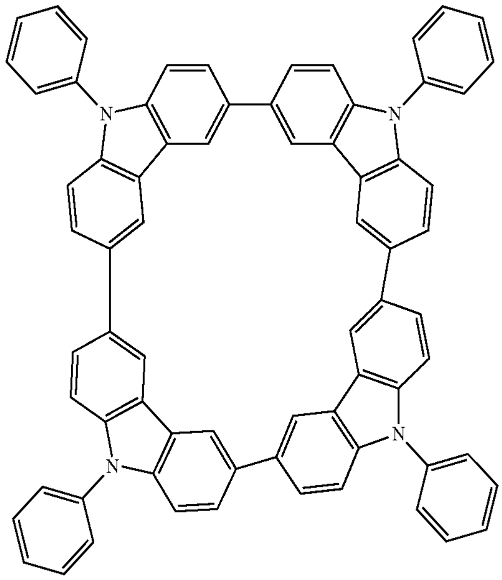

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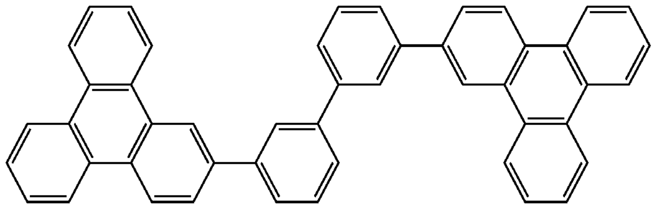

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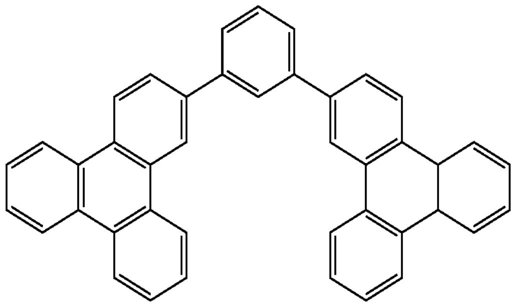

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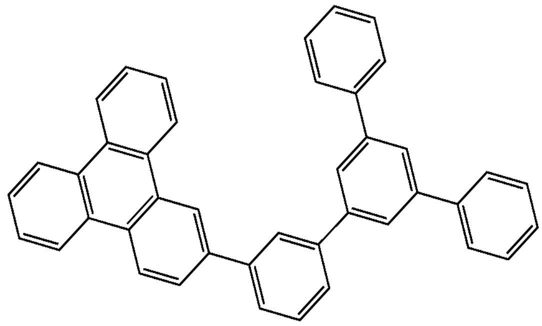

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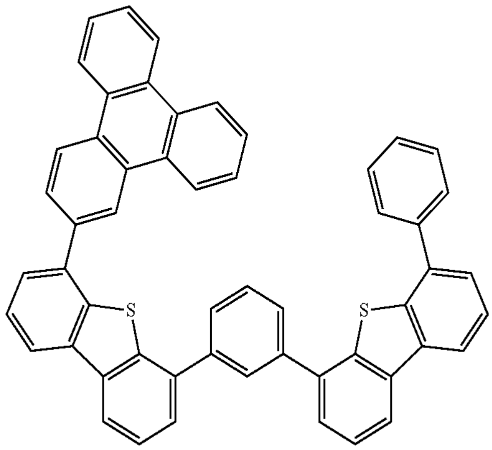

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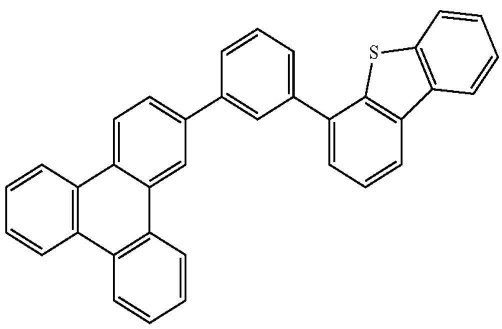

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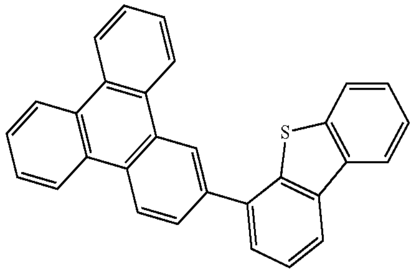
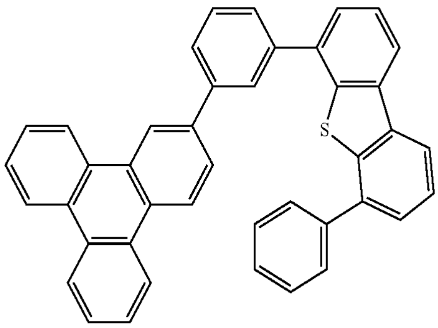
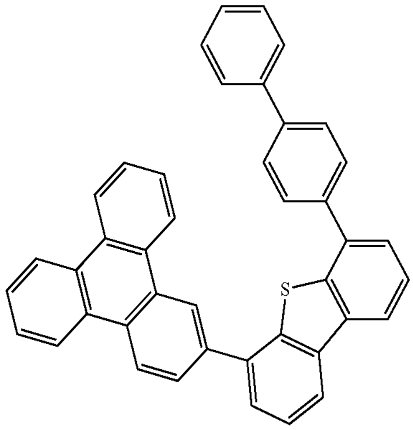
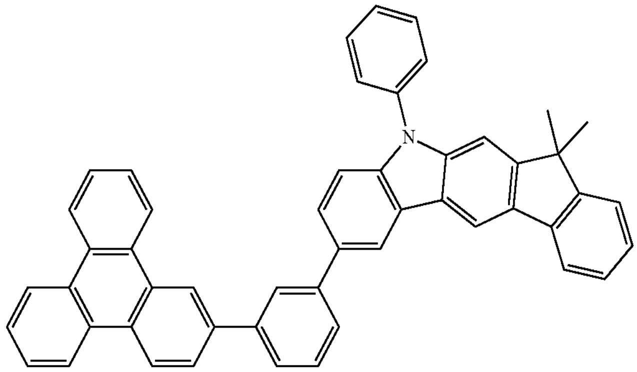
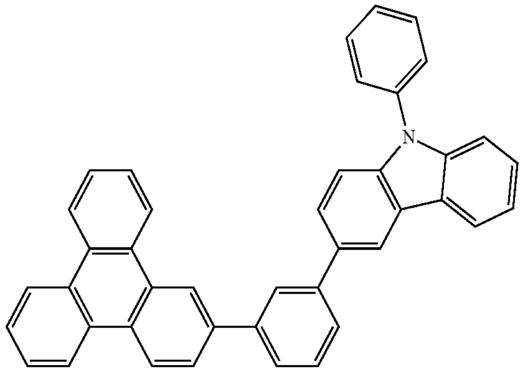
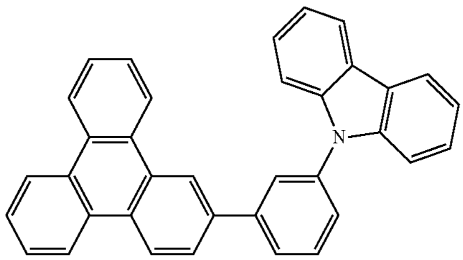
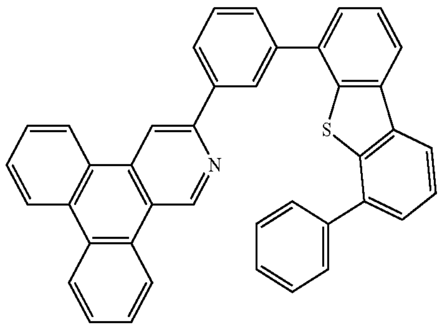
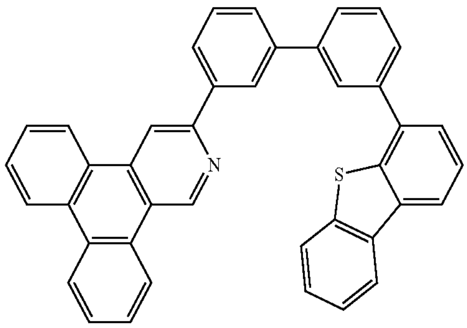
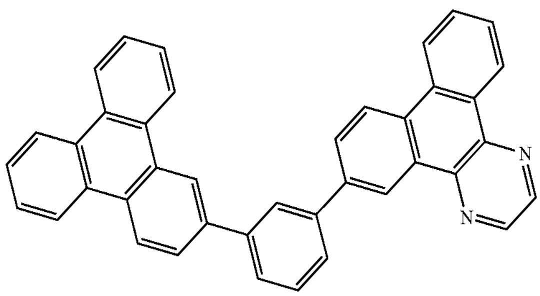
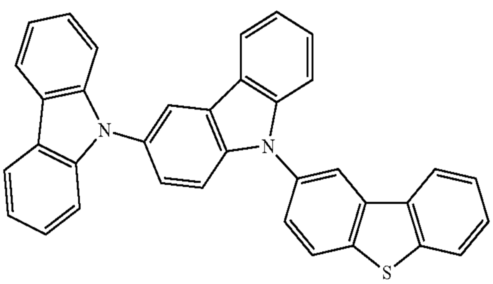
,
,
,
,
,
,
,
,
,
,

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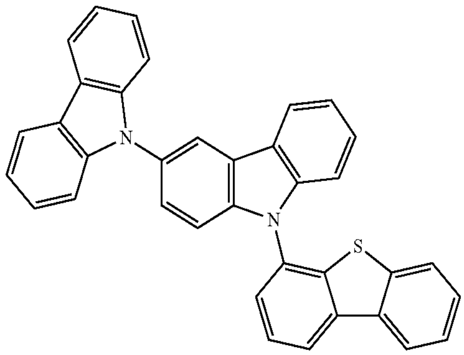
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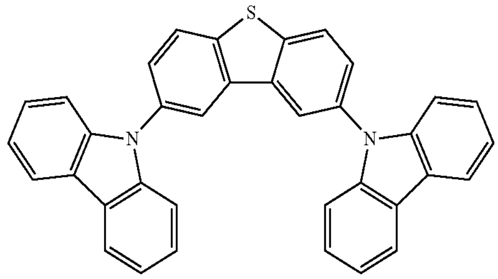
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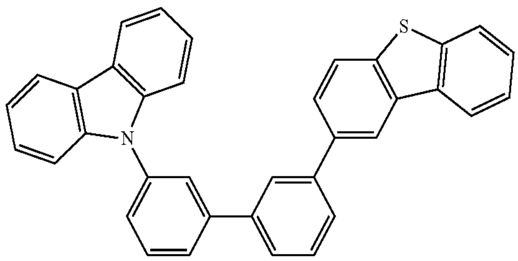
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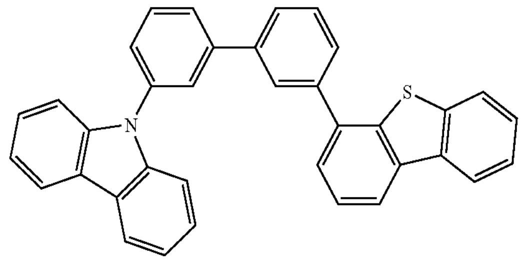
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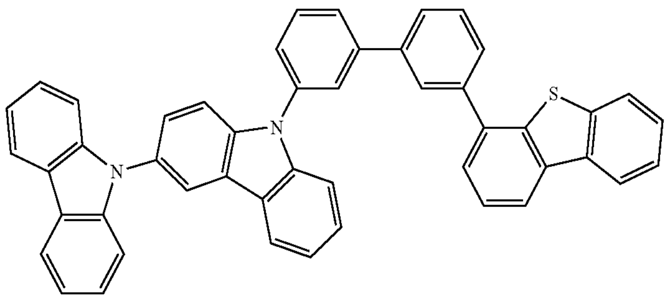
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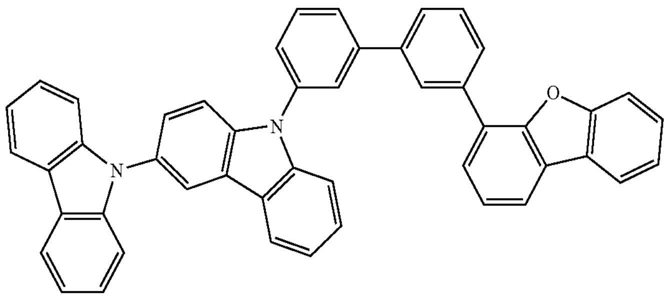
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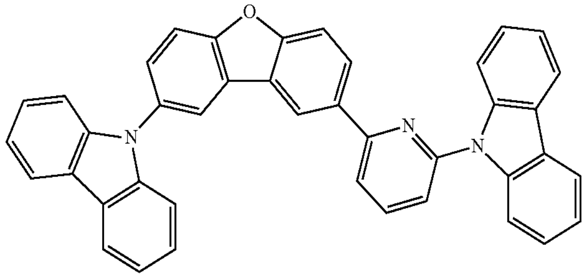
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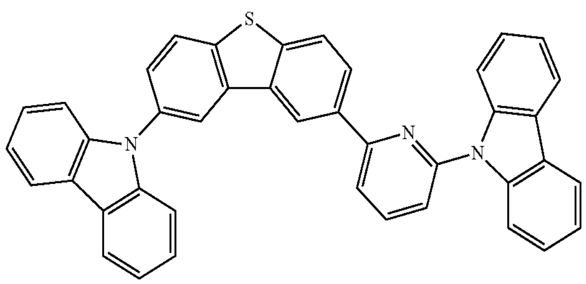
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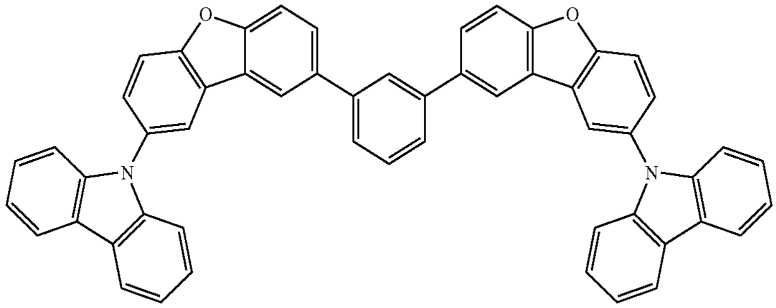

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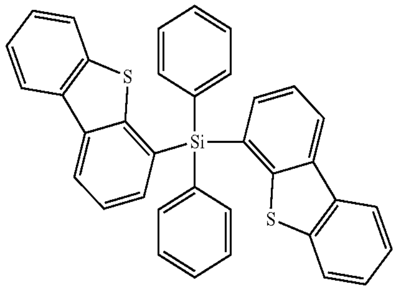

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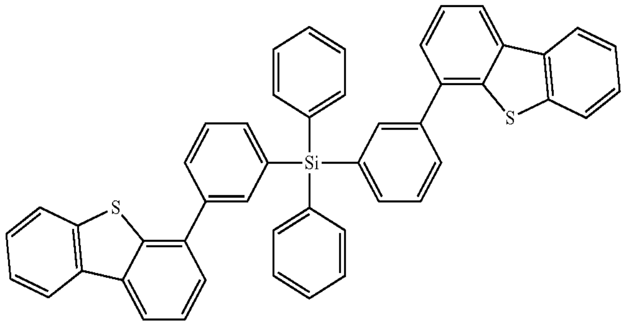

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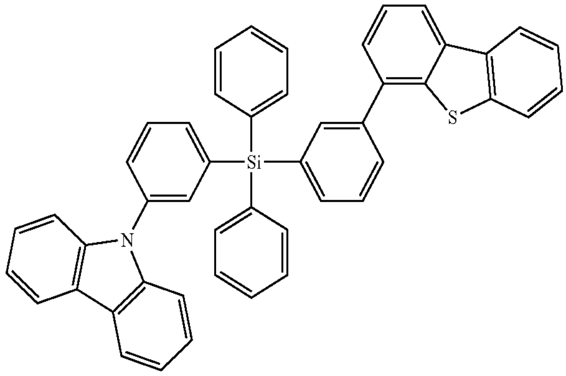

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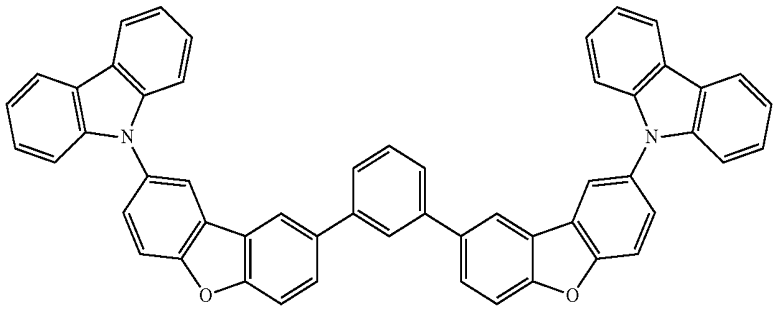

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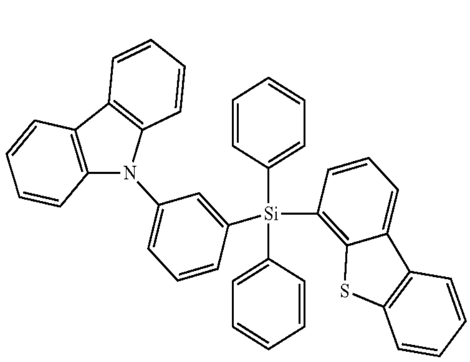

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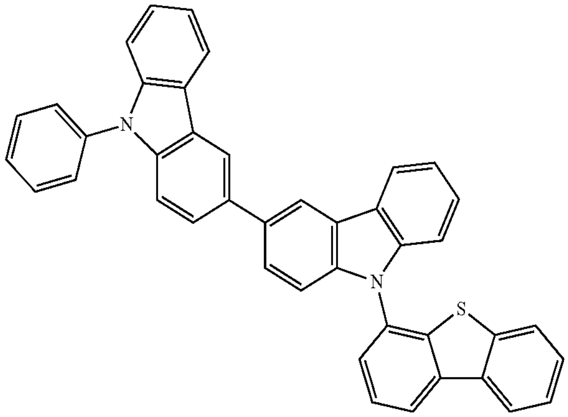

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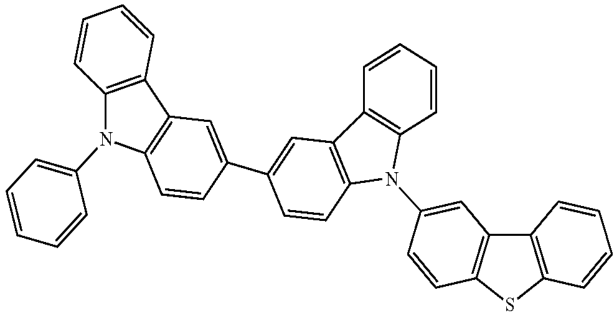

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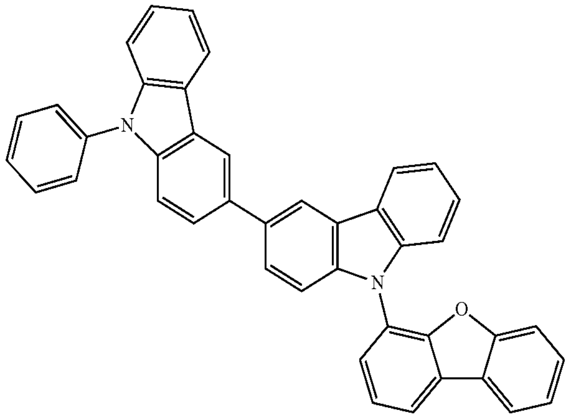

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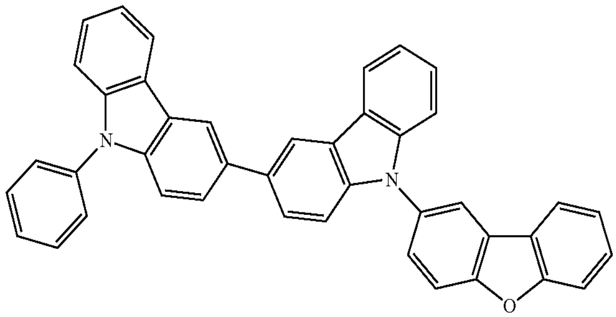

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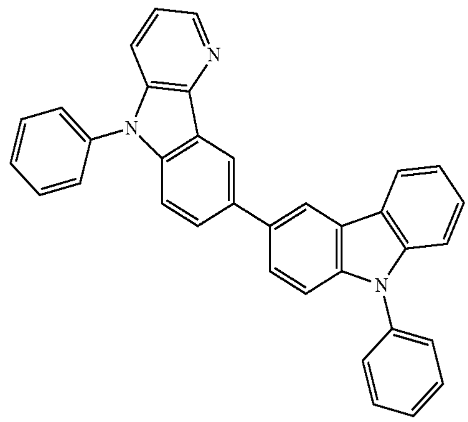

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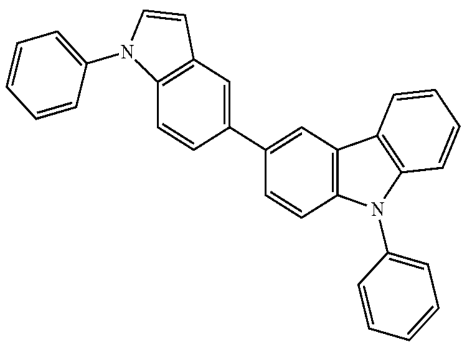

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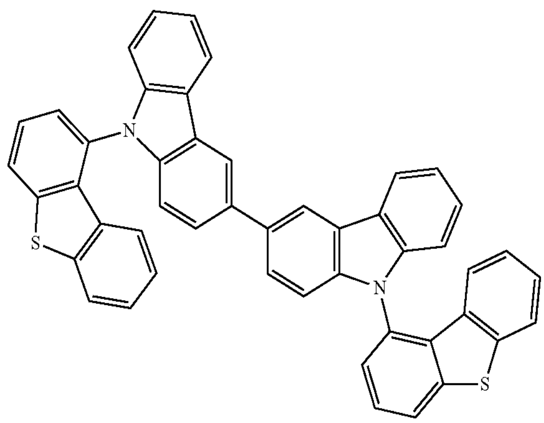

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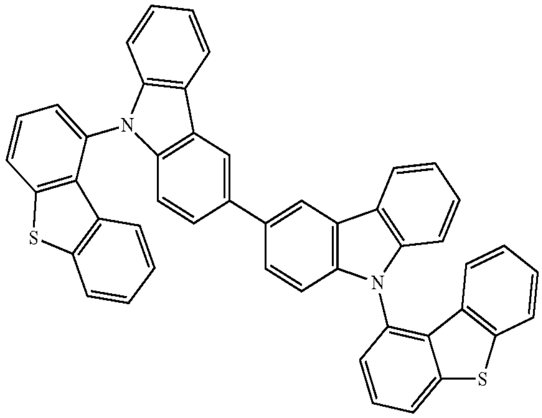

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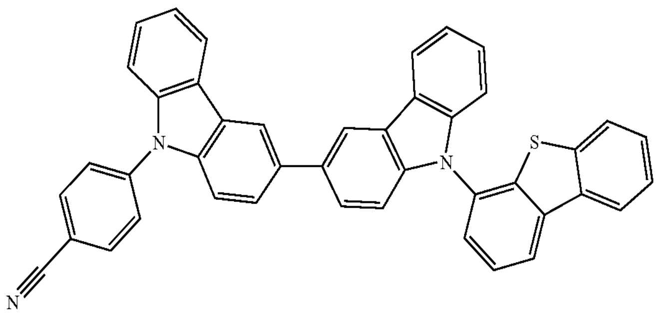

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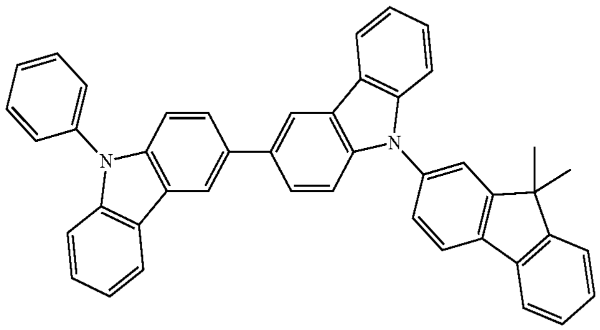

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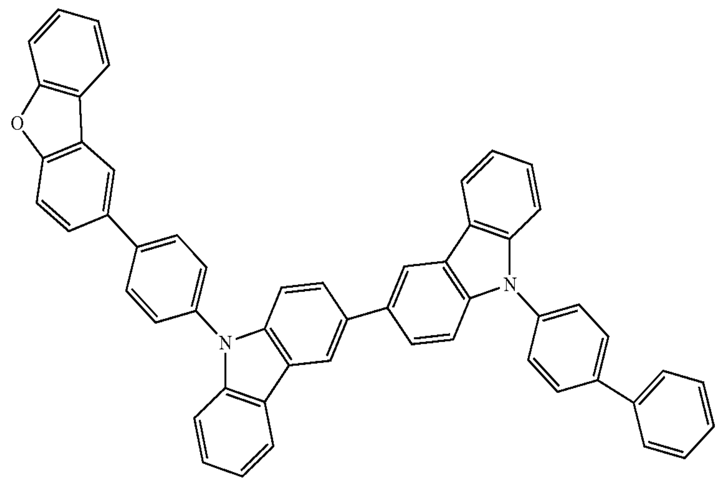

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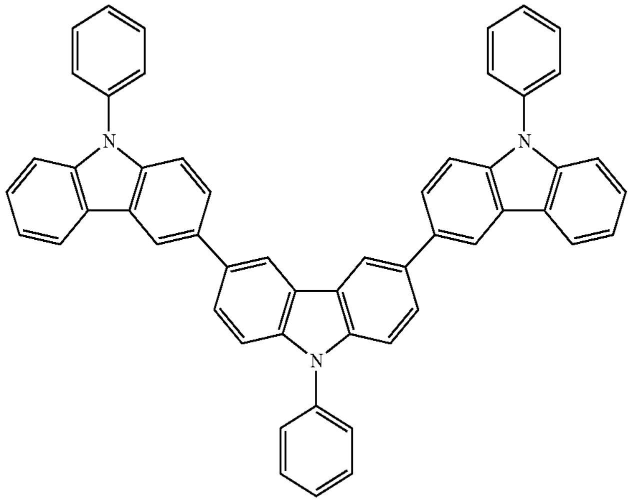

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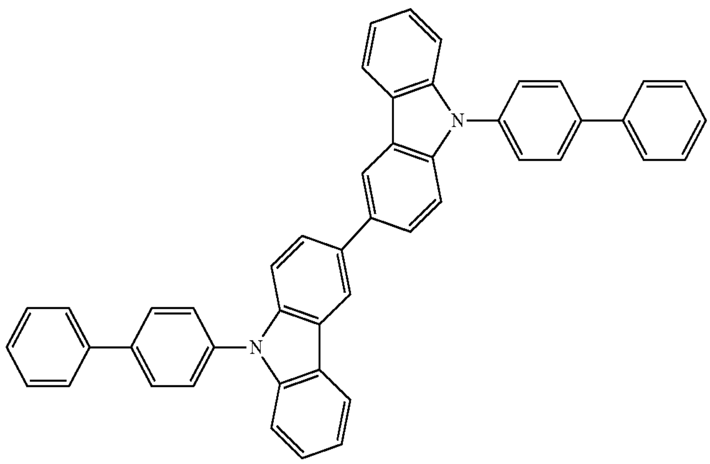

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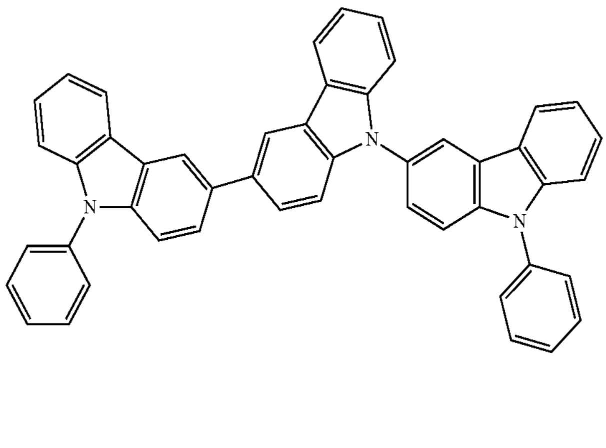

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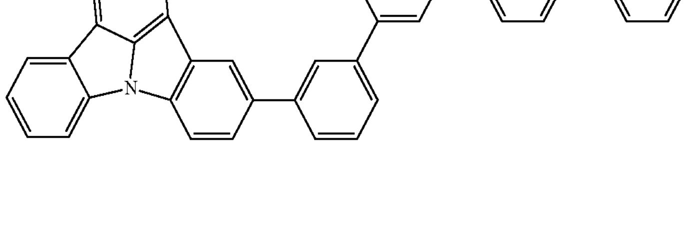

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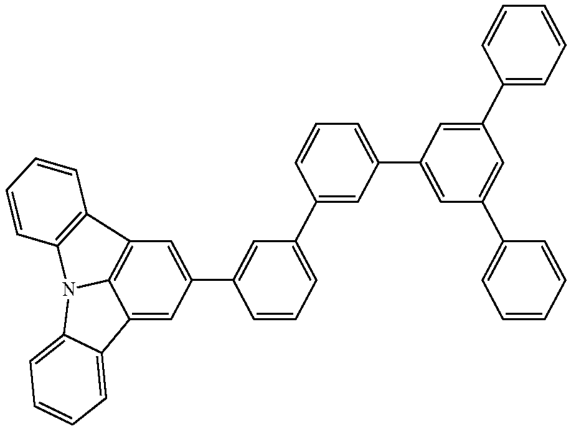
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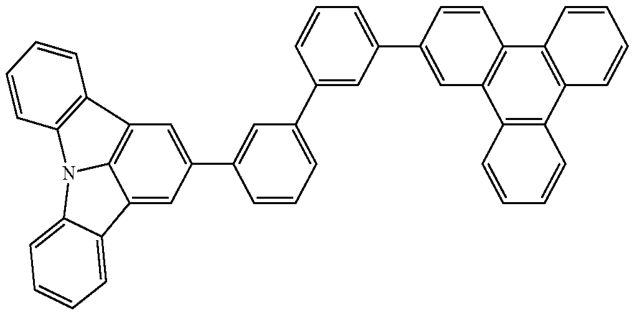
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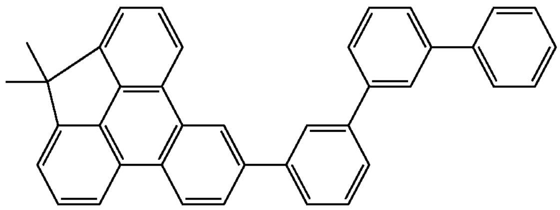
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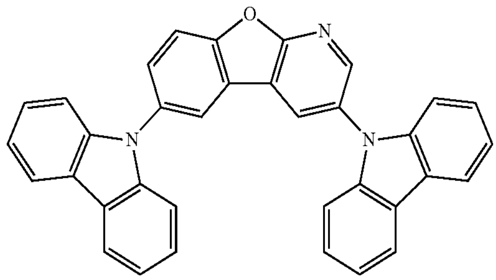
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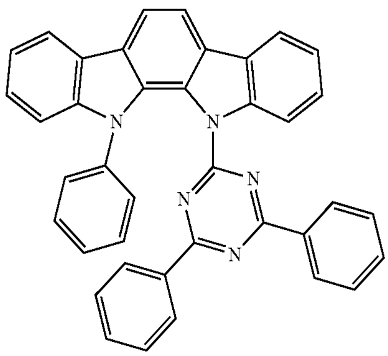
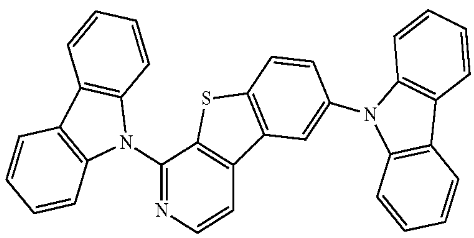
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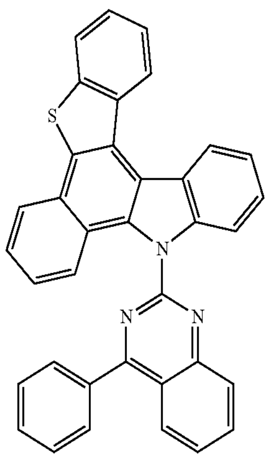
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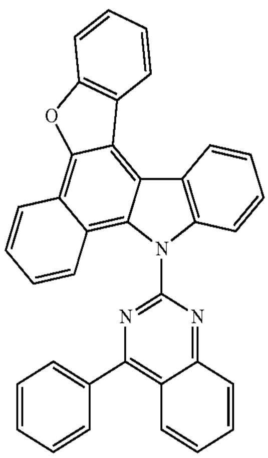
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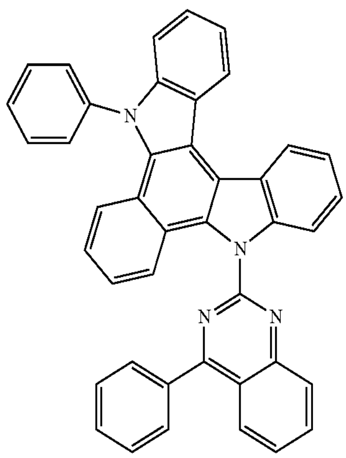
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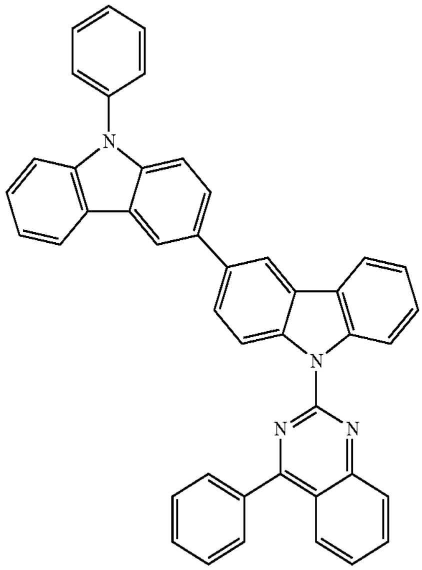

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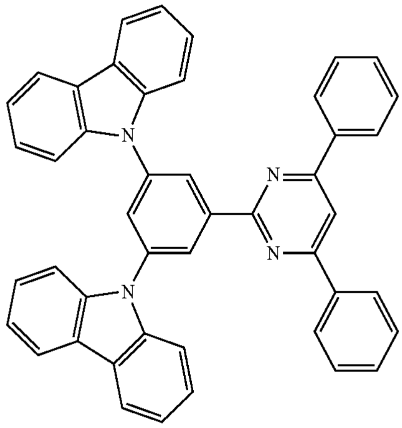

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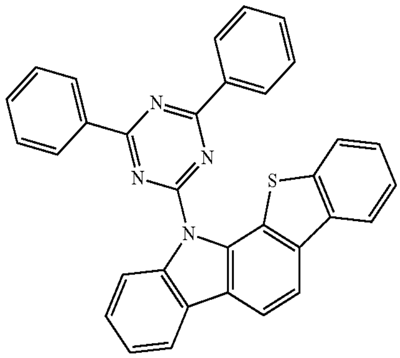

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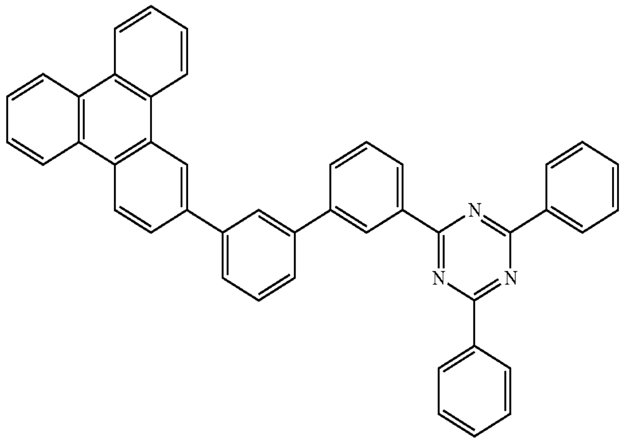

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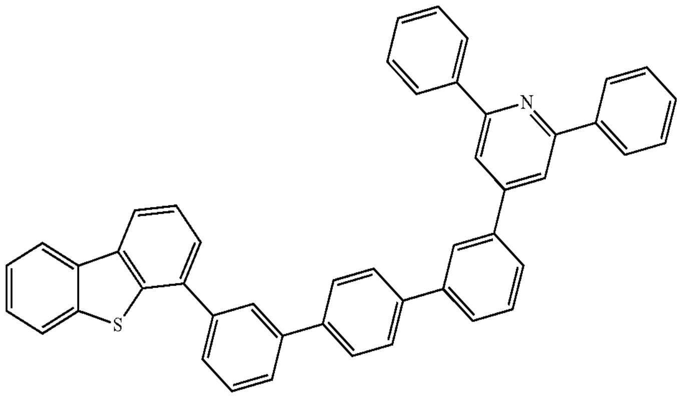

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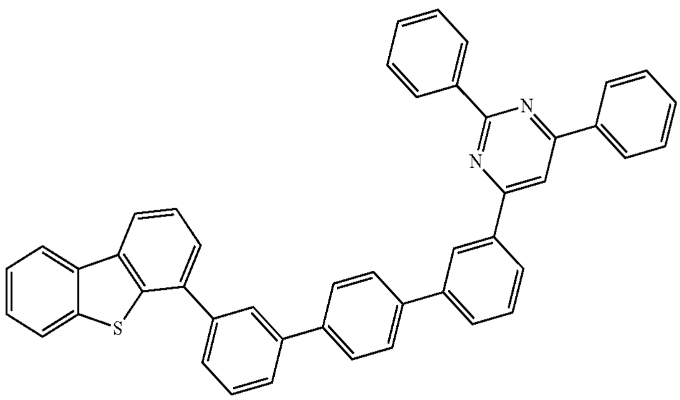

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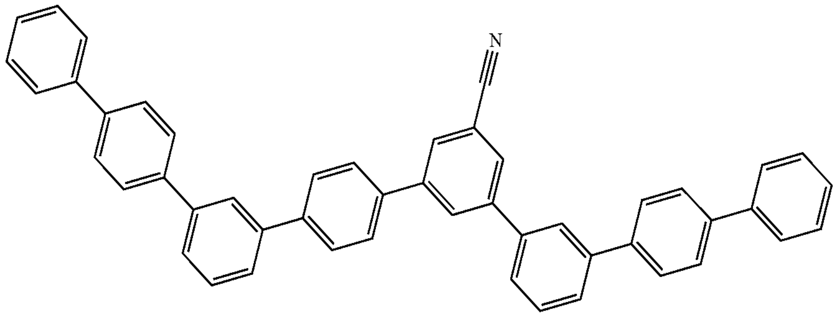
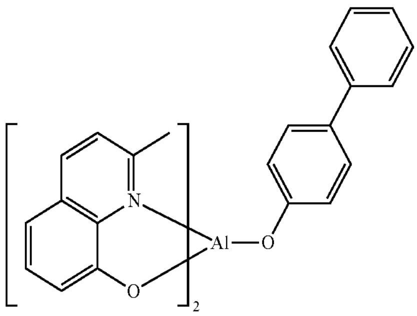
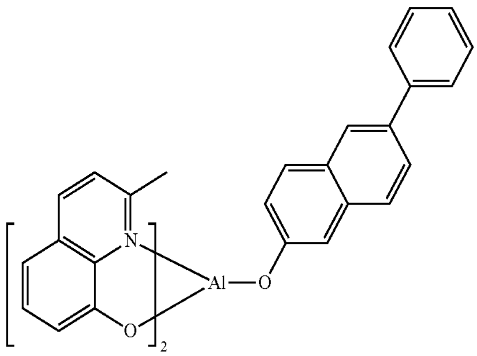
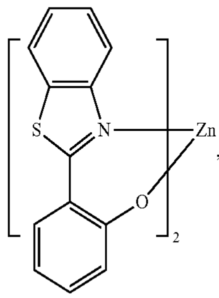
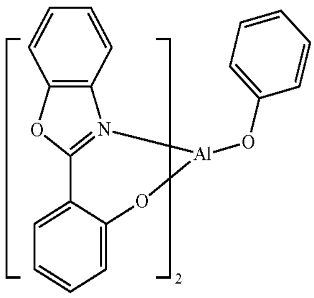
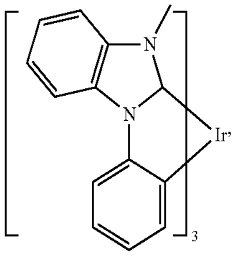
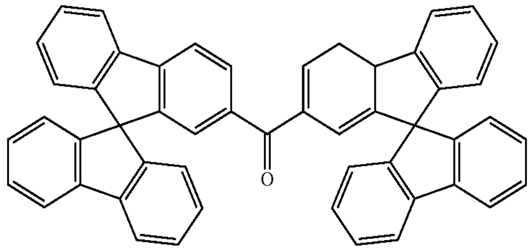
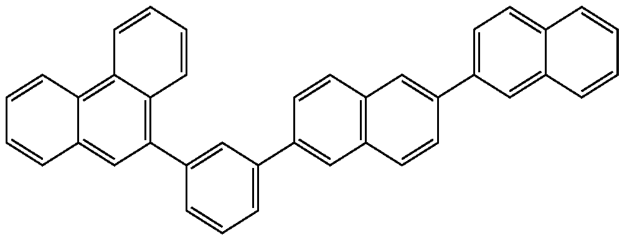
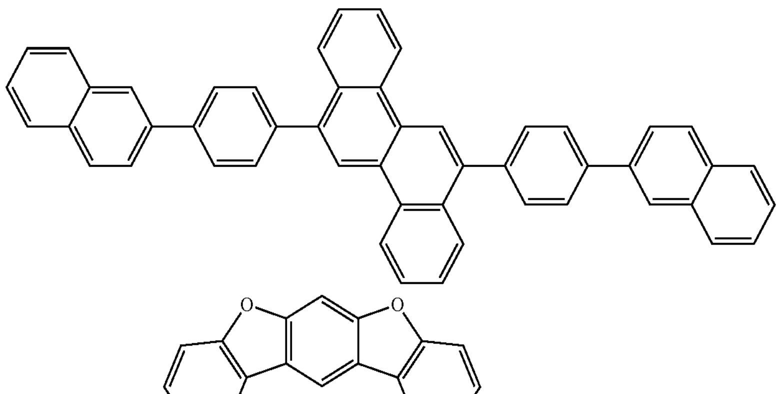
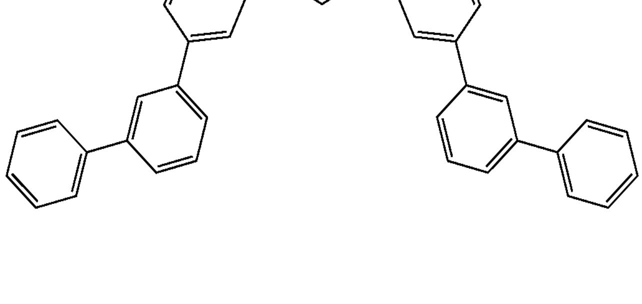
,

, , ,

,  ,

,

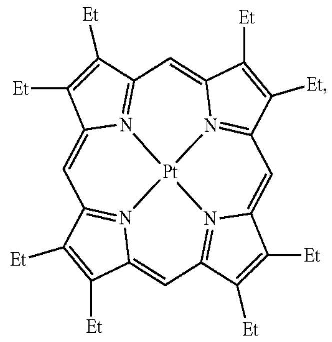
, and

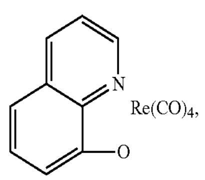
.

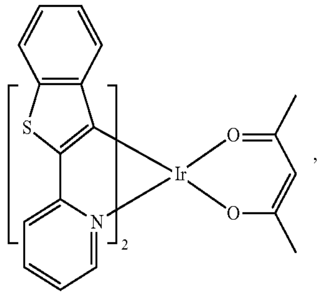
Additional Emitters:

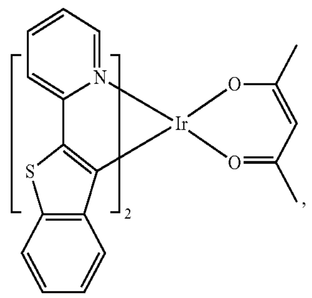
One or more additional emitter dopants may be used in conjunction with the compound of the present disclosure. Examples of the additional emitter dopants are not particularly limited, and any compounds may be used as long as the compounds are typically used as emitter materials. Examples of suitable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

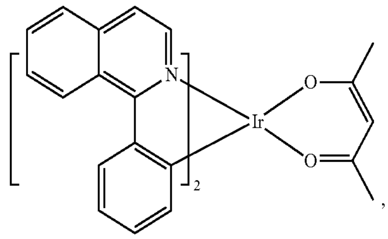
Non-limiting examples of the emitter materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: CN103694277, CN1696137, EB01238981, EP01239526, EP01961743, EP1239526, EP1244155, EP1642951, EP1647554, EP1841834, EP1841834B, EP2062907, EP2730583, JP2012074444, JP2013110263, JP4478555, KR1020090133652, KR20120032054, KR20130043460, TW201332980, U.S. Ser. No. 06/699,599, U.S. Ser. No. 06/916,554, US20010019782, US20020034656, US20030068526, US20030072964, US20030138657, US20050123788, US20050244673, US2005123791, US2005260449, US20060008670, US20060065890, US20060127696, US20060134459, US20060134462, US20060202194, US20060251923, US20070034863, US20070087321, US20070103060, US20070111026, US20070190359, US20070231600, US2007034863, US2007104979, US2007104980, US2007138437, US2007224450, US2007278936, US20080020237, US20080233410, US20080261076, US20080297033, US200805851, US2008161567, US2008210930, US20090039776, US20090108737, US20090115322, US20090179555, US2009085476, US2009104472, US20100090591, US20100148663, US20100244004, US20100295032, US2010102716, US2010105902, US2010244004, US2010270916, US20110057559, US20110108822, US20110204333, US2011215710, US2011227049, US2011285275, US2012292601, US20130146848, US2013033172, US2013165653, US2013181190, US2013334521, US20140246656, US2014103305, U.S. Pat. Nos. 6,303,238, 6,413,656, 6,653,654, 6,670,645, 6,687,266, 6,835,469, 6,921,915, 7,279,704, 7,332,232, 7,378,162, 7,534,505, 7,675,228, 7,728,137, 7,740,957, 7,759,489, 7,951,947, 8,067,099, 8,592,586, 8,871,361, WO06081973, WO06121811, WO07018067, WO07108362, WO07115970, WO07115981, WO08035571, WO2002015645, WO2003040257, WO2005019373, WO2006056418, WO2008054584, WO2008078800, WO2008096609, WO2008101842, WO2009000673, WO2009050281, WO2009100991, WO2010028151, WO2010054731, WO2010086089, WO2010118029, WO2011044988, WO2011051404, WO2011107491, WO2012020327, WO2012163471, WO2013094620, WO2013107487, WO2013174471, WO2014007565, WO2014008982, WO2014023377, WO2014024131, WO2014031977, WO2014038456, WO2014112450.

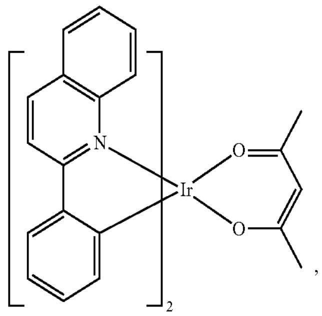


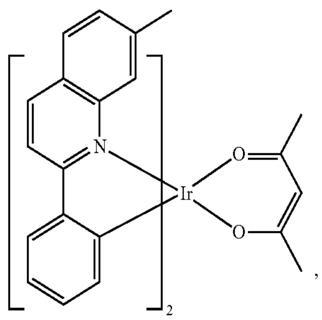


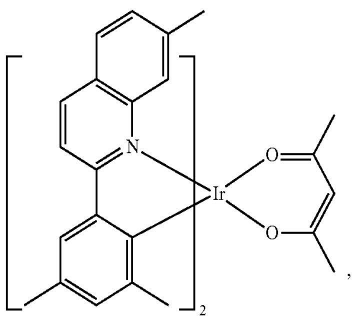


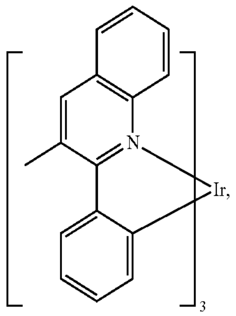


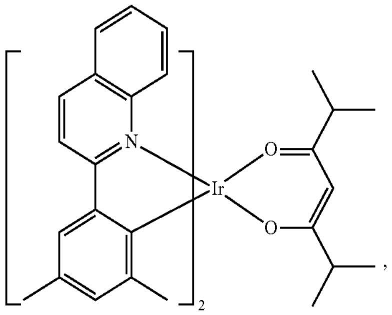


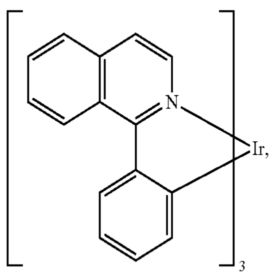


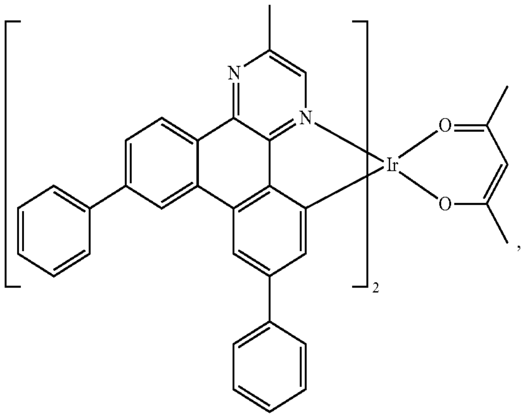


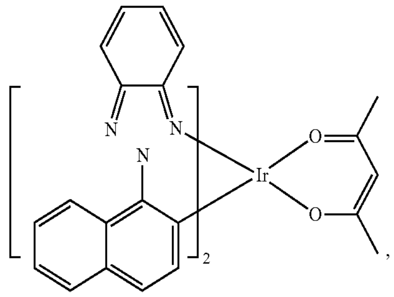


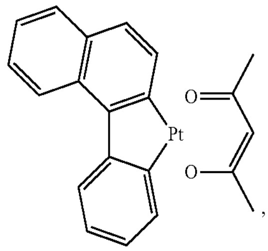


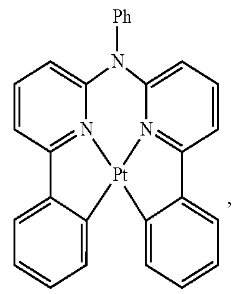


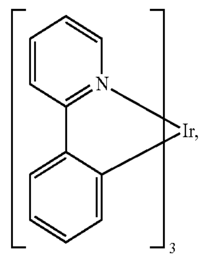


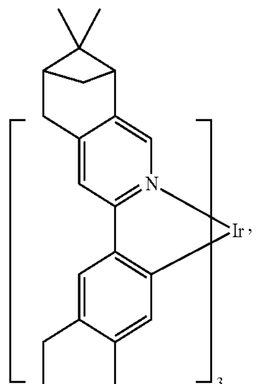


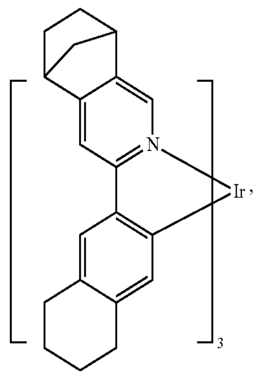












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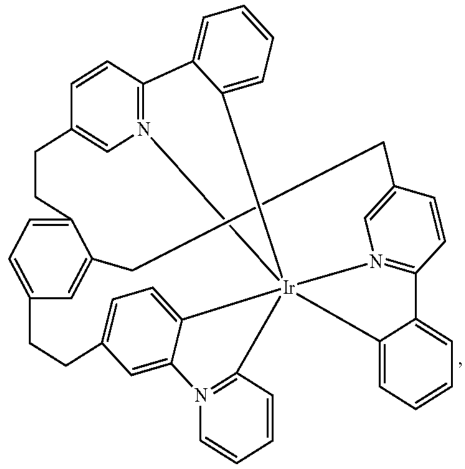

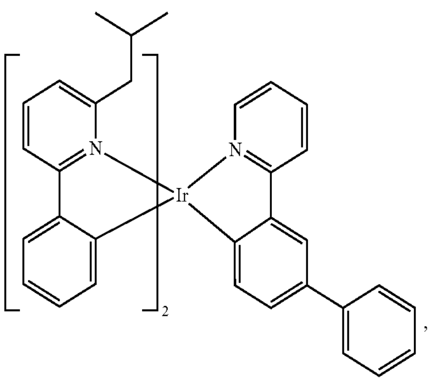

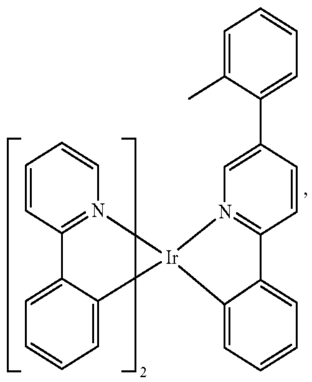

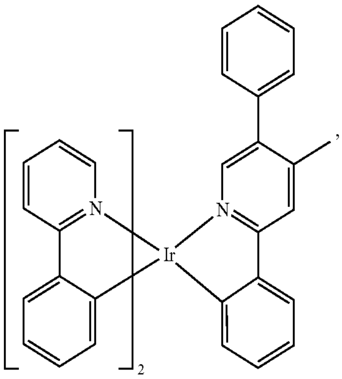

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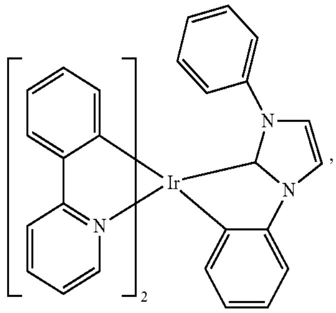

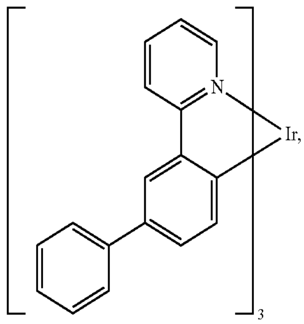

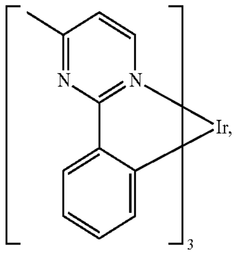

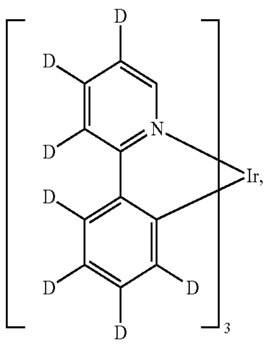

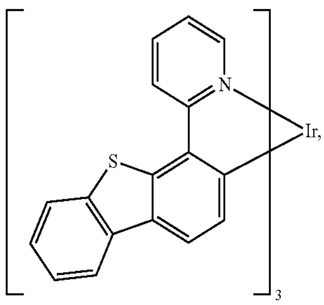

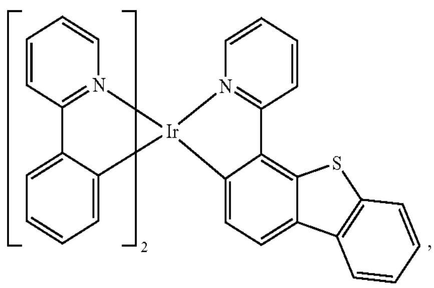

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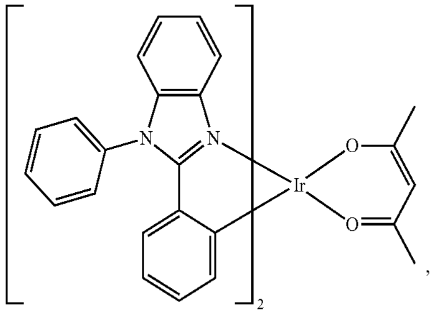

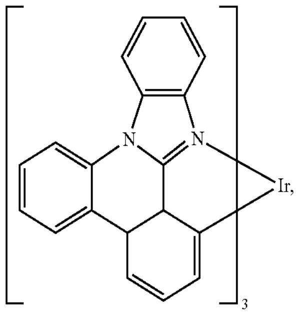

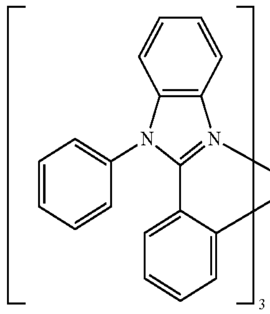

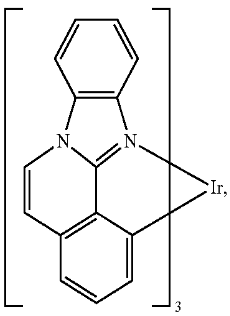

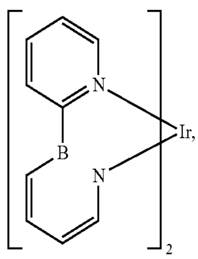

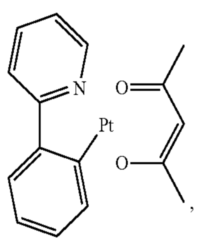

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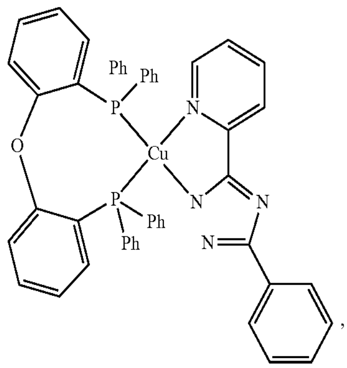

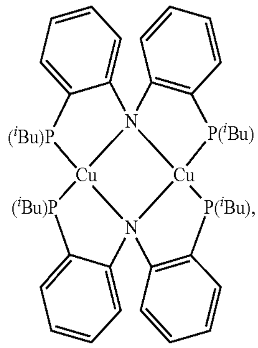

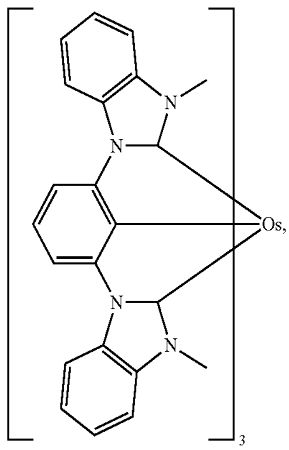

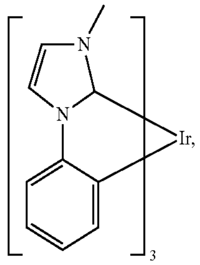

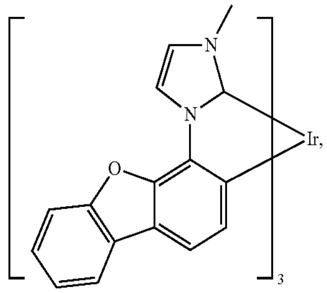

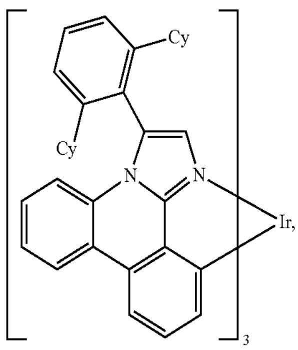

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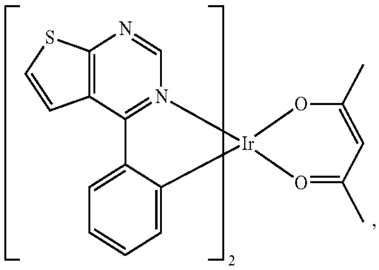

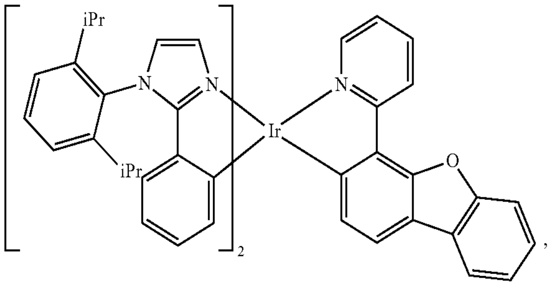

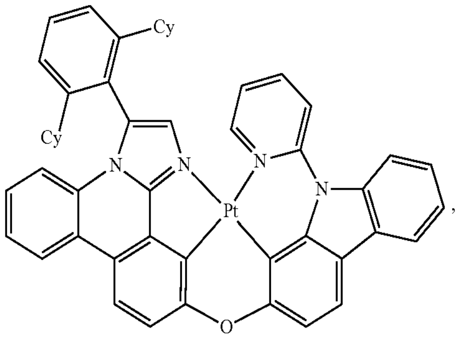

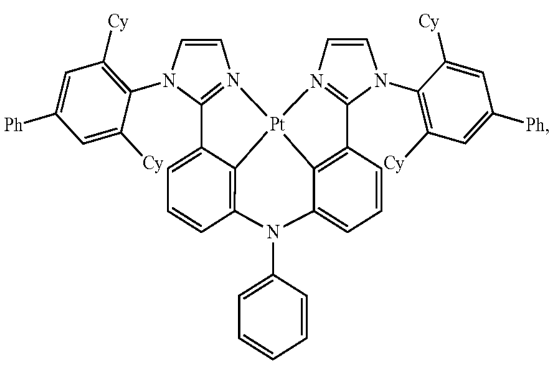

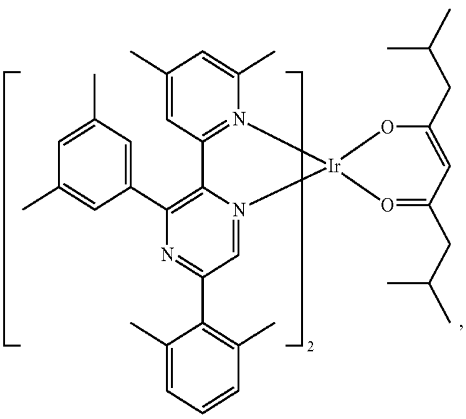

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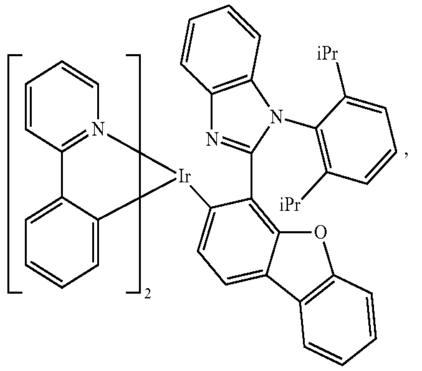

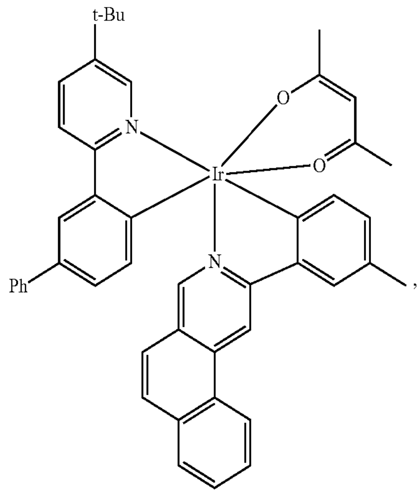

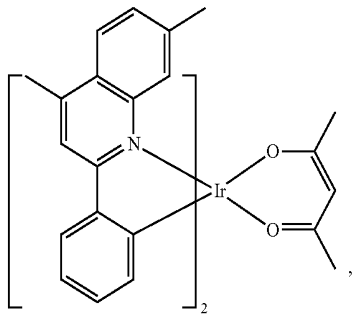

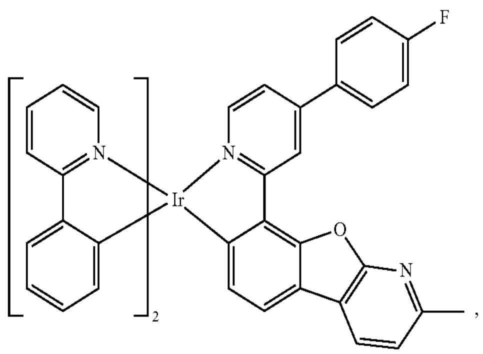

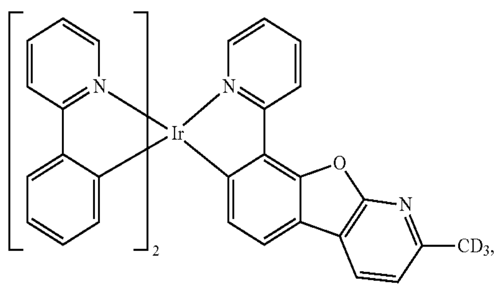

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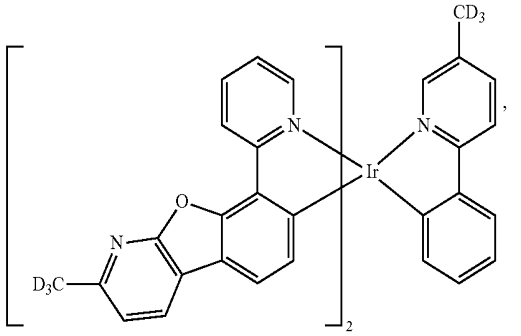

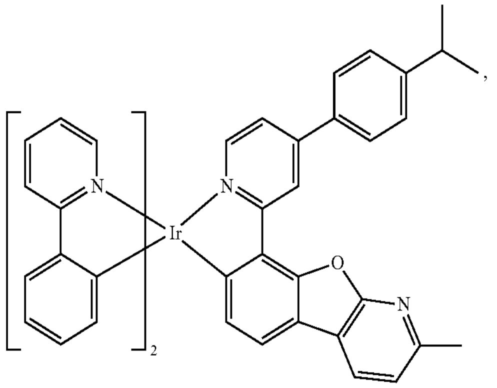

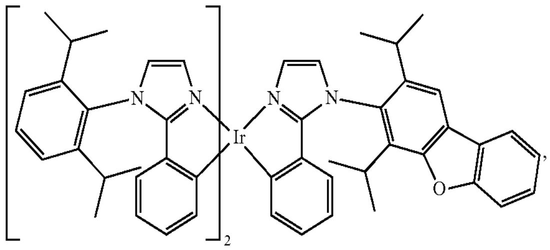

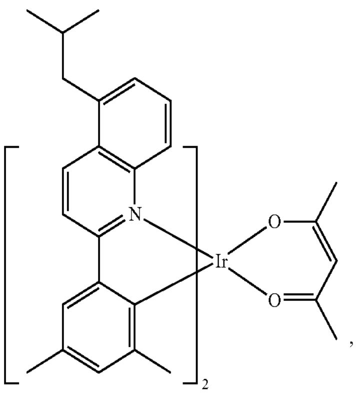

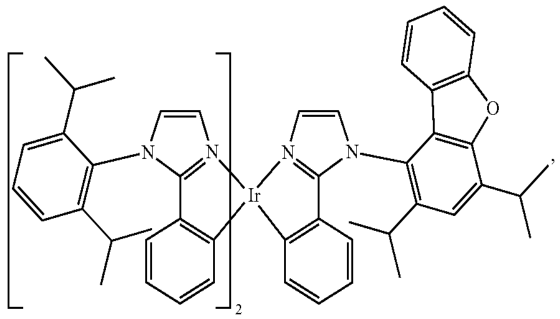

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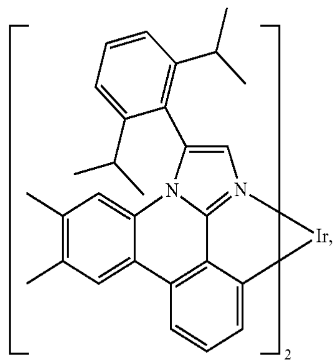

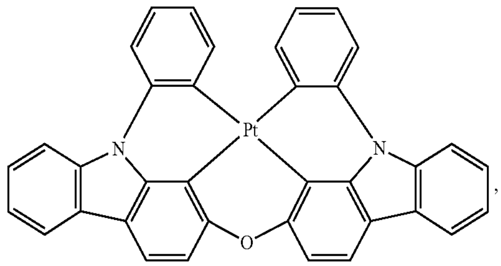

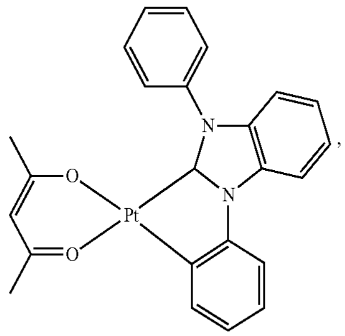

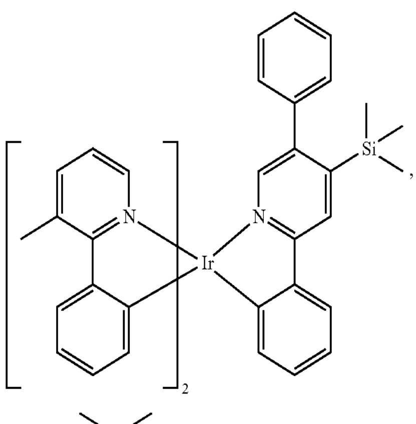

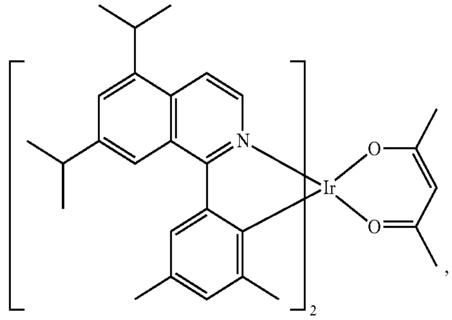

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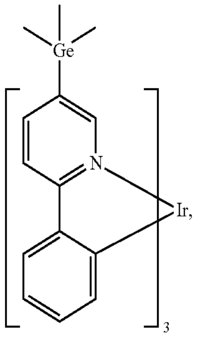

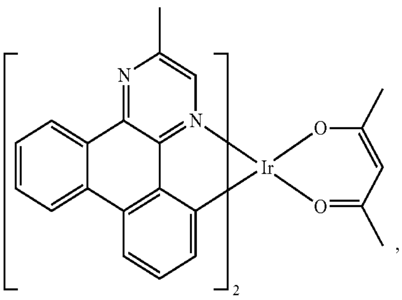

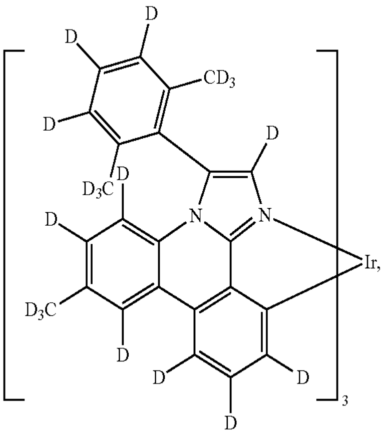

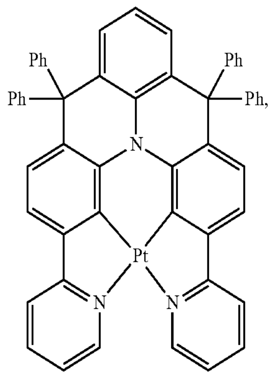

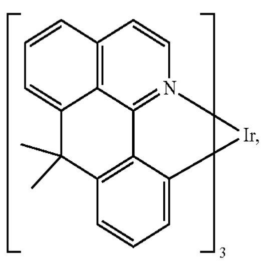

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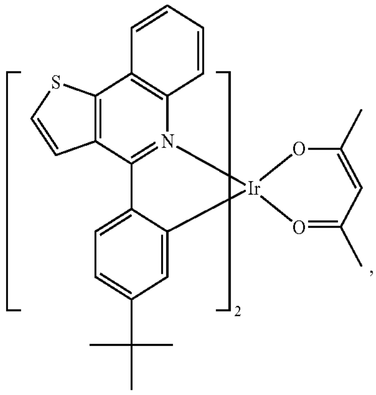

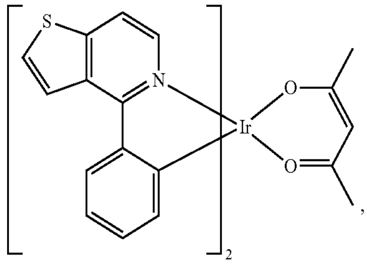

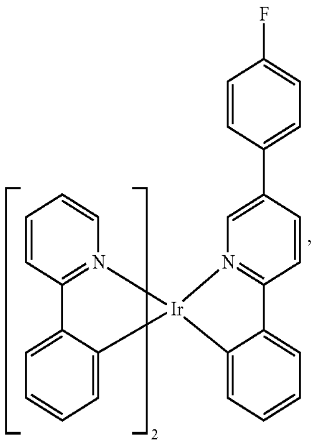

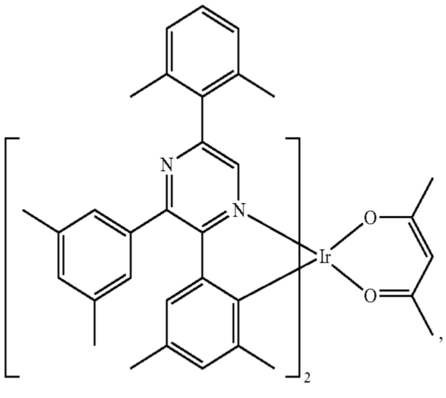

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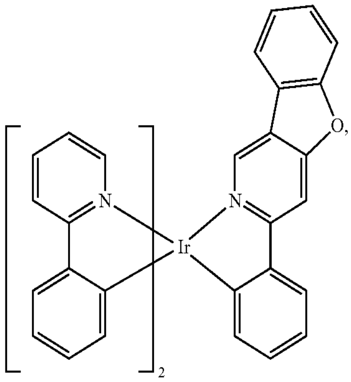

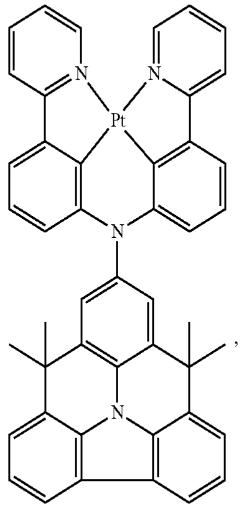

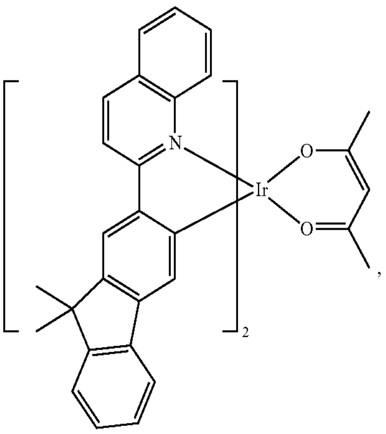

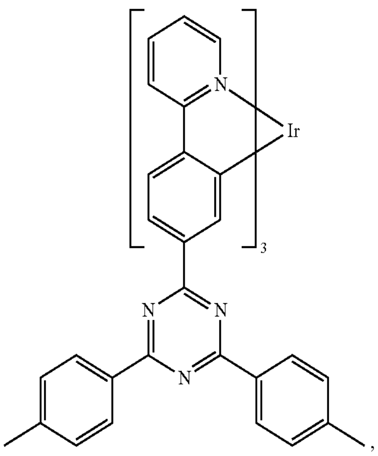

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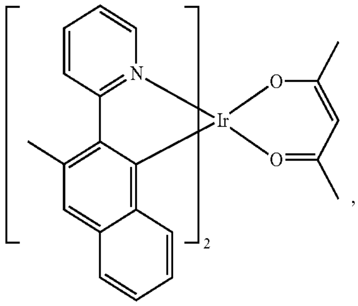

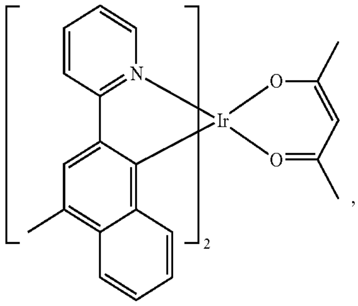

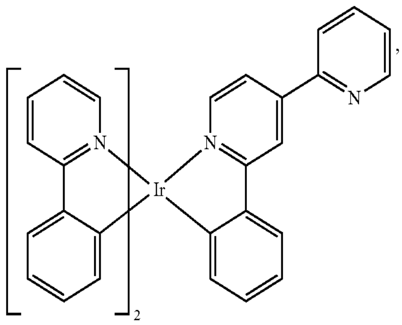

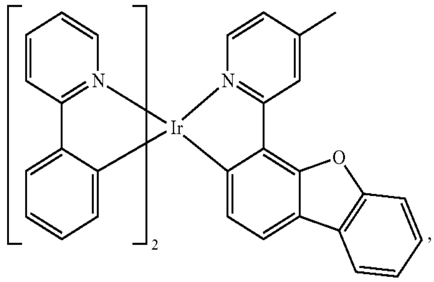

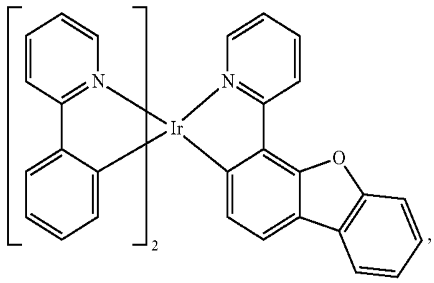

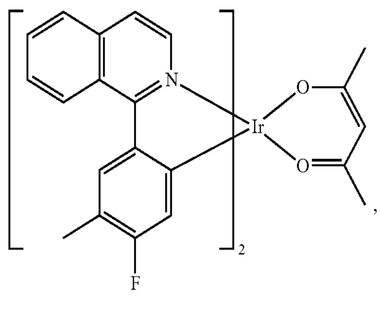

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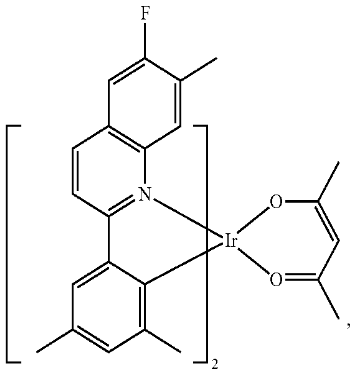

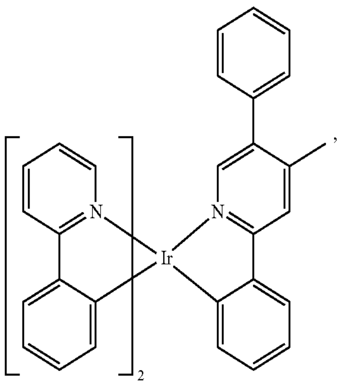

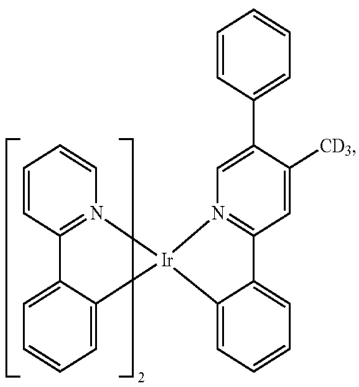

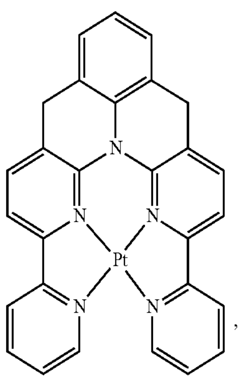

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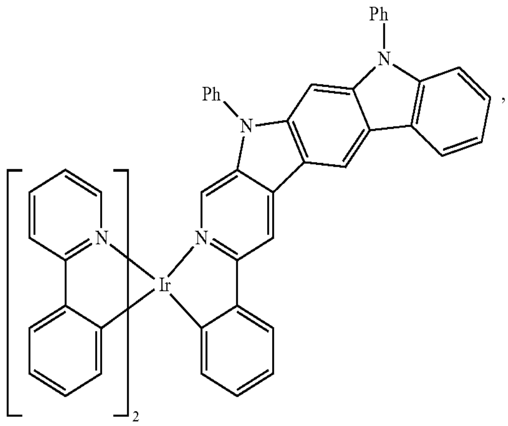

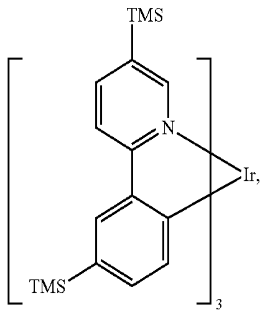

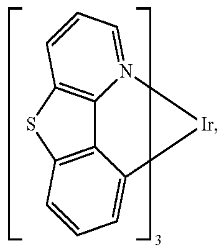

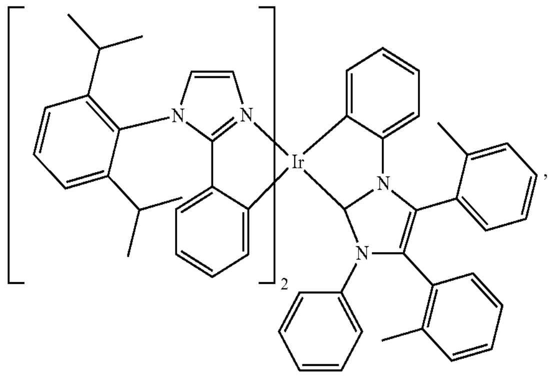

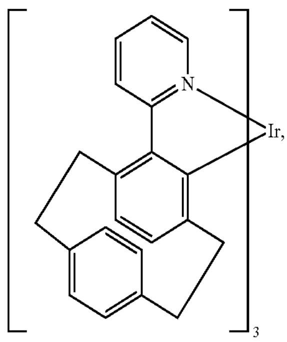

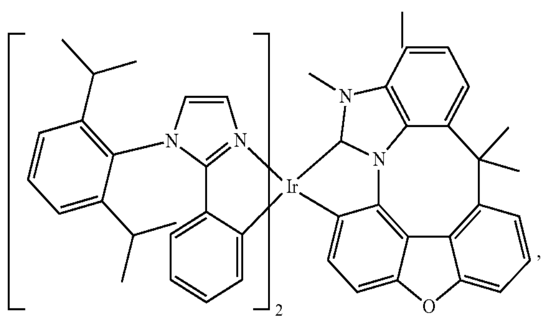

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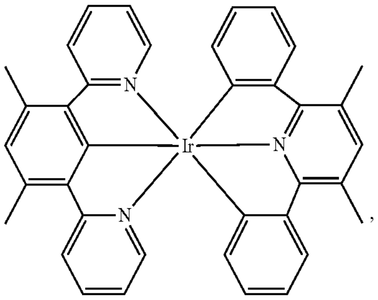

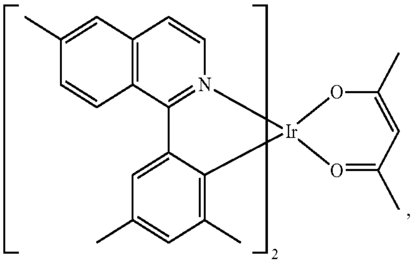

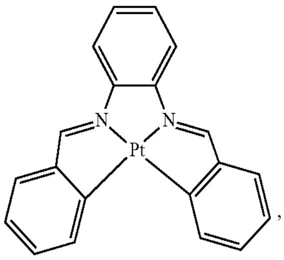

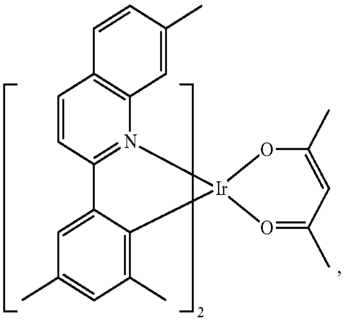

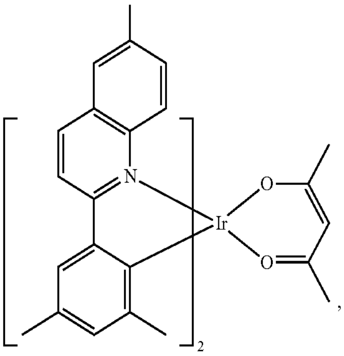

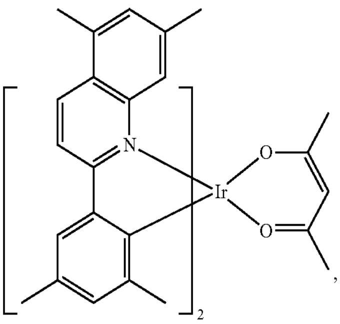

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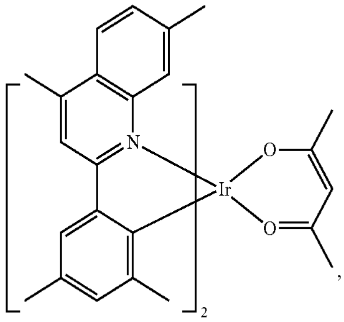

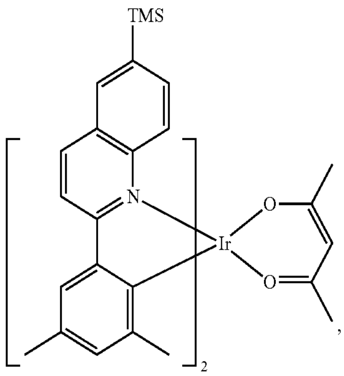

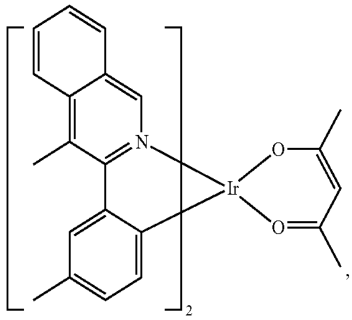

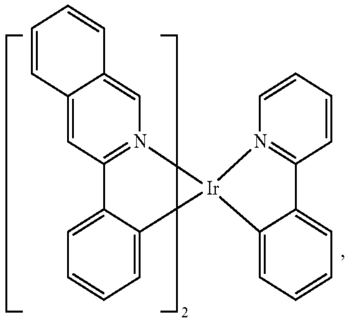

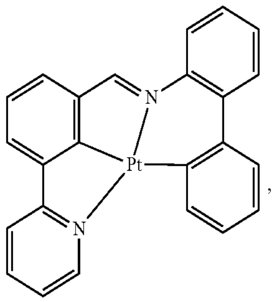

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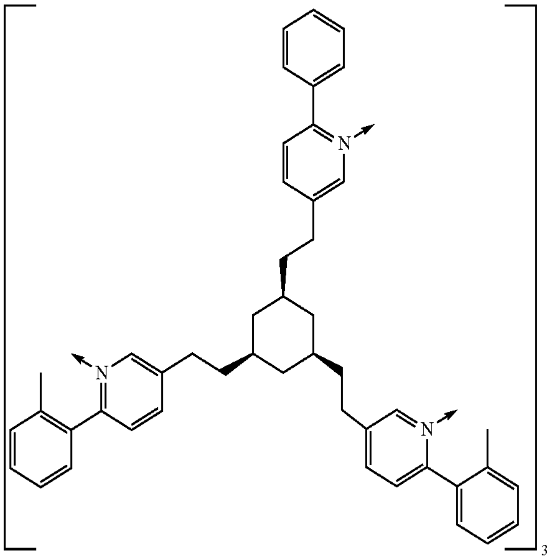

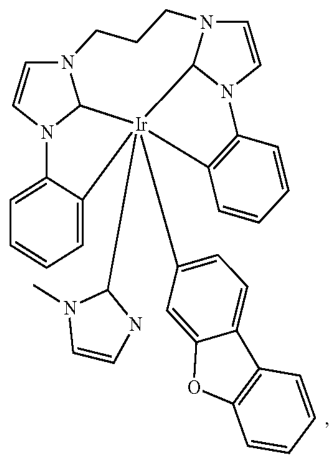

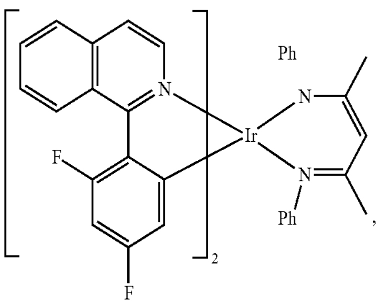

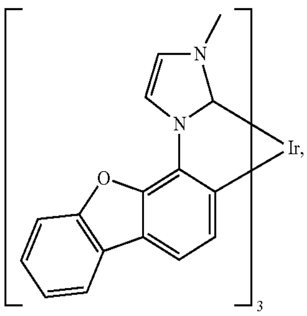

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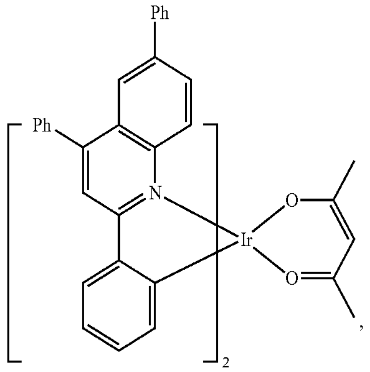

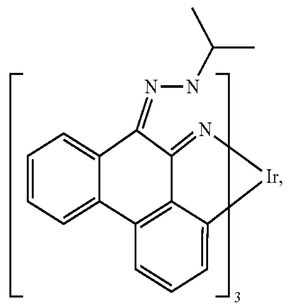

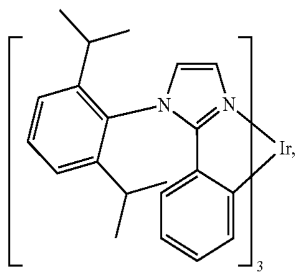

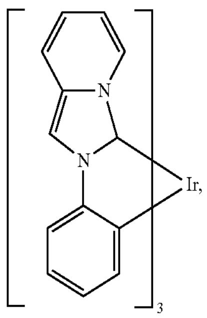

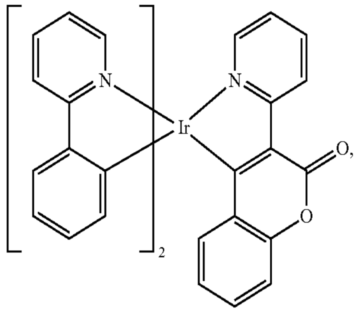

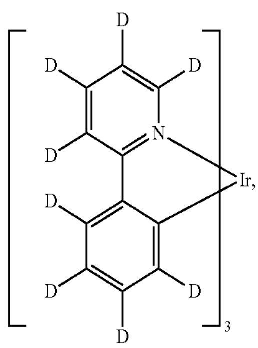

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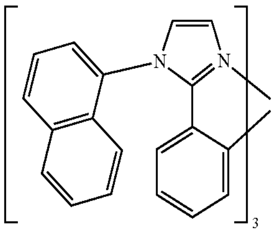

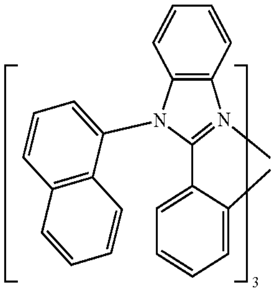

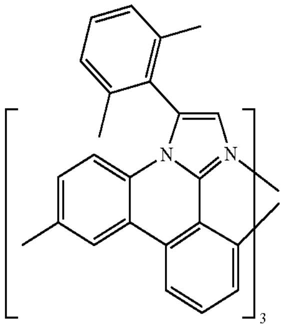

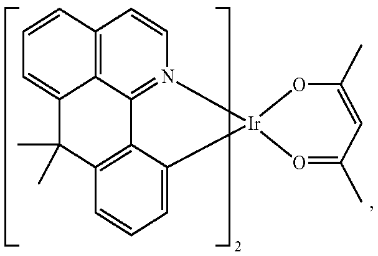

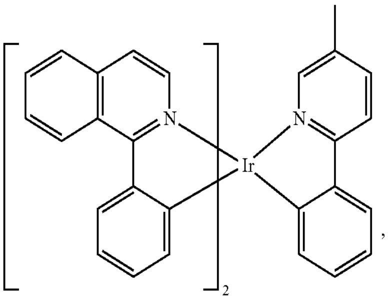

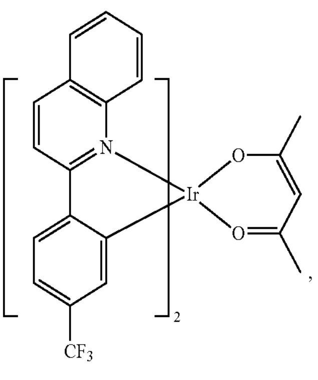

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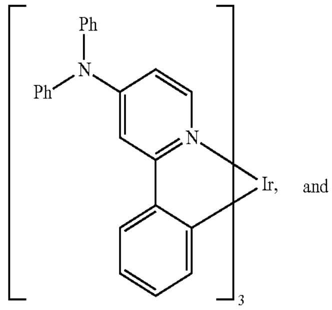
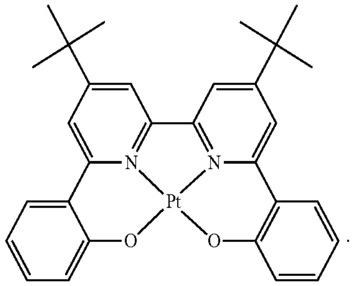


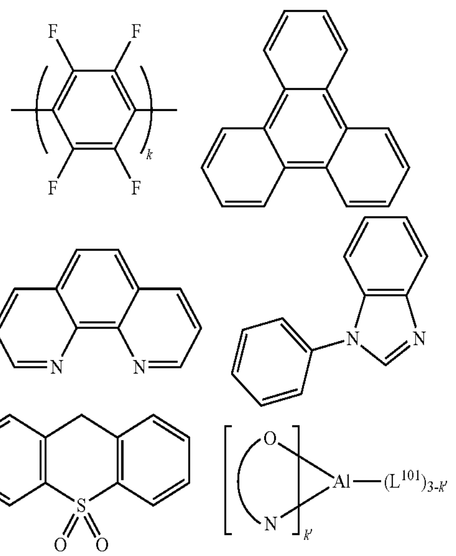


HBL:

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

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

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

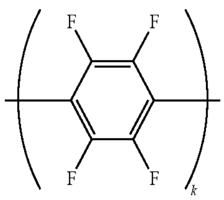


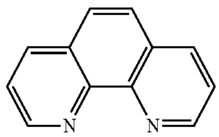
wherein k is an integer from 1 to 20; L^{101} is an another ligand, k' is an integer from 1 to 3.

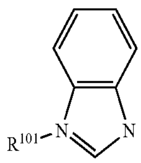
ETL:

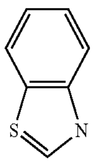
Electron transport layer (ETL) may include a material capable of transporting electrons. Electron transport layer may be intrinsic (undoped), or doped. Doping may be used to enhance conductivity. Examples of the ETL material are not particularly limited, and any metal complexes or organic compounds may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

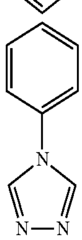
In one aspect, compound used in ETL contains at least one of the following groups in the molecule:

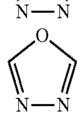


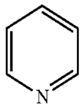


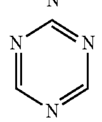


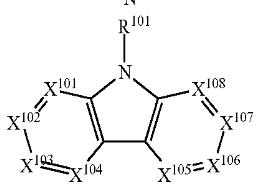


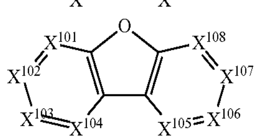












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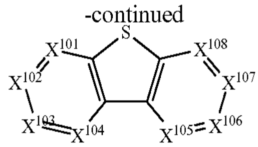
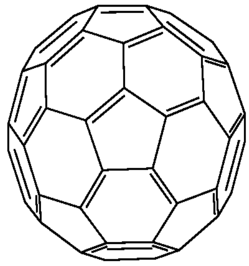
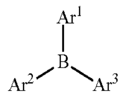
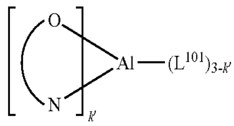


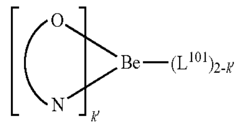


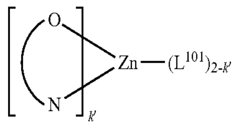


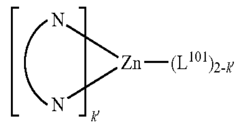
wherein R^{101} is selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl,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

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



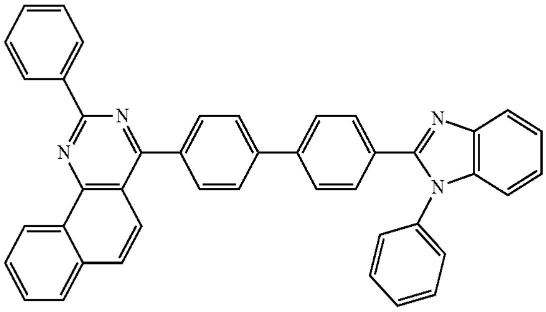






wherein (O—N) or (N—N) is a bidentate ligand, having metal coordinated to atoms O, N or N, N; L^{101} is another ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached to the metal.

Non-limiting examples of the ETL materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: CN103508940, EP01602648, EP01734038, EP01956007, JP2004-022334, JP2005149918, JP2005-268199, KR0117693, KR20130108183, US20040036077, US20070104977, US2007018155, US20090101870, US20090115316, US20090140637, US20090179554, US2009218940, US2010108990, US2011156017, US2011210320, US2012193612, US2012214993, US2014014925, US2014014927, US20140284580, U.S. Pat. Nos. 6,656,612, 8,415,031, WO2003060956, WO2007111263, WO2009148269, WO2010067894, WO2010072300, WO2011074770, WO2011105373, WO2013079217, WO2013145667, WO2013180376, WO2014104499, WO2014104535,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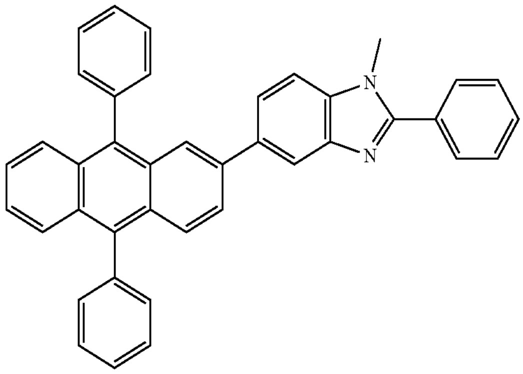
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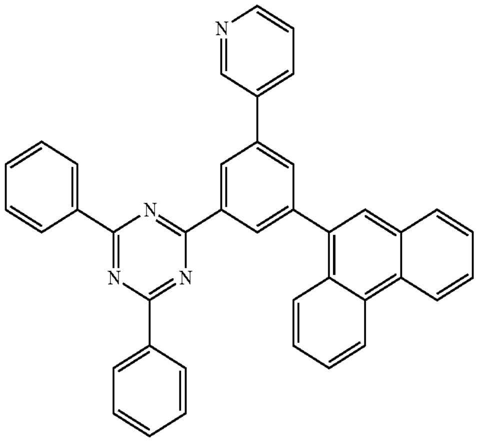
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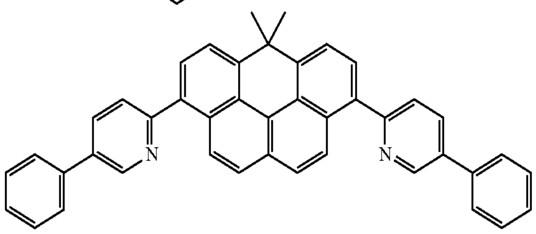
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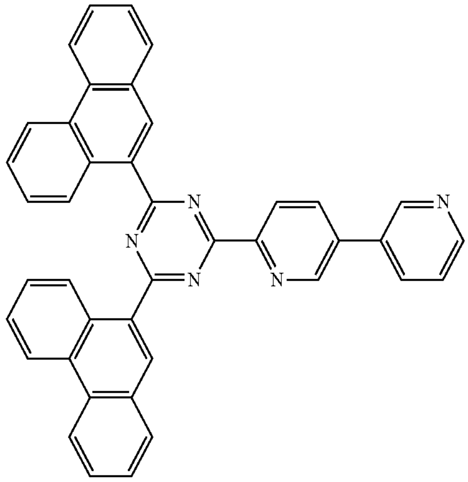
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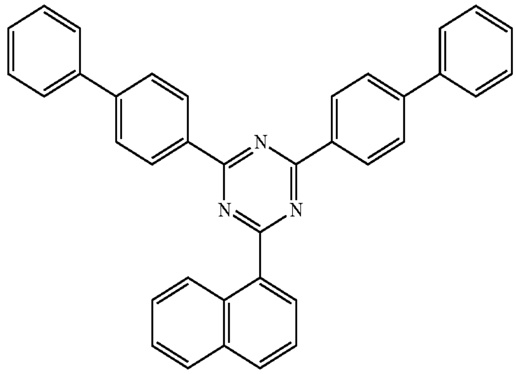
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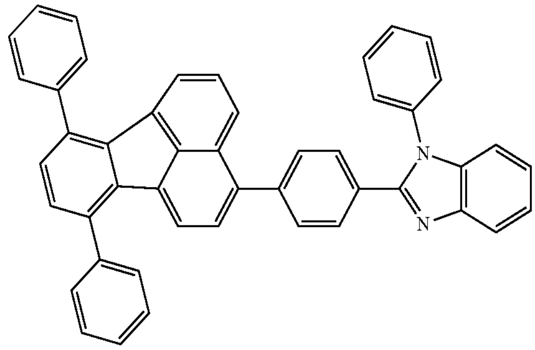
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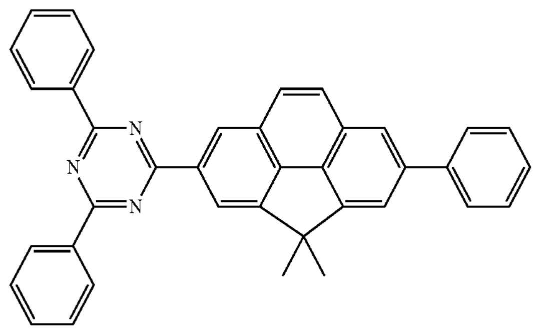
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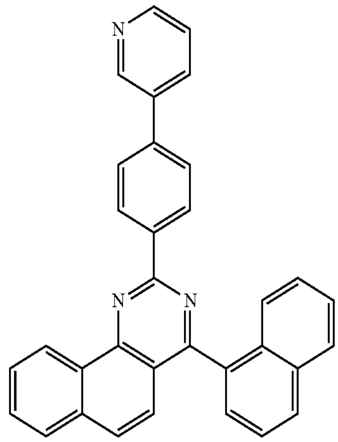
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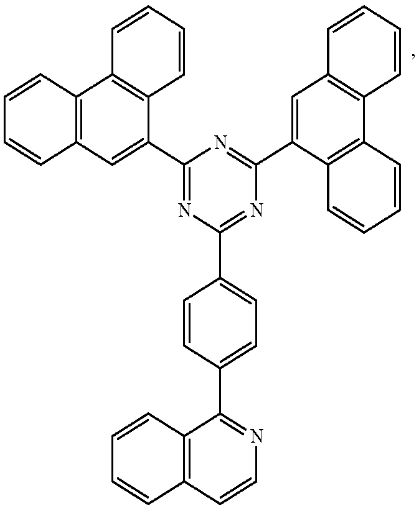

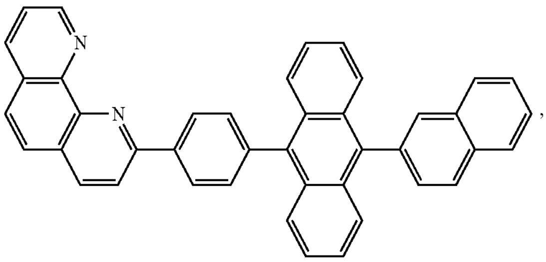

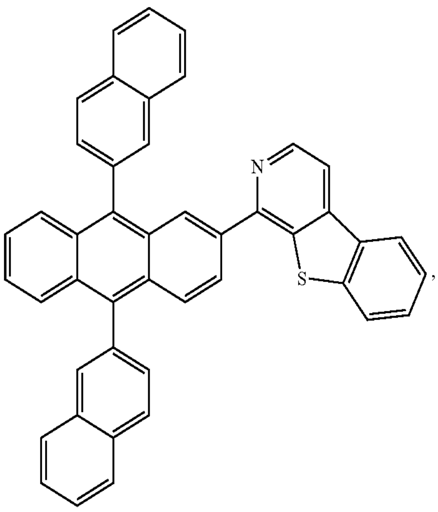

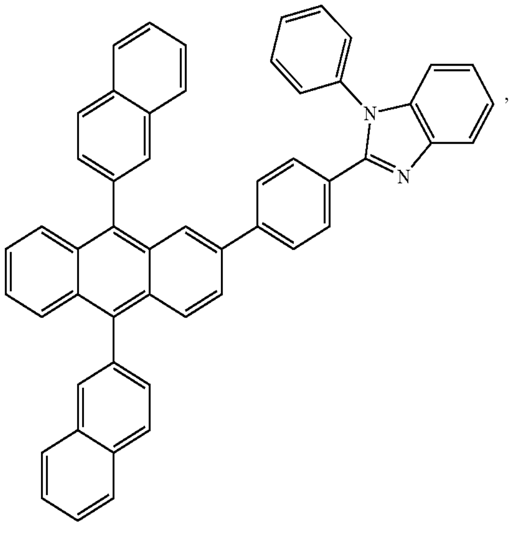

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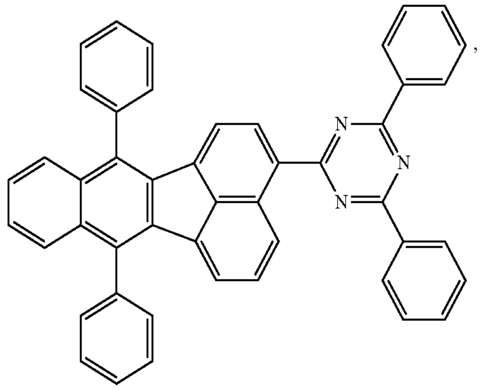

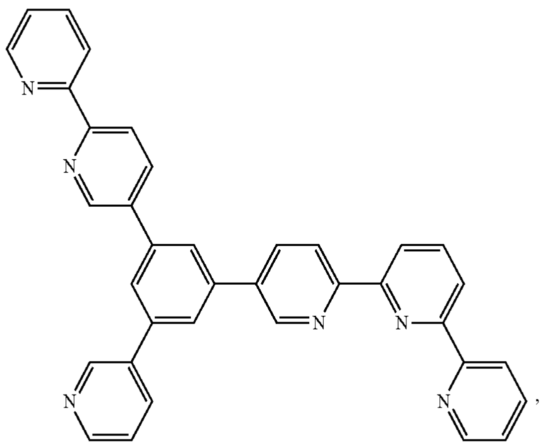

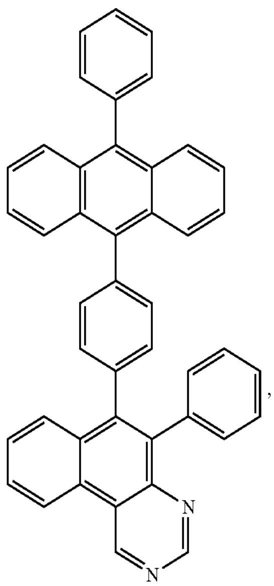

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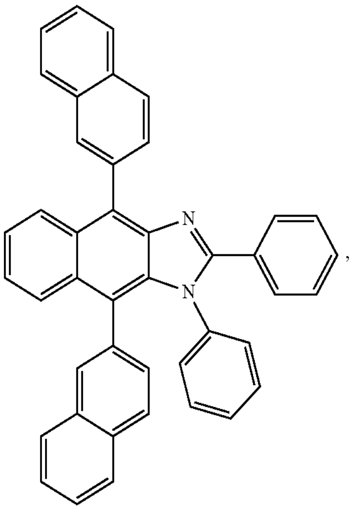

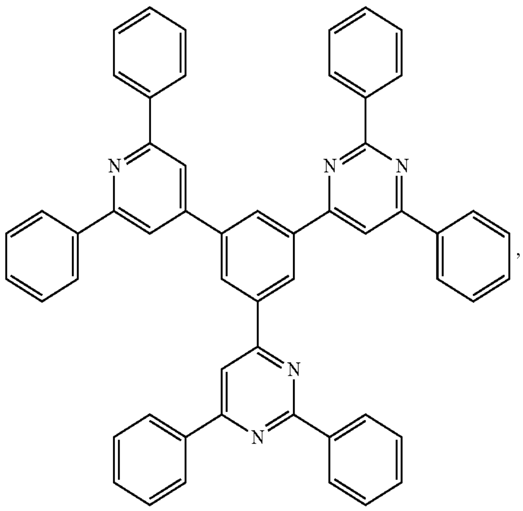

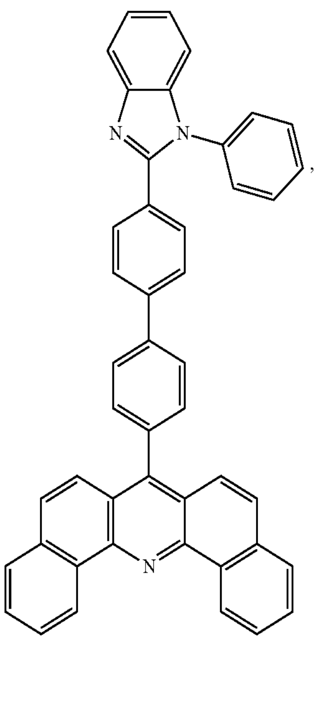

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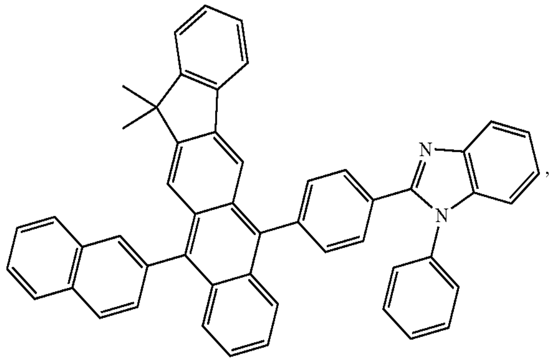

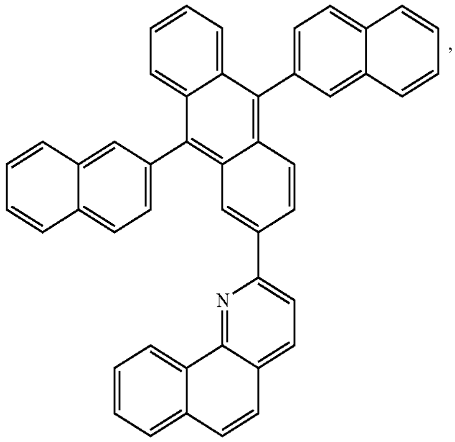

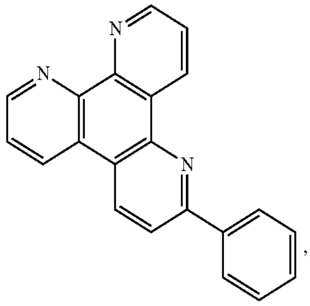

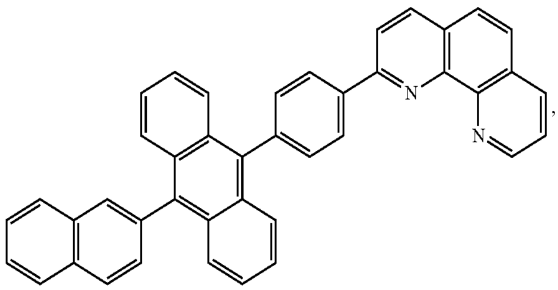

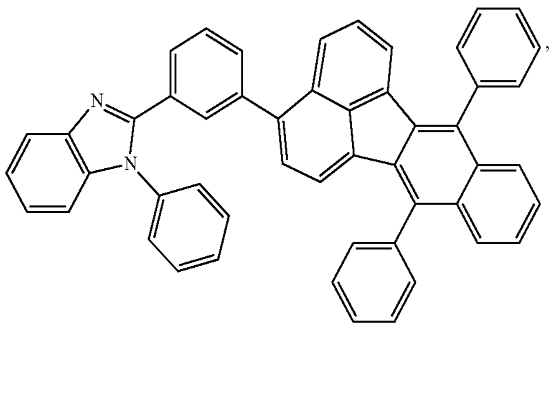

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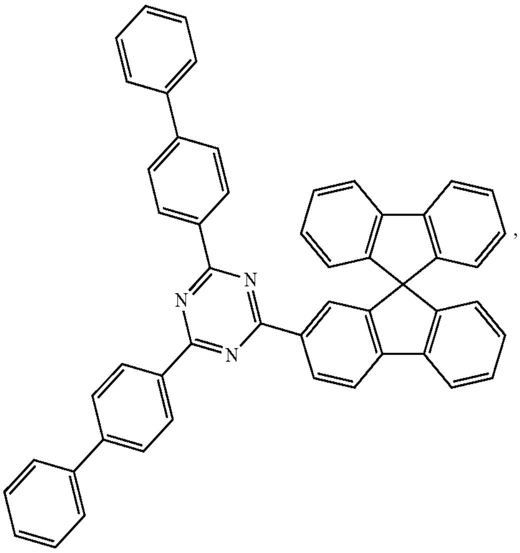

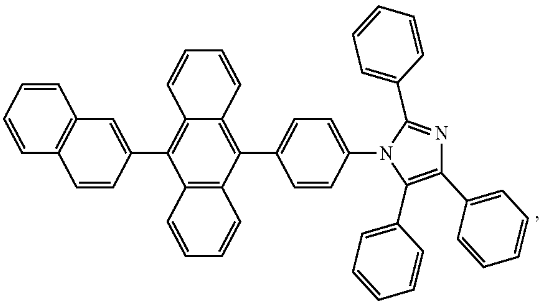

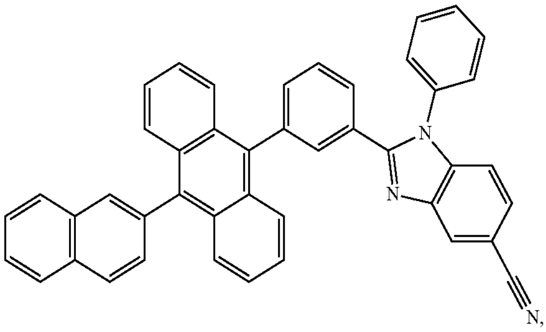

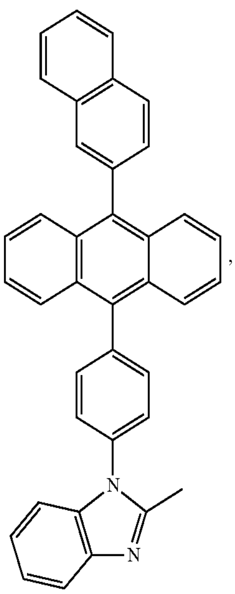

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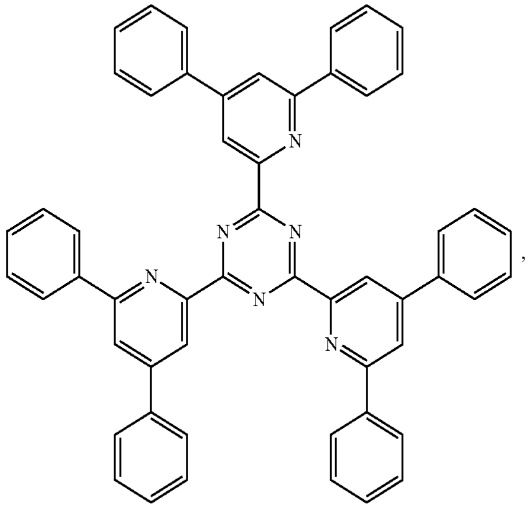

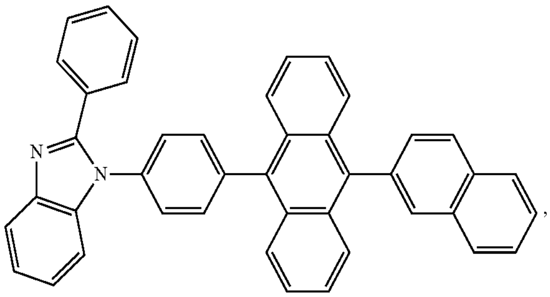

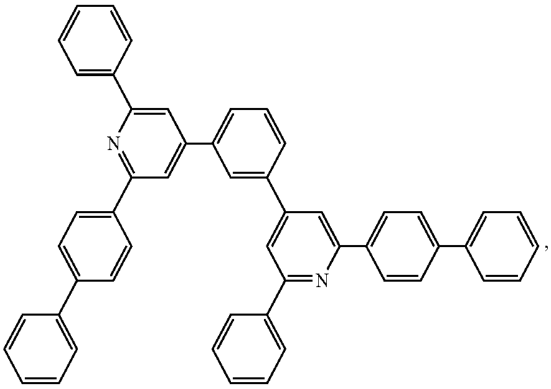

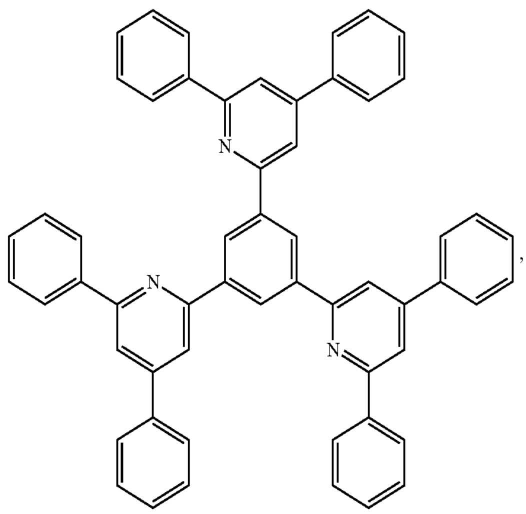

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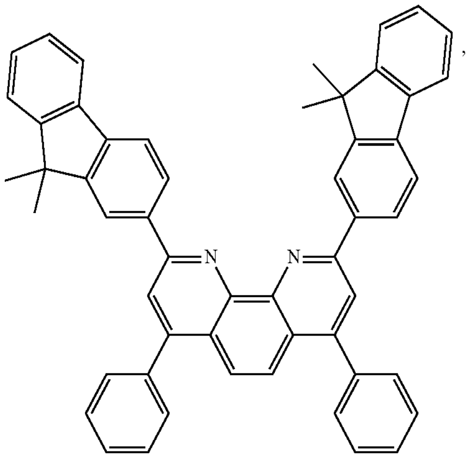

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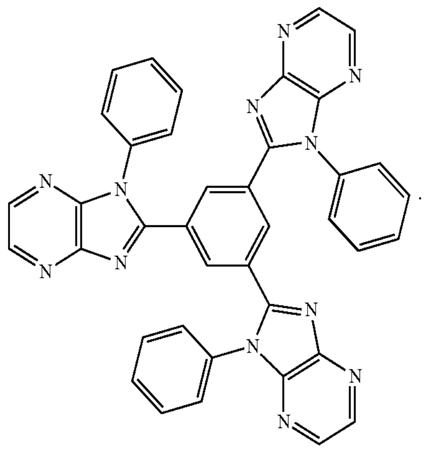


Charge Generation Layer (CGL)

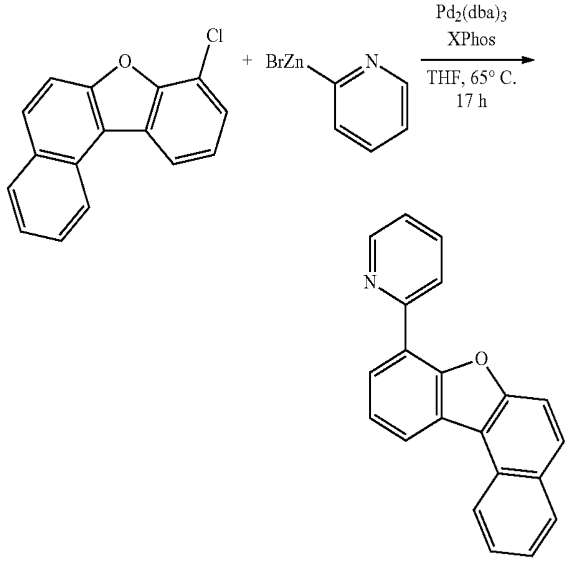
In tandem or stacked OLEDs, the CGL plays an essential role in the performance, which is composed of an n-doped layer and a p-doped layer for injection of electrons and holes, respectively. Electrons and holes are supplied from the CGL and electrodes. The consumed electrons and holes in the CGL are refilled 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.

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

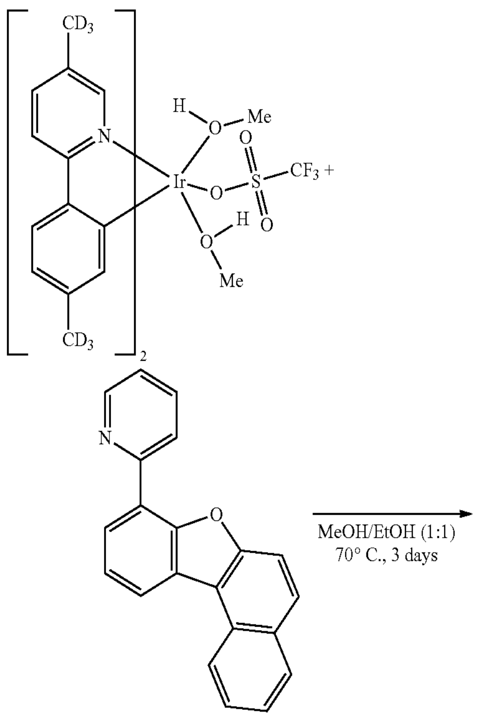
EXPERIMENTAL

Synthesis

Synthesis of Compound 91 [Ir(L_{A1})(L_{B91})$_2$]



A solution of 8-chloronaphtho[2,1-b]benzofuran (4.50 g, 17.8 mmol), $Pd_2(dba)_3$ (0.49 g, 0.53 mmol), XPhos (1.02 g, 2.14 mmol), and pyridin-2-ylzinc(II) bromide (45.0 mL, 0.5 M in THF) in THF (70.0 mL) was heated to 65° C. under N_2 for 17 h. After this time, the reaction flask was cooled to rt and the reaction mixture was diluted with EtOAc, washed with brine, and the separated organic layer was dried over Na_2SO_4, filtered, and concentrated in vacuo. The crude product was adsorbed onto Celite and purified via flash chromatography (EtOAc/Heptanes, 1:49 to 1:5) to provide 2-(naphtho[2,1-b]benzofuran-8-yl)pyridine as a white solid (3.91 g, 74%).



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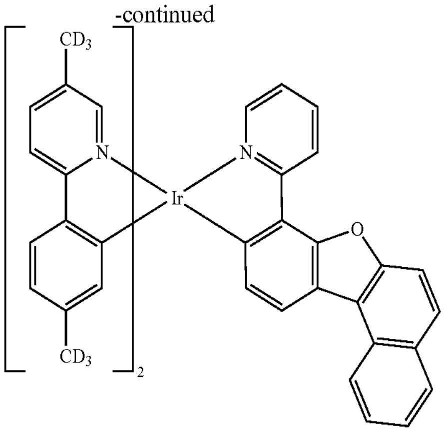
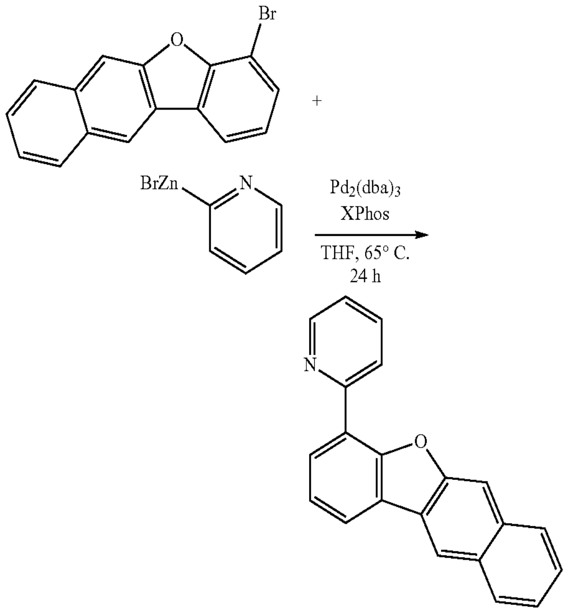


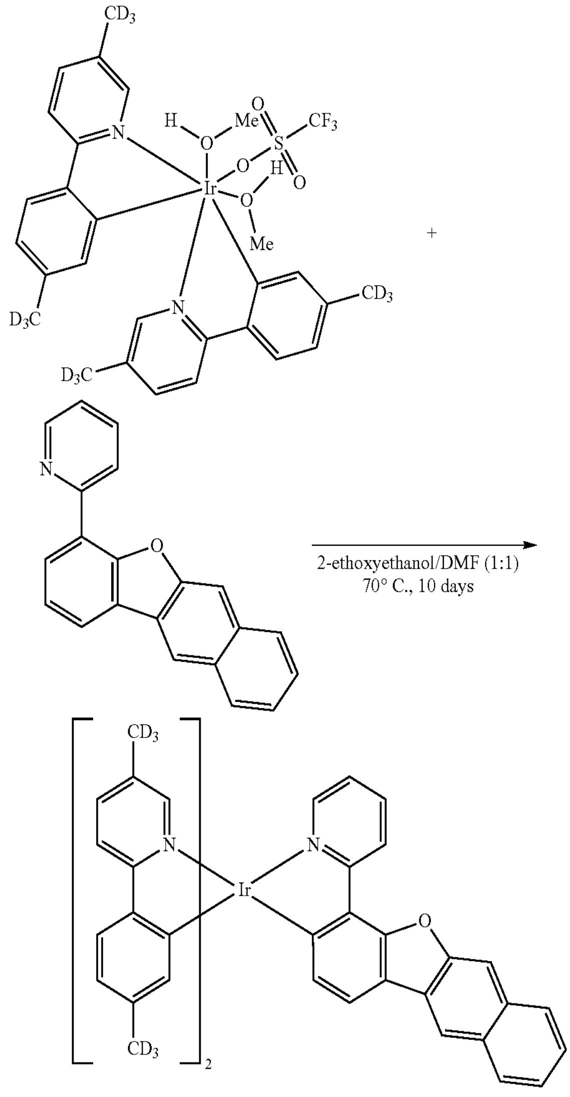
Compound 91
$[Ir(L_{A1})(L_{B91})_2]$

A mixture of iridium precursor (2.50 g, 3.20 mmol) and 2-(naphtho[2,1-b]benzofuran-8-yl)pyridine (2.17 g, 7.35 mmol) in EtOH (25 mL) and MeOH (25 mL) was heated to 70° C. for 3 days. After this time, the reaction flask was cooled to rt and filtered. The residue was dissolved in CH_2Cl_2, filtered through a plug of Celite, and the filtrate was concentrated in vacuo. The crude product was adsorbed onto silica gel and purified via flash chromatography (Heptanes/Toluene, 7:3) to provide Compound 91 $[Ir(L_{A1})(L_{B91})_2]$ as an orange solid (1.00 g, 36%).

Synthesis of Compound 61591 $[Ir(L_{A206})(L_{B91})_2]$



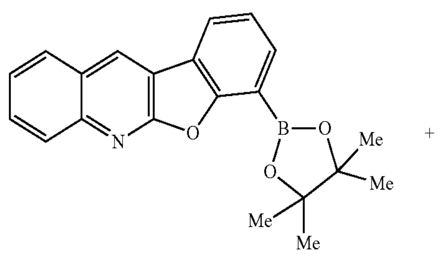
A solution of 4-bromonaphtho[2,3-b]benzofuran (4.00 g, 13.46 mmol), $Pd_2(dba)_3$ (0.62 g, 0.67 mmol), XPhos (1.28 g, 2.69 mmol), and pyridin-2-ylzinc(II) bromide (40.0 mL, 0.5 M in THF) in THF (30.0 mL) was heated to 65° C. under N_2 for 24 h. After this time, the reaction flask was cooled to rt and the reaction mixture was diluted with EtOAc, washed with brine, and the separated organic layer was dried over Na_2SO_4, filtered, and concentrated in vacuo. The crude was adsorbed onto Celite and purified via flash chromatography (EtOAc/Heptanes, 1:19 to 1:4) to provide 2-(naphtho[2,3-b]benzofuran-4-yl)pyridine as a white solid (3.23 g, 81%).

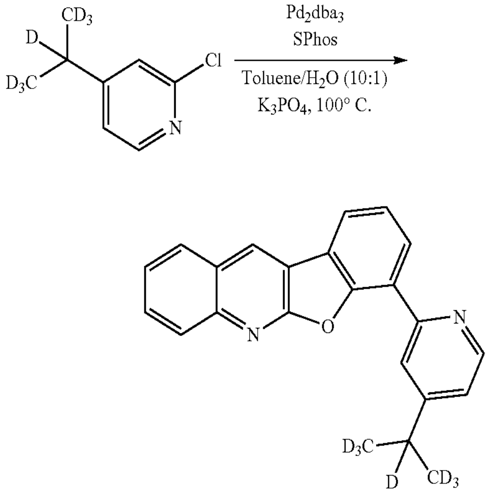


Compound 61591
$[Ir(L_{A206})(L_{B91})_2]$

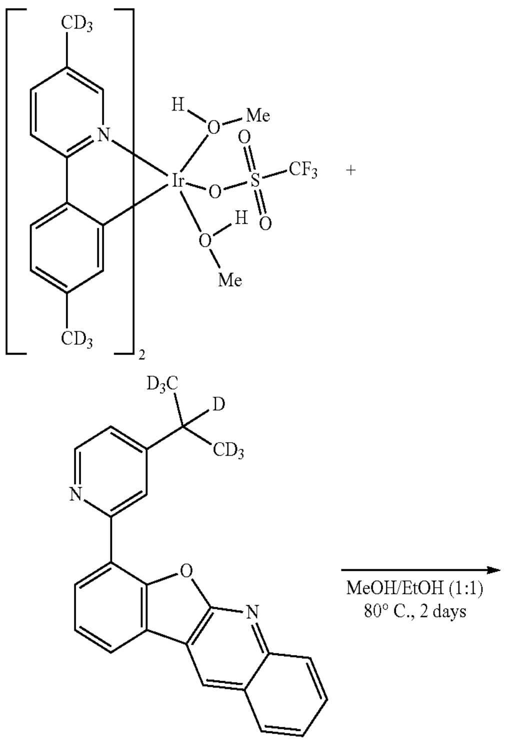
A mixture of iridium precursor (2.00 g, 2.56 mmol) and 2-(naphtho[2,3-b]benzofuran-4-yl)pyridine (1.66 g, 5.63 mmol) in 2-ethoxyethanol (25 mL) and DMF (25 mL) was heated to 70° C. for 10 days. After this time, the reaction flask was cooled to 50° C. and filtered. The residue was dissolved in CH_2Cl_2, filtered through a plug of Celite, and the filtrate was concentrated in vacuo. The crude product was adsorbed onto silica gel and purified via flash chromatography (Heptanes/Toluene, 3:7) to provide Compound 6159 $[Ir(L_{A206})(L_{B91})_2]$ as an orange-yellow solid (0.54 g, 24%).

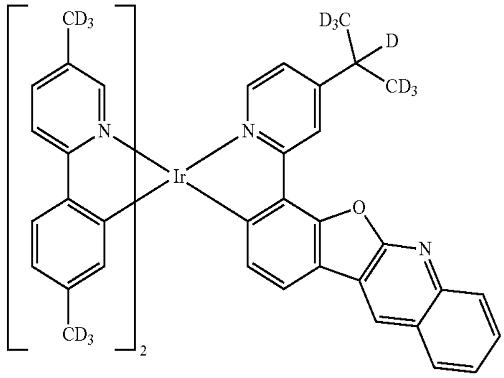
Synthesis of Compound 105691 $[Ir(L_{A353})(L_{B91})_2]$





A solution of 4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzofuro[2,3-b]quinoline (3.60 g, 10.43 mmol), 2-chloro-4-(propan-2-yl-d$_7$)pyridine (2.39 g, 13.56 mmol), $Pd_2(dba)_3$ (0.19 g, 0.21 mmol), SPhos (0.34 g, 0.83 mmol), and K_3PO_4 (6.64 g, 31.30 mmol) in toluene (60 mL) and H_2O (6 mL) was refluxed under N_2 for 5 h. After this time, the reaction flask was cooled to rt and the reaction mixture was diluted with EtOAc, washed with brine and the separated organic layer was dried over Na_2SO_4, filtered, and concentrated in vacuo. The crude product was adsorbed onto Celite and purified via flash chromatography (EtOAc/Heptanes, 1:9 to 1:1) to provide 4-(4-(propan-2-yl-d$_7$)pyridin-2-yl)benzofuro[2,3-b]quinoline as a white solid (1.40 g, 39%).





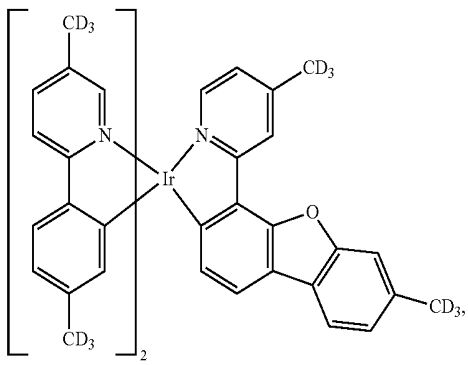
Compound 105691
[Ir(L_{A353})(L_{B91})$_2$]

A mixture of iridium precursor (1.58 g, 2.03 mmol) and 4-(4-(propan-2-yl-d$_7$)pyridin-2-yl)benzofuro[2,3-b]quinoline (1.40 g, 4.05 mmol) in EtOH (40 mL) and MeOH (40 mL) was heated to 80° C. for 2 days. After this time, the reaction flask was cooled to rt and filtered. The residue was dissolved in CH_2Cl_2, adsorbed onto silica gel and purified via flash chromatography (CH_2Cl_2) to provide Compound 105691 [Ir(L_{A353})(L_{B91})$_2$] as an orange solid (0.79 g, 42%).

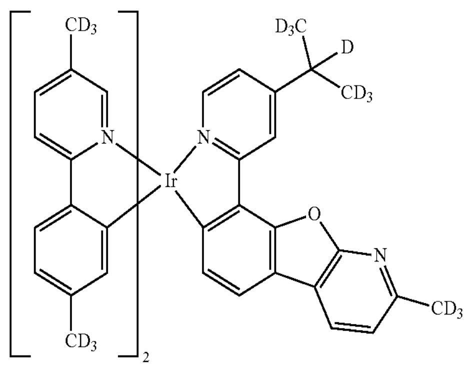
Photoluminescence Results

The chemical structures of the comparative and inventive compounds are shown below:

Compound A



Compound B



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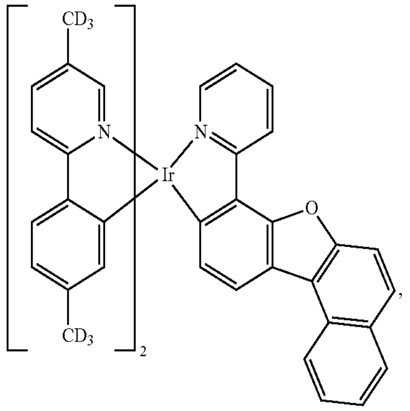
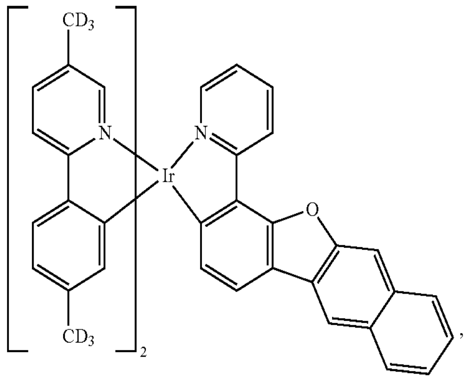
Compound 91



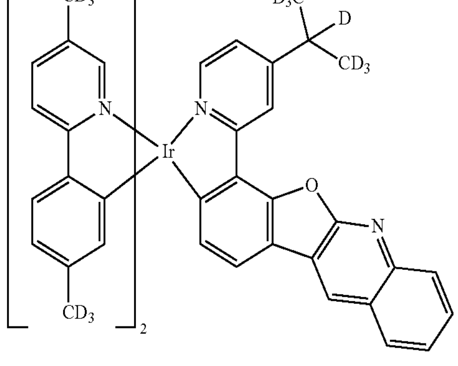
[Ir(L_{A1})(L_{B91})$_2$]

Compound 61591



[Ir(L_{A206})(L_{B91})$_2$]

Compound 105691



[Ir(L_{A353})(L_{B91})$_2$]

Provided in Table 1 is a summary of the photoluminescence (PL) data including emission peak and full width at half maximum (FWHM), in 2-methyltetrahydroduran and in 5% doped PMMA solid film, recorded at room temperature (rt).

TABLE 1

Photoluminescence data at room temperature

	2-methyltetrahydrofuran		5% doped PMMA solid film	
	λ_{max} (nm)	FWHM (nm)	λ_{max} (nm)	FWHM (nm)
Comparative Example 1 (Compound A)	528	65	525	68
Comparative Example 2 (Compound B)	524	63	523	66
Inventive Example 1 (Compound 91 [Ir(L_{A1})(L_{B91})$_2$])	542	35	540	32
Inventive Example 2 (Compound 61591 [Ir(L_{A206})(L_{B91})$_2$])	534	19	533	21
Inventive Example 3 (Compound 105691 [Ir(L_{A353})(L_{B91})$_2$])	549	31	545	34

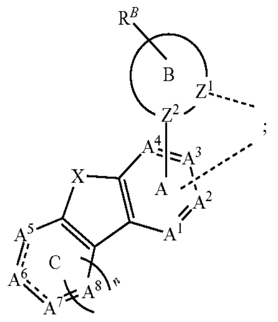
The photoluminescence results for Inventive Examples 1, 2 and 3 in both solution and solid state exemplified a much narrower FWHM when compared to the comparative Compounds A and B. The Inventive Example 1 has a FWHM of 35 nm, which is 30 nm narrower than comparative Compound A in solution; and a FWHM of 32 nm, which is 36 nm narrower than comparative Compound A in 5% doped PMMA solid film. Similarly, Inventive Example 2 has a FWHM of 19 nm, which is 46 nm narrower than comparative Compound A in solution; and a FWHM of 21 nm, which is 47 nm narrower than comparative Compound A in 5% doped PMMA solid film. Likewise, Inventive Example 3 has a FWHM of 31 nm, which is 32 nm narrower than comparative Compound B in solution; and a FWHM of 34 nm, which is 32 nm narrower than comparative Compound B in 5% doped PMMA solid film. These PL results convincingly demonstrated that benzoannulation on a DBX or aza-DBX containing ligand can result in a significant PL spectral narrowing for emitters as shown in Table 1 which will benefit device performance.

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

We claim:

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

Formula I



wherein ring B is a 5 or 6-membered carbocyclic or heterocyclic ring;

wherein R^B represents mono to the possible maximum number of substitution, or no substitution;

wherein Z^2 is selected from the group consisting of carbon or nitrogen;

wherein, when ring B is a 5-membered ring, Z^1 is nitrogen or carbon, and when ring B is a 6-membered ring, Z^1 is nitrogen;

wherein A^1, A^2, A^3, and A^4 are each independently CR or N;

wherein ring C is a 6 membered aromatic ring;

n is 1;

wherein A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 are each independently CR, and the Rs of two adjacent A^5, A^6, A^7, and A^8 are joined together to form a six-membered ring fused to ring C;

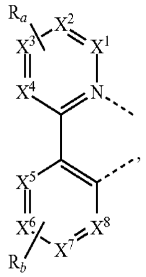
wherein X is O, S, or Se;

wherein the ligand L_A is coordinated to an Ir atom;

wherein the Ir atom is bonded to ring A through an Ir—C bond;

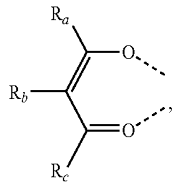
wherein the Ir atom is also coordinated to at least one of:

(1) a ligand L_B and the compound has a structure $Ir(L_A)(L_B)_2$, wherein L_B has a structure



wherein X^1, X^2, X^3, X^4, X^5, X^6, X^7, and X^8 are C, wherein R_a and R_b are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof, or

(2) a ligand L_C and the compound has a formula of $Ir(L_A)_2(L_C)$, wherein L_C has a structure



wherein Ra, Rb, and Rc are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, and combinations thereof;

wherein, when the Ir atom is coordinated to L_B, Ring B is pyridine, Z^1 is nitrogen, Z^2 is carbon;

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

wherein any adjacent substituents are optionally joined or fused into a ring;

wherein the ligand L_A is optionally linked with ligand L_B or ligand L_C to comprise a tetradentate or hexadentate ligand.

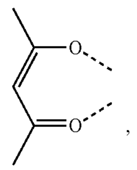
2. The compound of claim **1**, wherein X is O.

3. The compound of claim **1**, wherein the Rs of two adjacent A^5, A^6, A^7, and A^8 are joined together to form a phenyl ring fused to ring C.

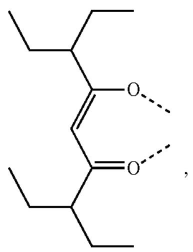
4. The compound of claim **1**, wherein the compound has formula of $Ir(L_A)_2(L_C)$;

wherein the ligand L_C is selected from the group consisting of:

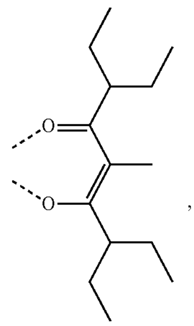
L_{C1}



L_{C2}



L_{C3}



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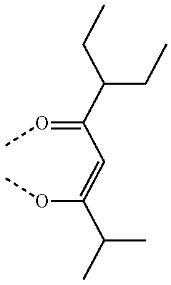
L_{C4}



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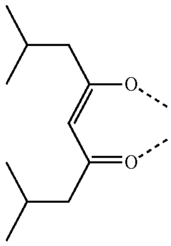
L_{C5}



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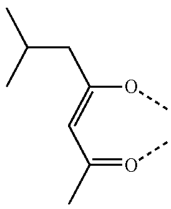
L_{C6}



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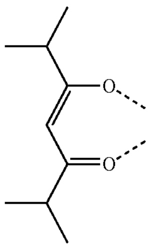
L_{C7}



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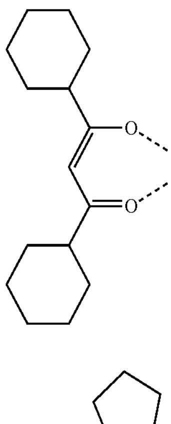
L_{C8}



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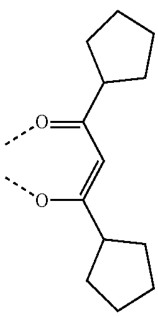
L_{C9}



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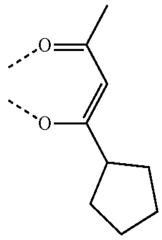
L_{C10}



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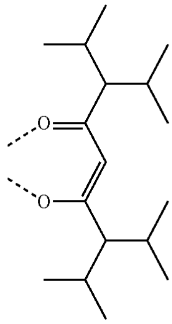
L_{C11}



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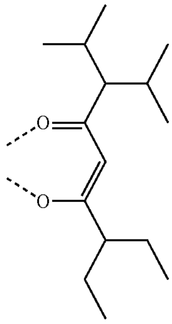
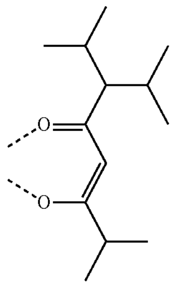
L_{C12}



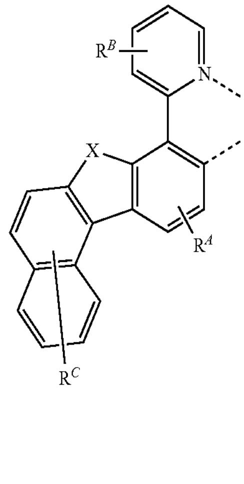
, and

L_{C13}



.

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



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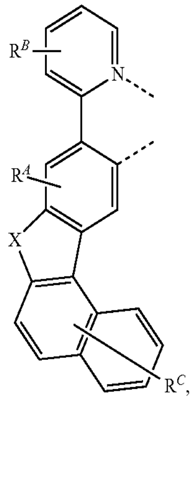

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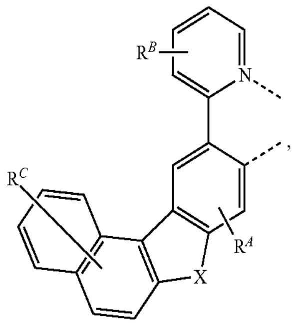

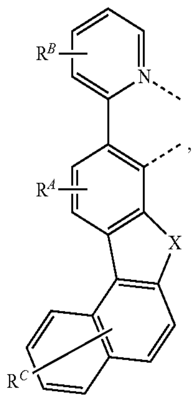

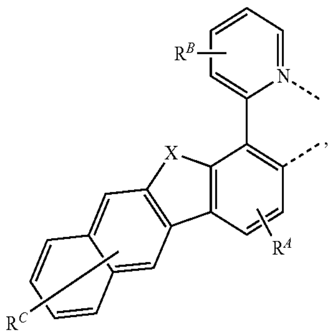

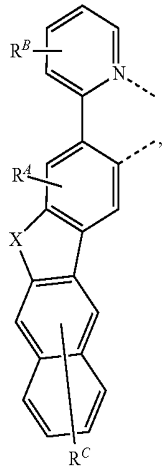

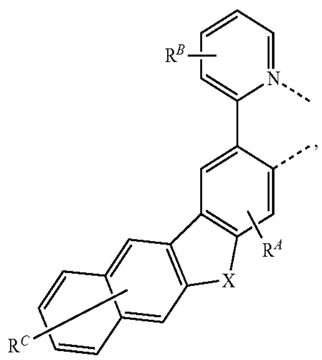

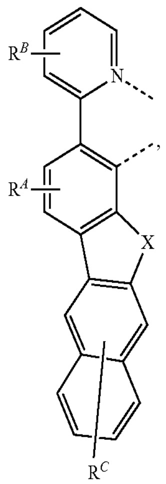

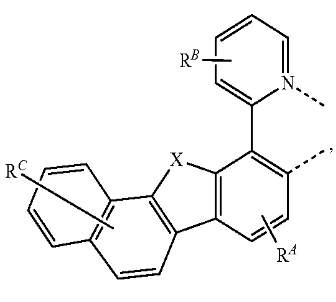

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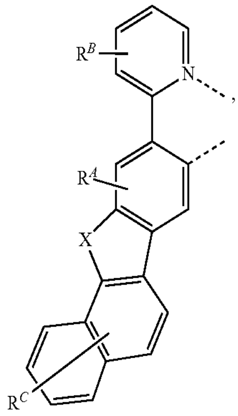

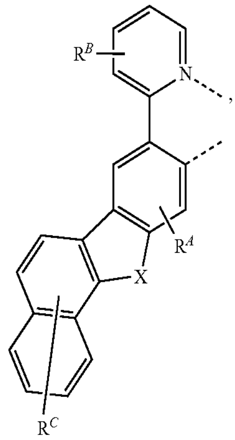

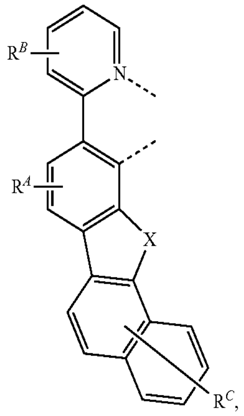

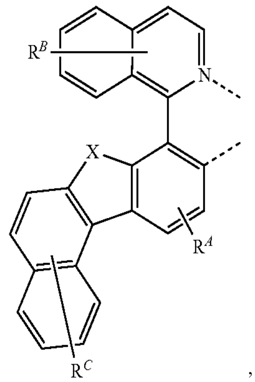

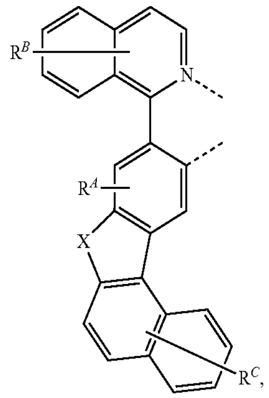

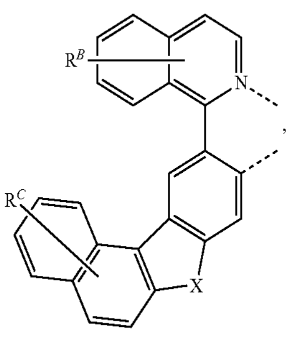

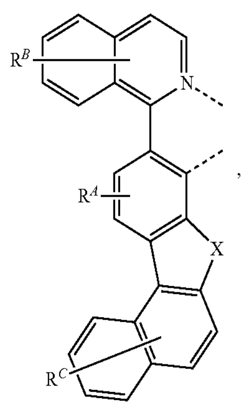

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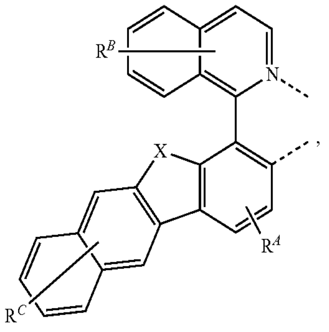

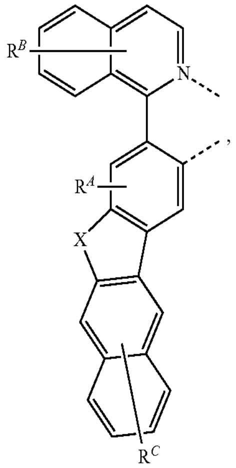

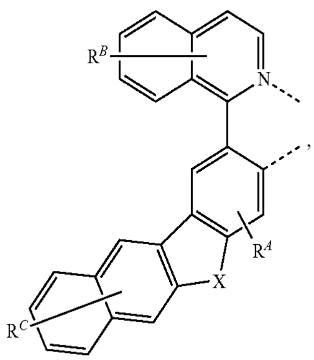

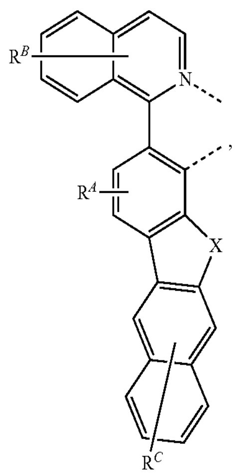

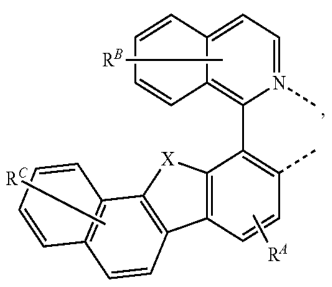

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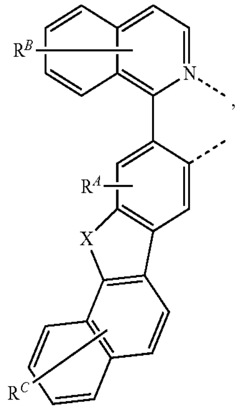

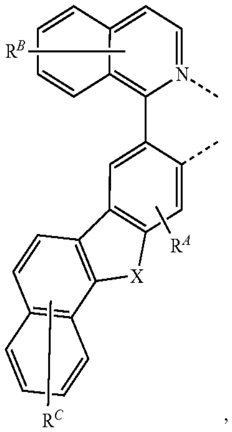

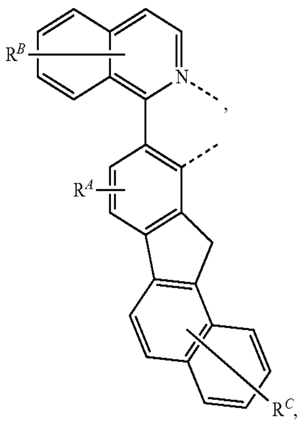

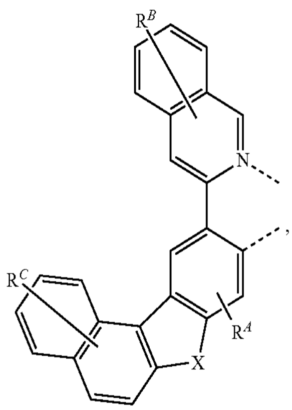

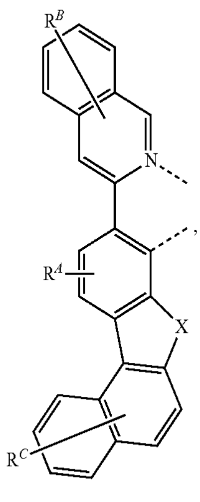

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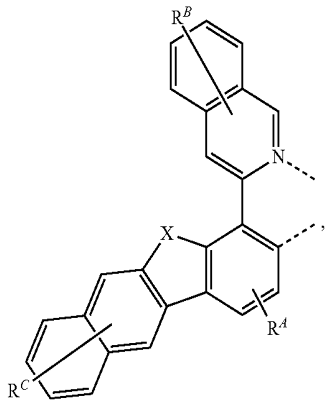

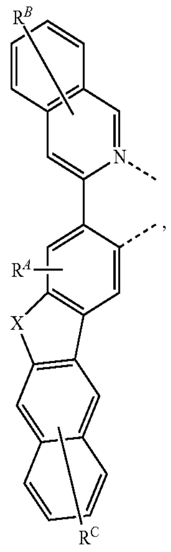

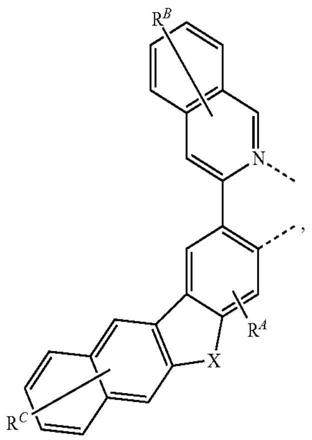

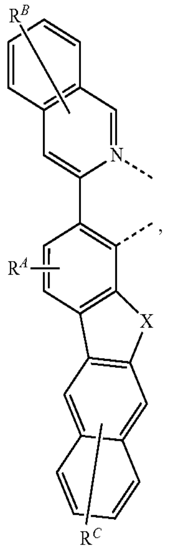

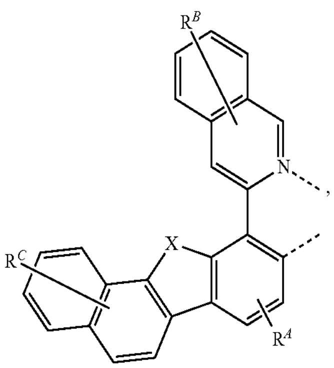

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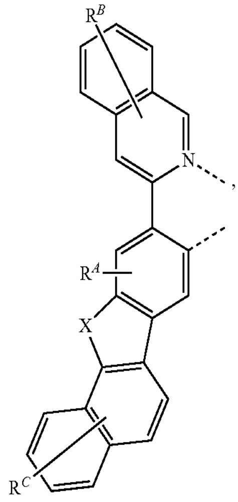

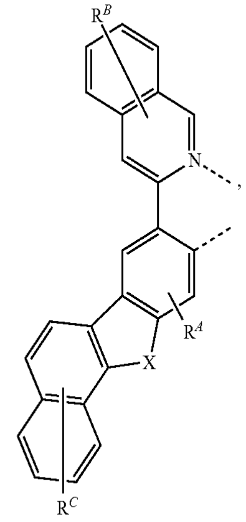

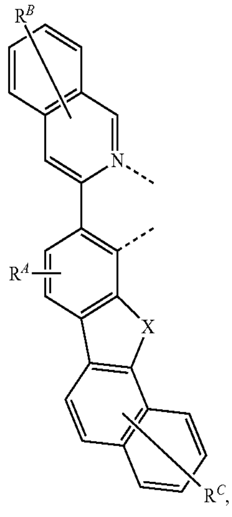

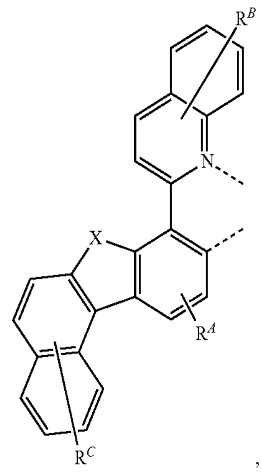

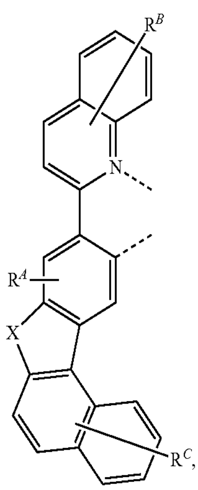

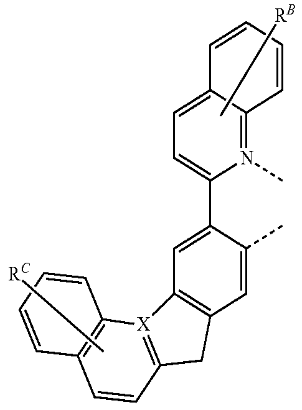

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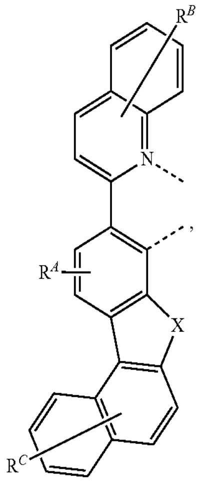

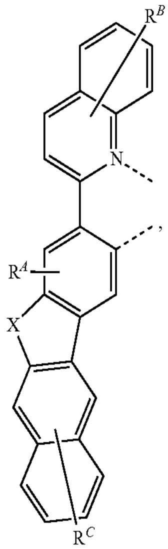

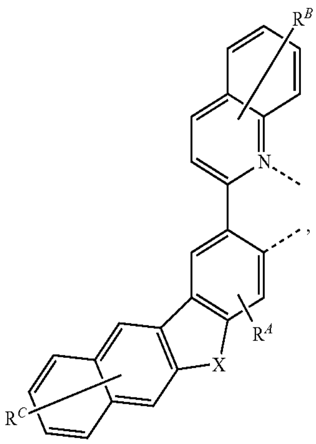

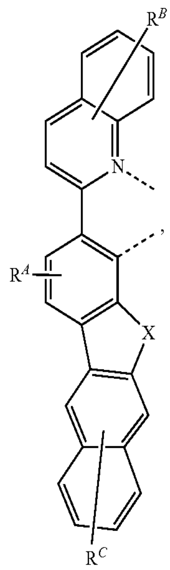

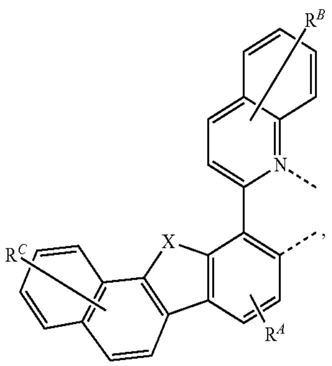

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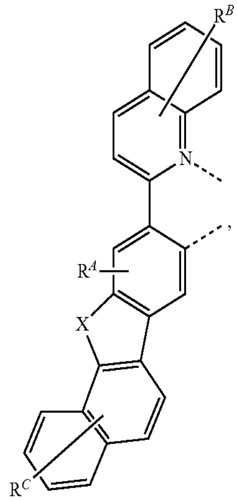

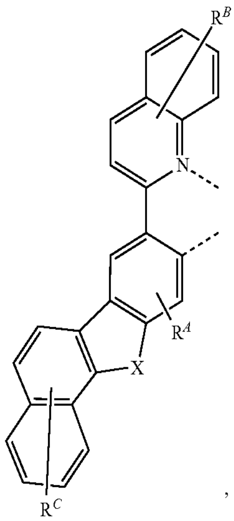

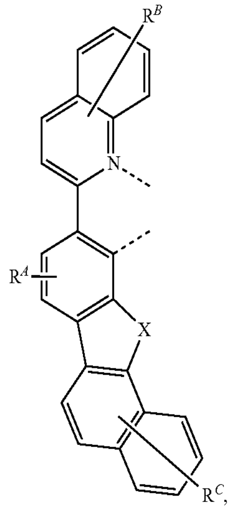

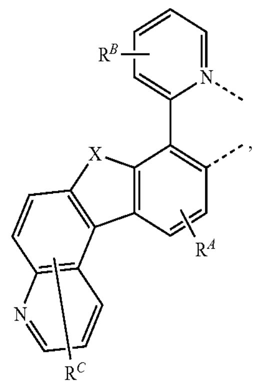

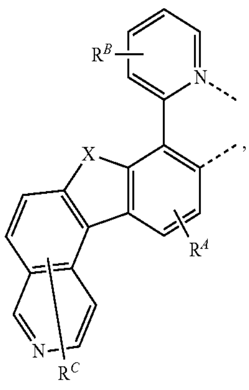

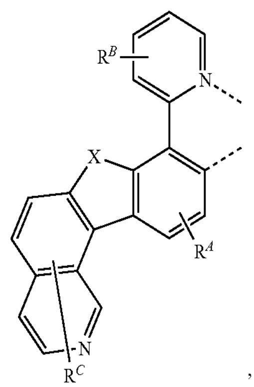

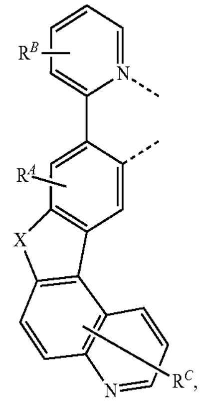

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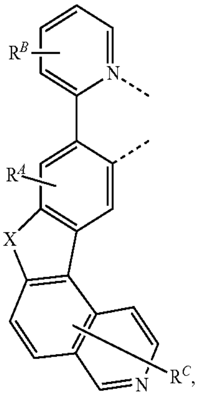

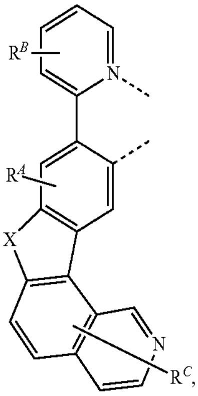

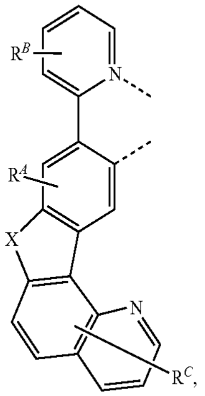

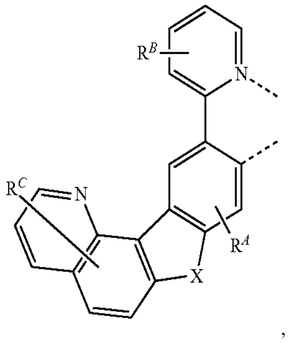

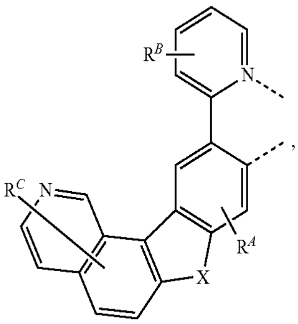

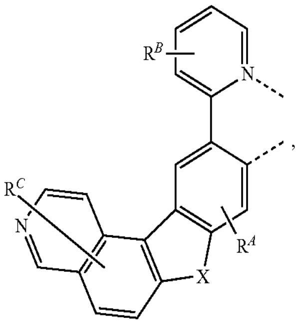

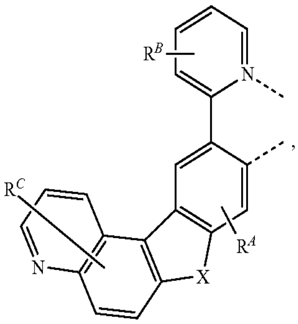

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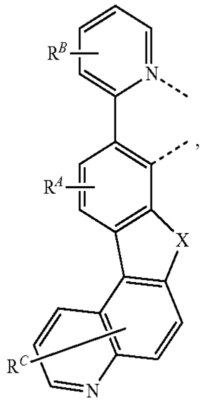

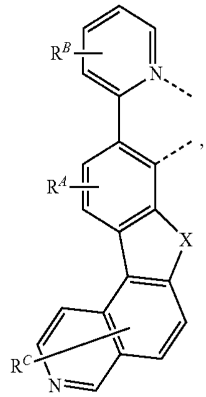

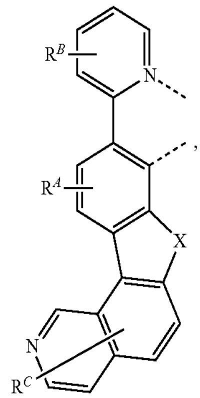

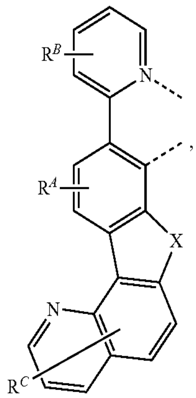

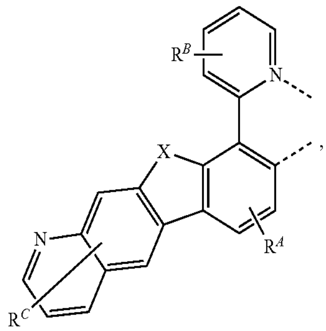

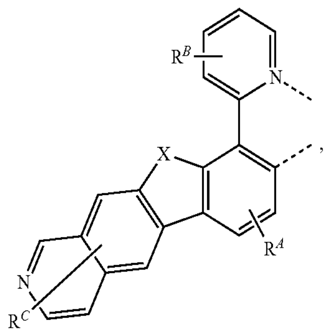

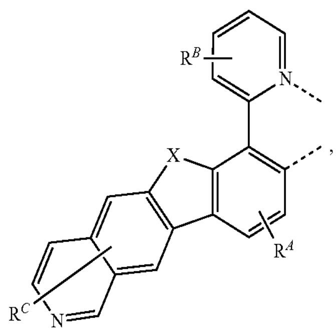

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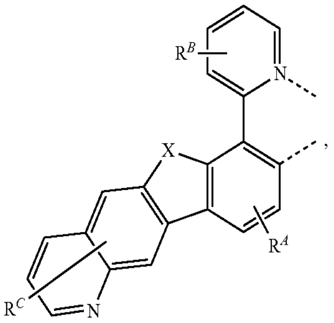

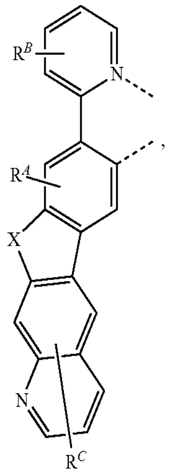

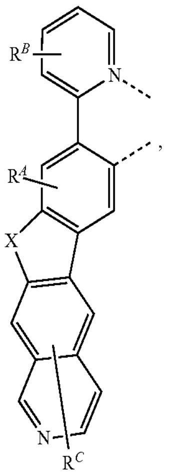

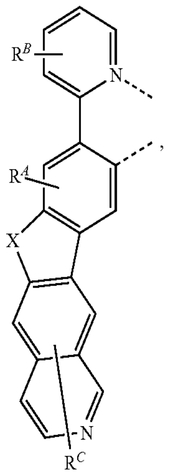

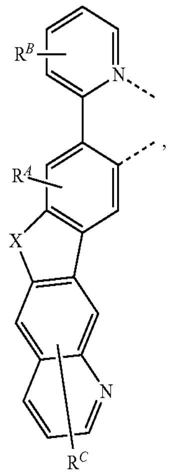

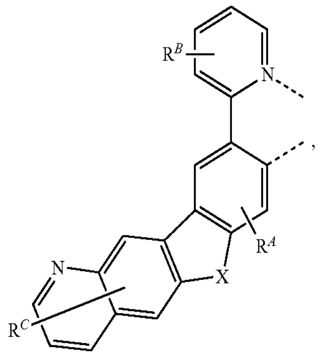

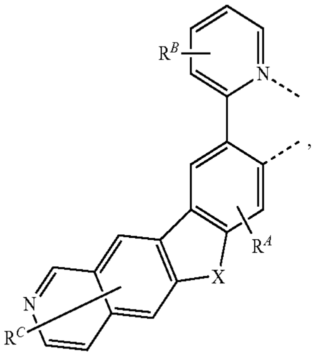

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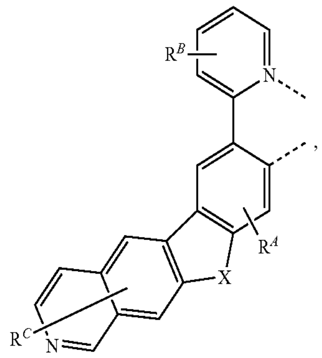

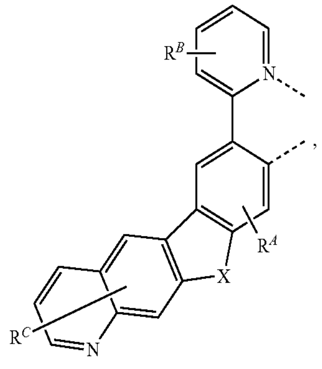

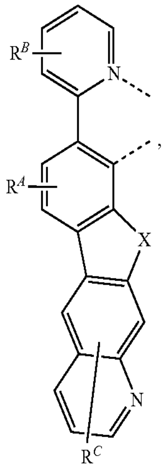

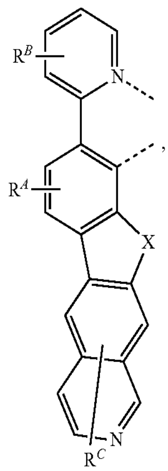

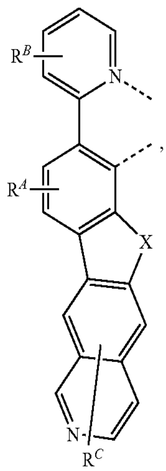

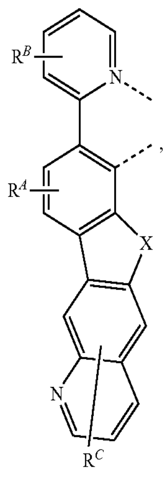

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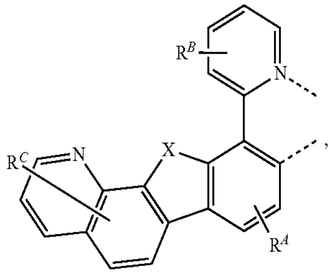

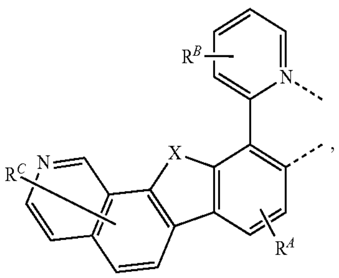

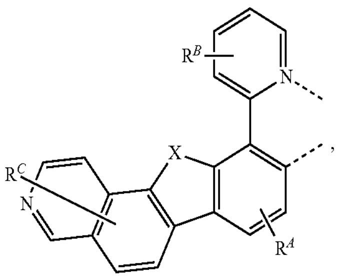

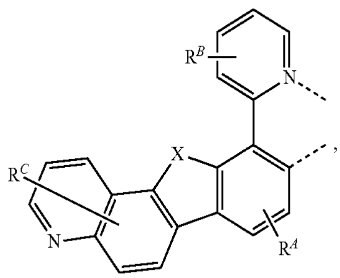

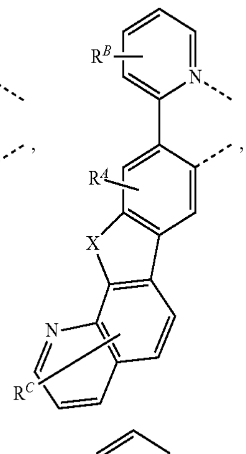

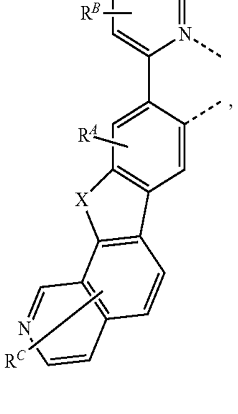

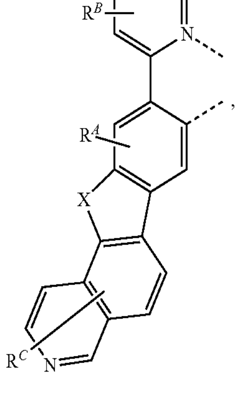

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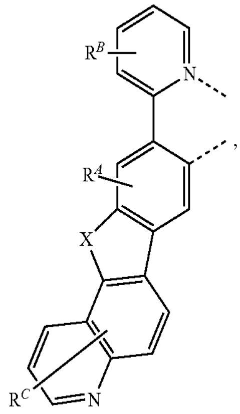

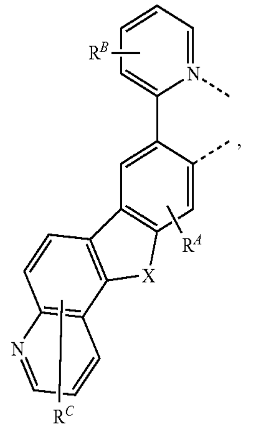

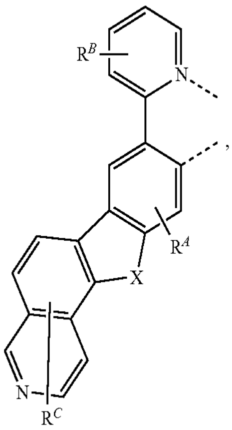

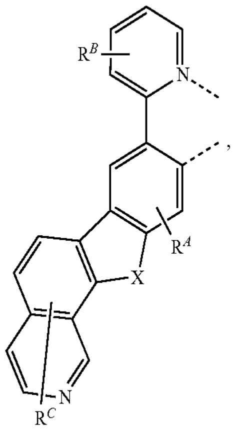

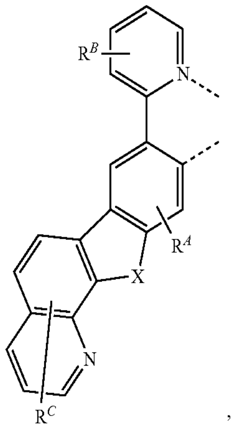

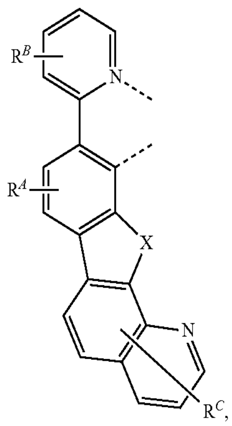

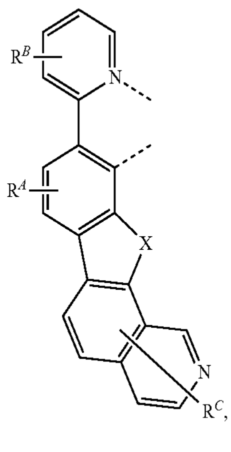

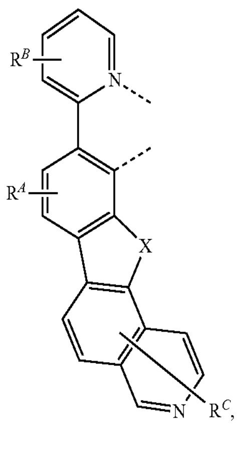

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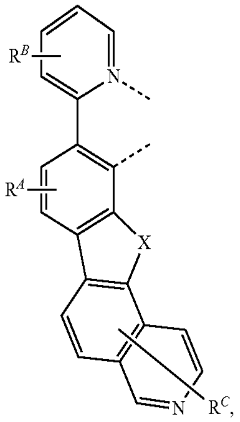
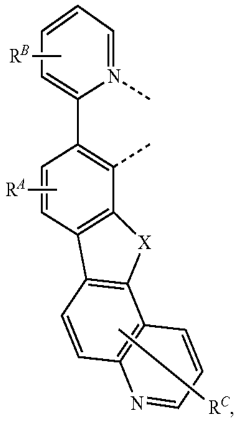
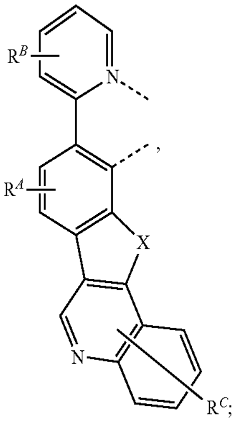




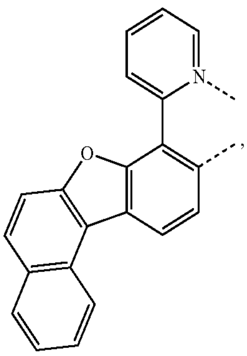


and

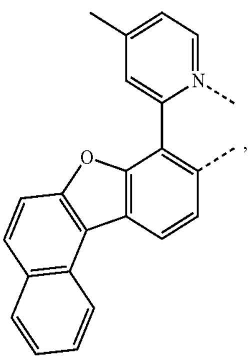
wherein R^A and R^C have the same definition as R^B.

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

L_{A1}



L_{A2}



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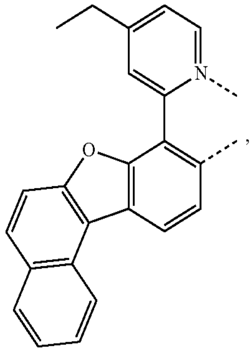
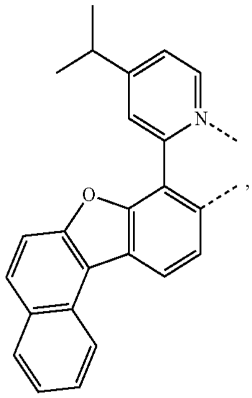
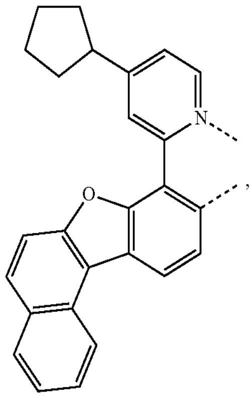
L_{A3}



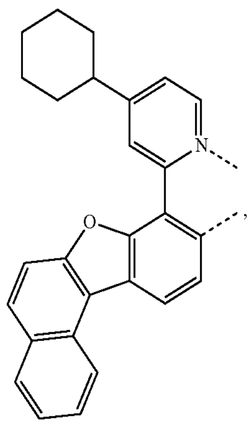
L_{A4}



L_{A5}



L_{A6}



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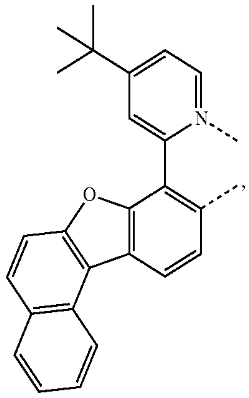
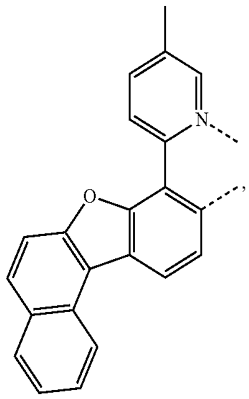
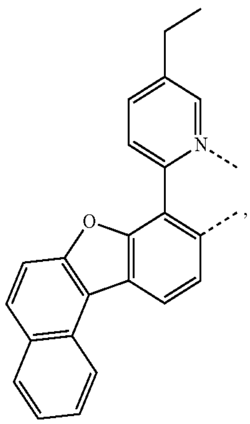
L_{A7}



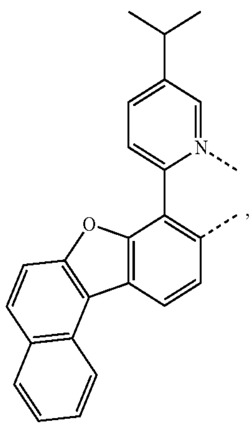
L_{A8}



L_{A9}



L_{A10}



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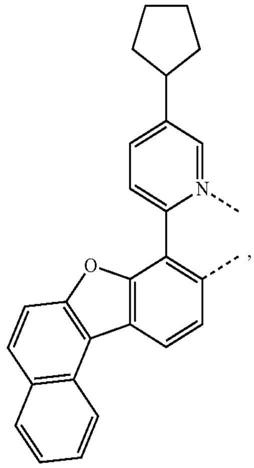
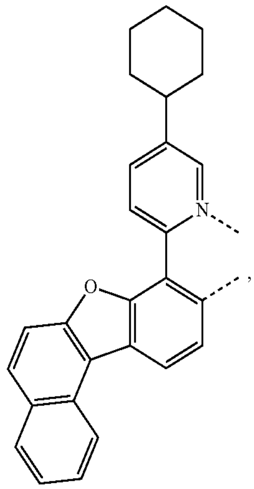
L_{A11}



L_{A12}



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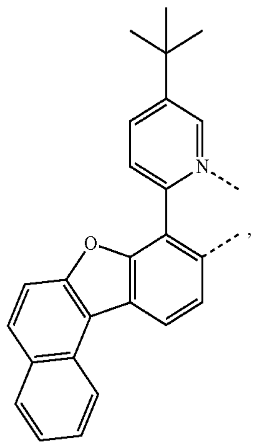

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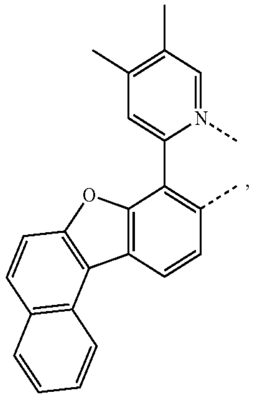

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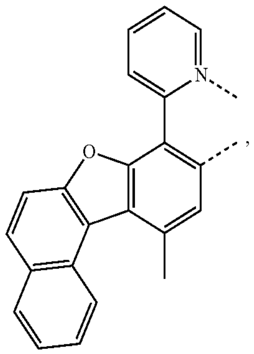

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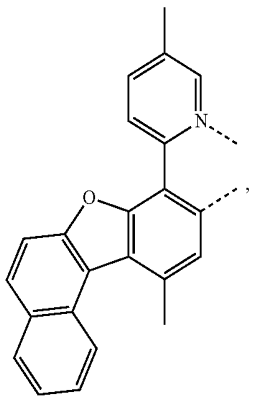

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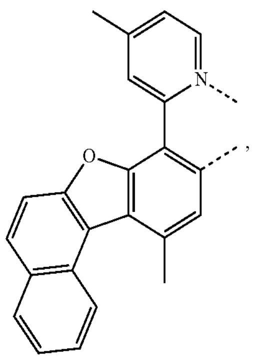

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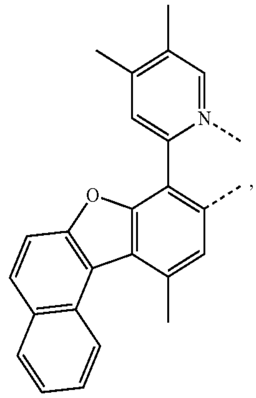

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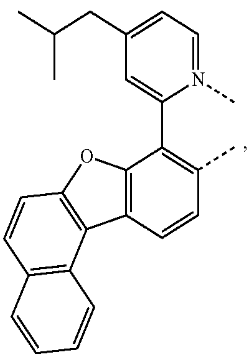

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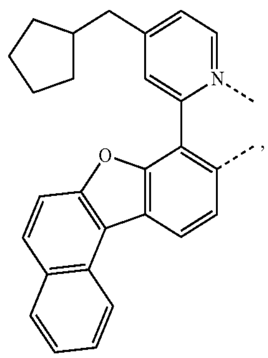

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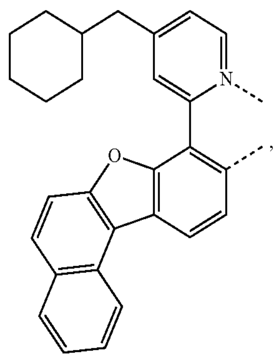

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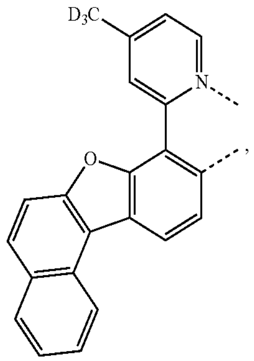

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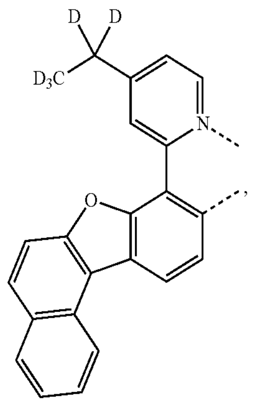

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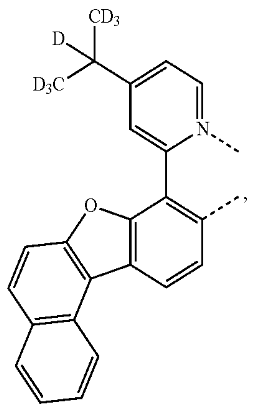

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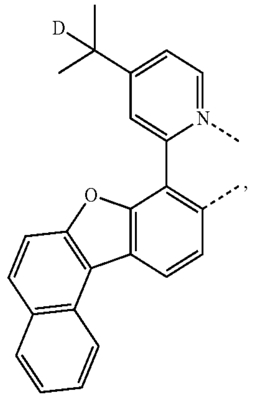

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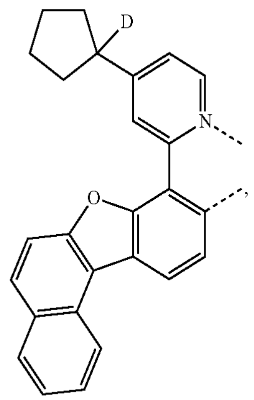

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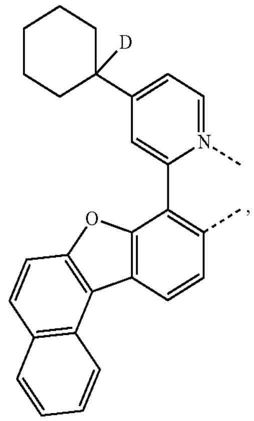

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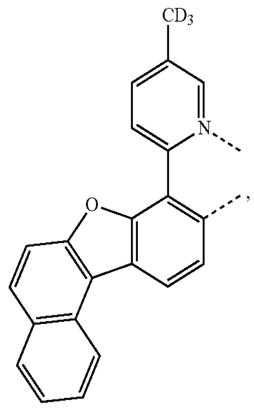

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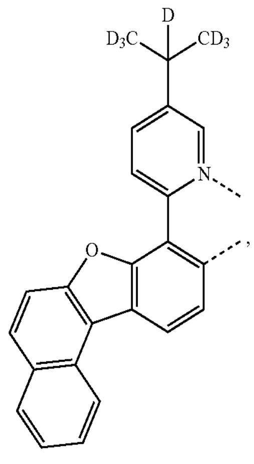

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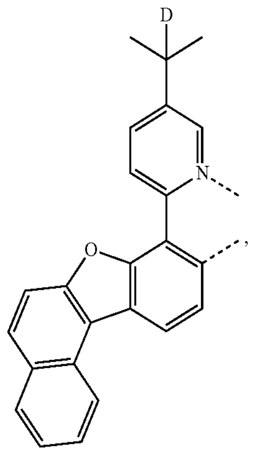

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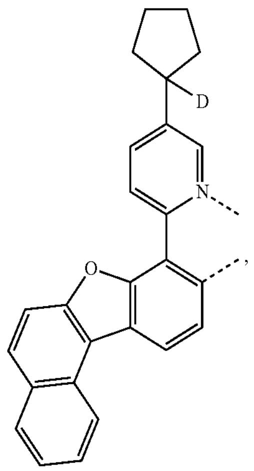

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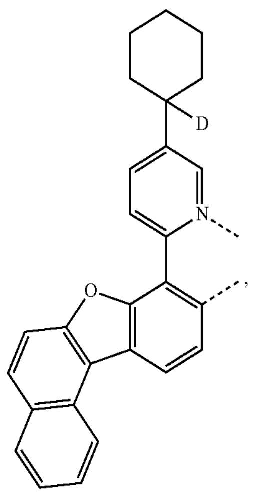

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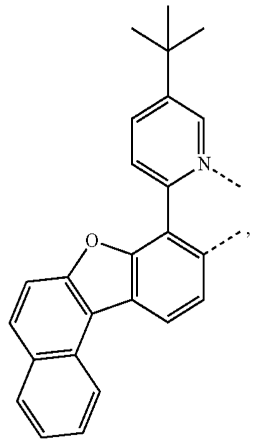

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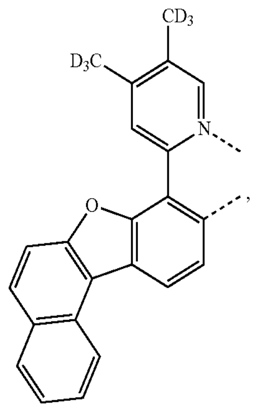

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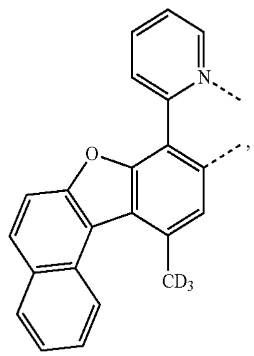

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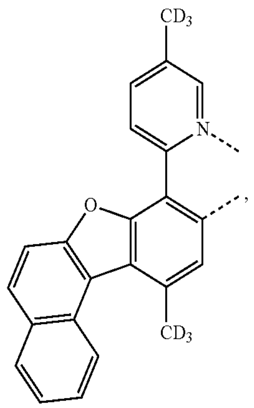

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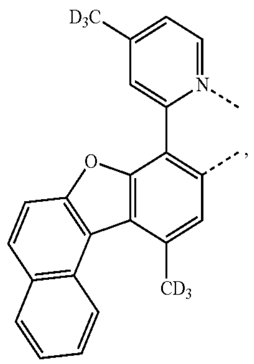

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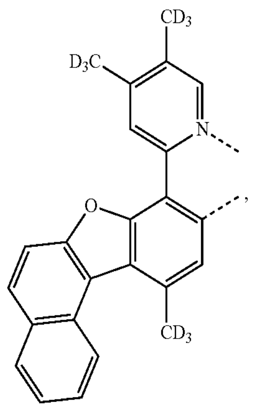

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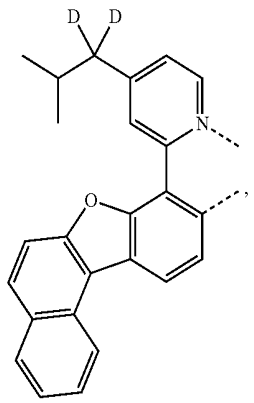

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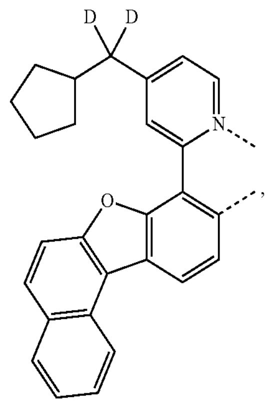

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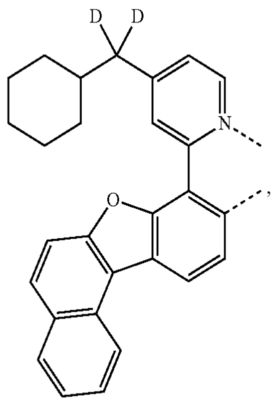

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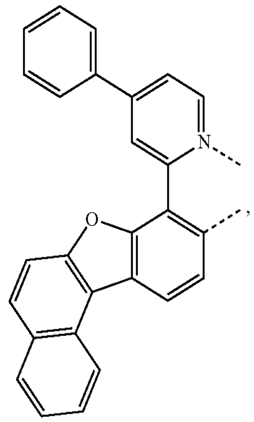

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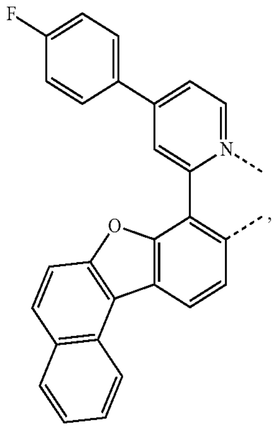

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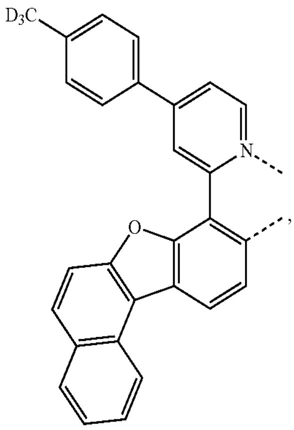

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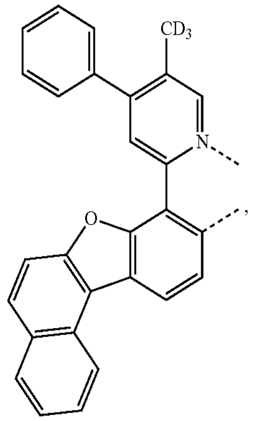
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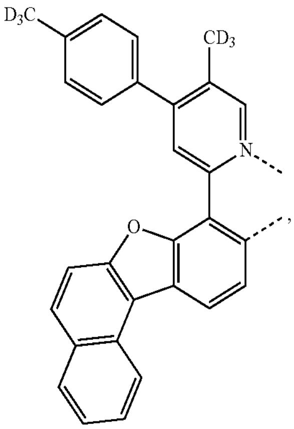
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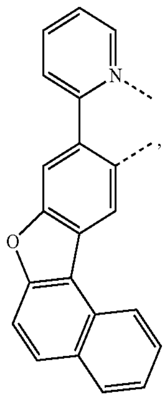
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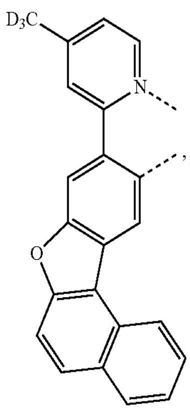
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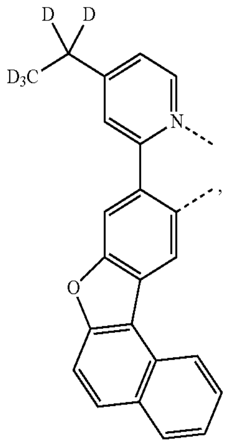
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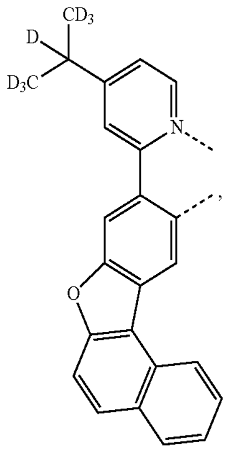
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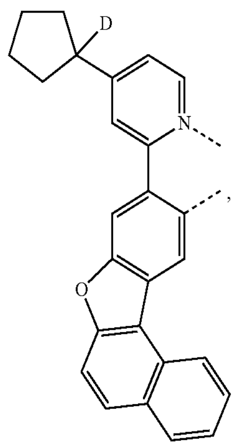
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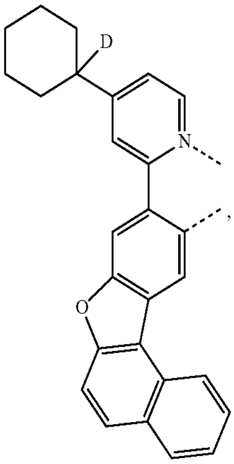

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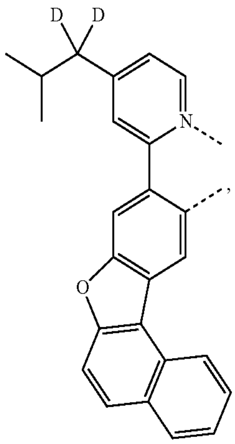

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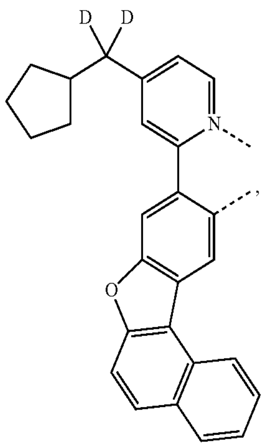

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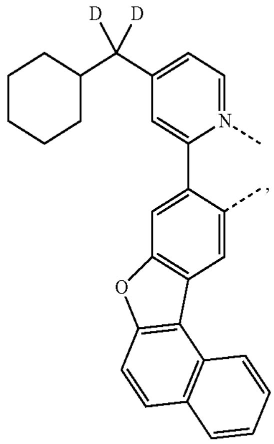

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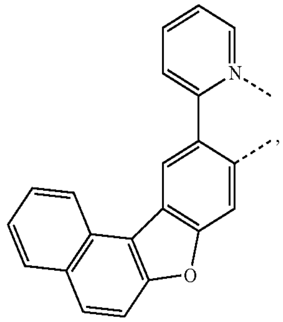

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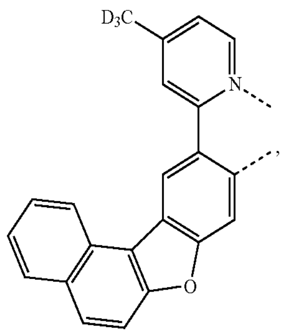

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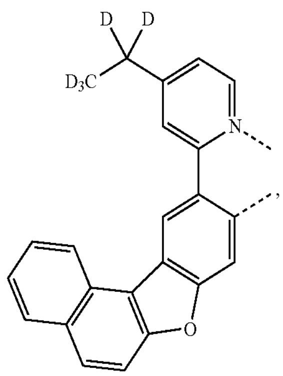

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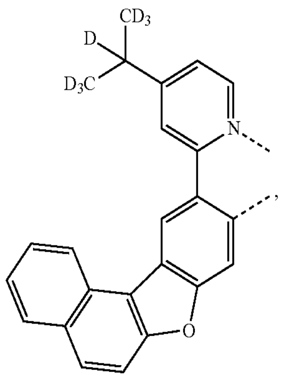

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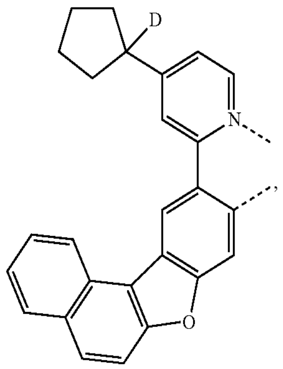

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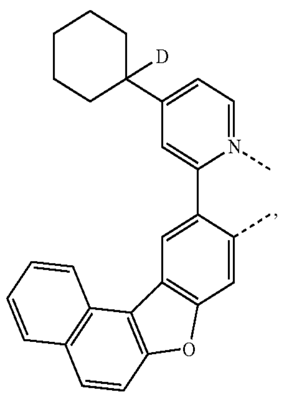

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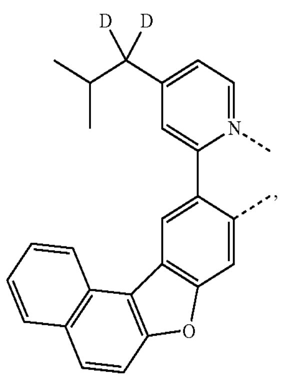

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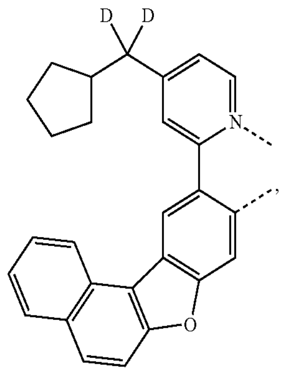

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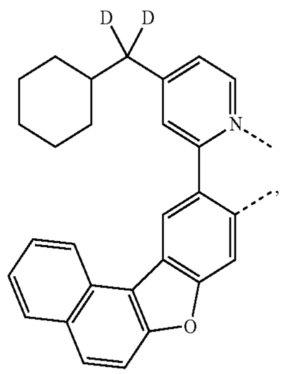

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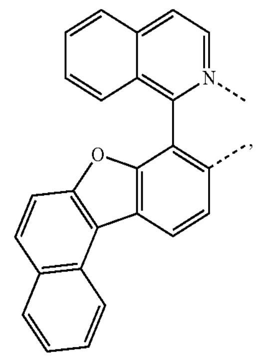

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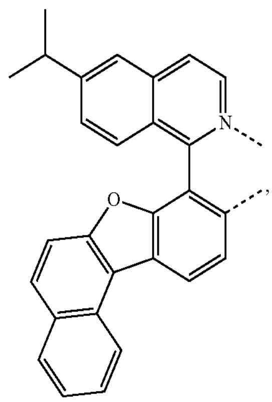

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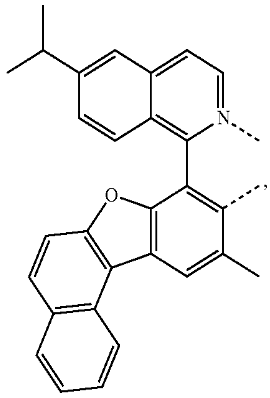

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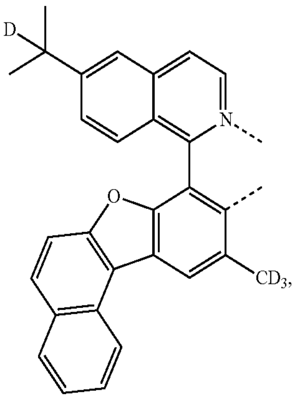

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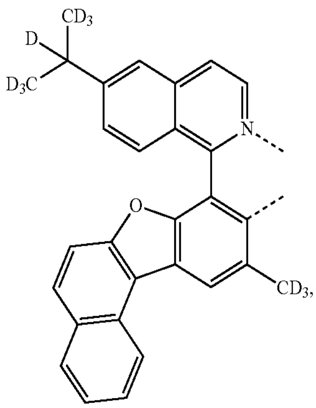

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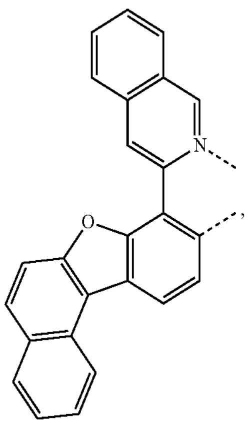

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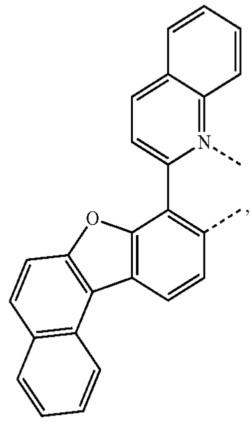

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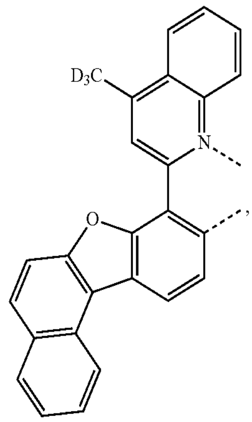

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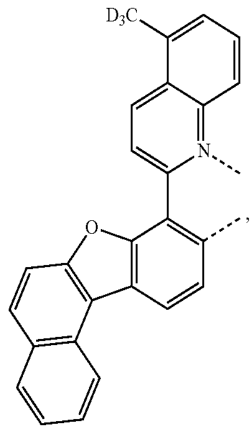

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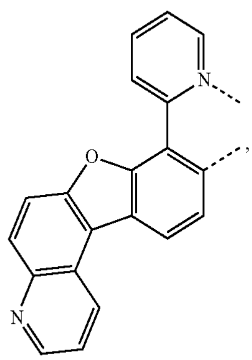

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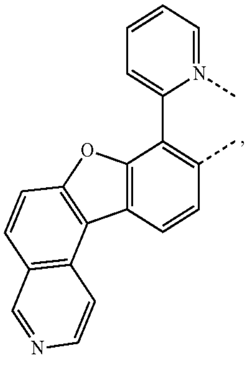

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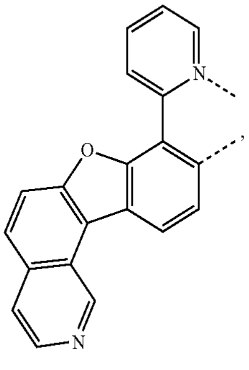

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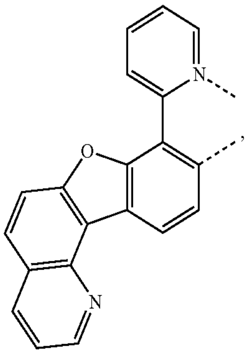

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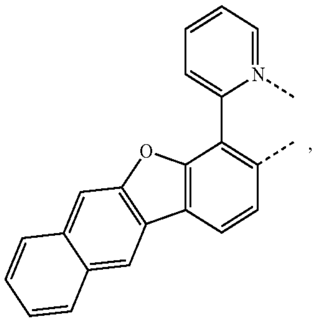

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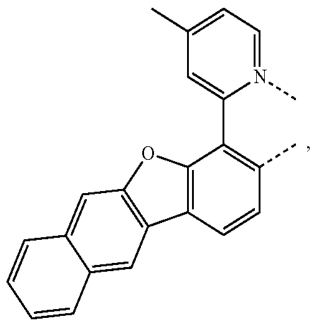

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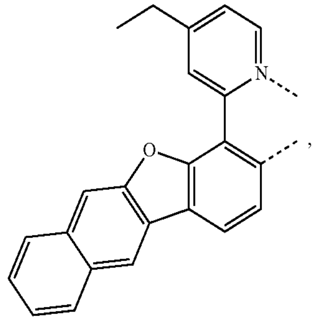

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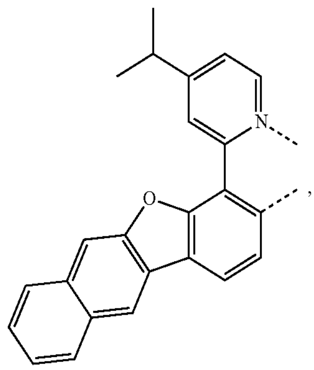

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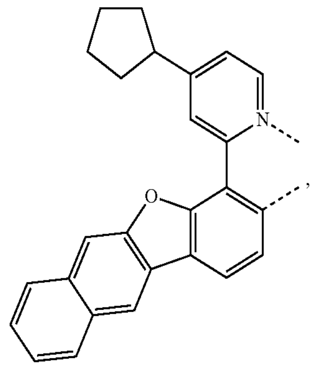

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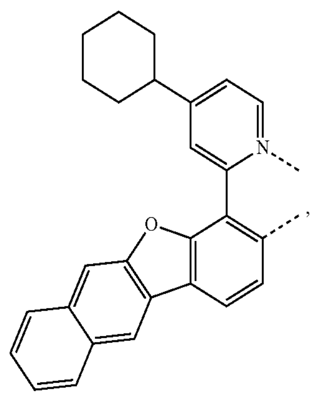

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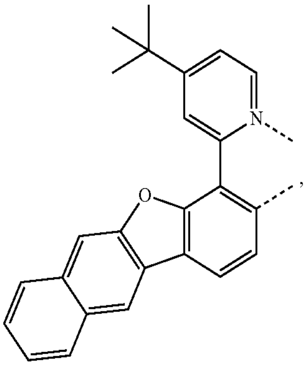

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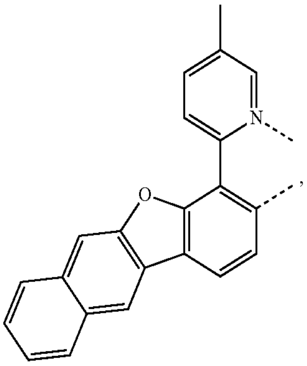

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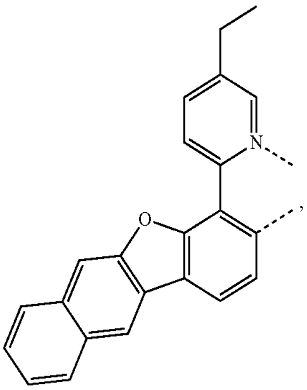

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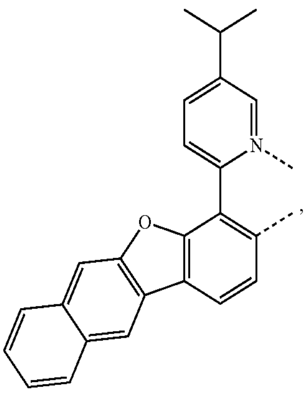

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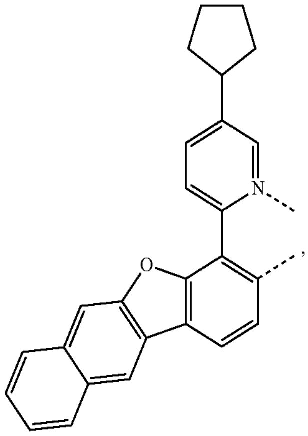

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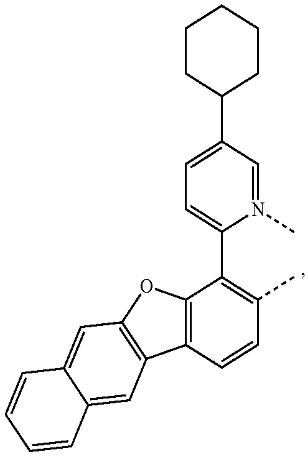

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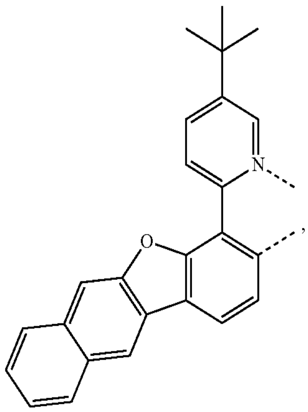

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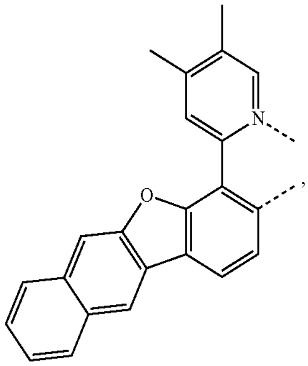

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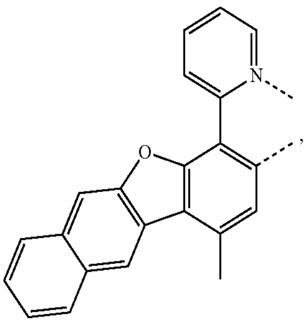

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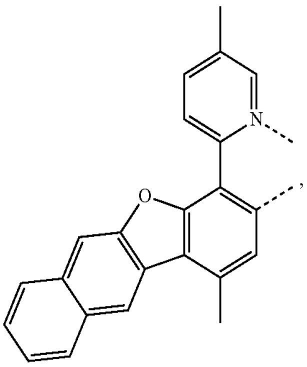

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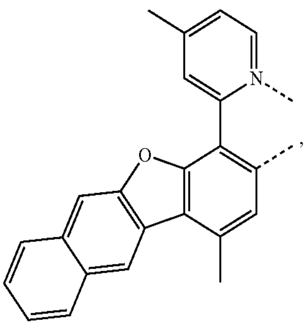

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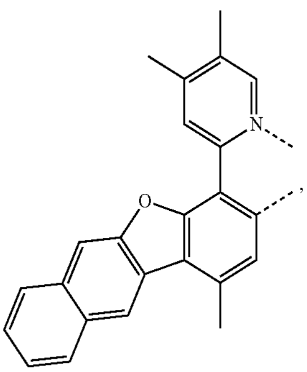

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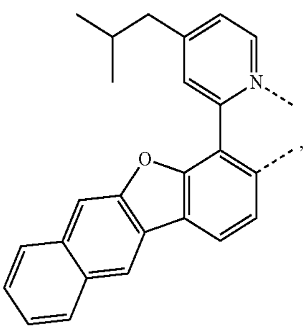

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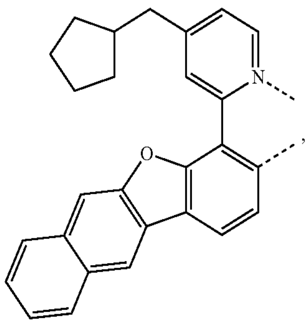

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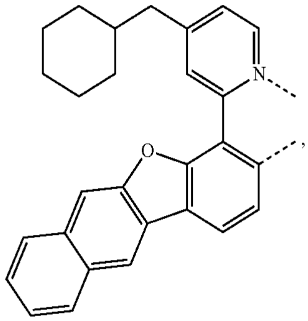

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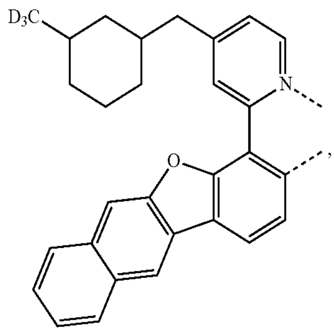

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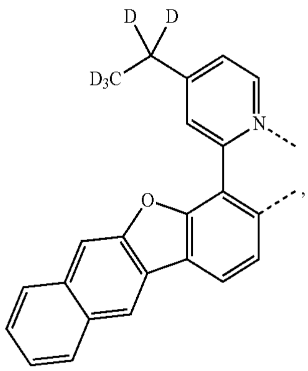

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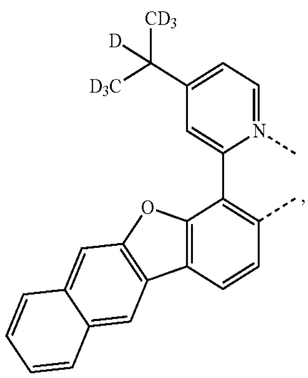

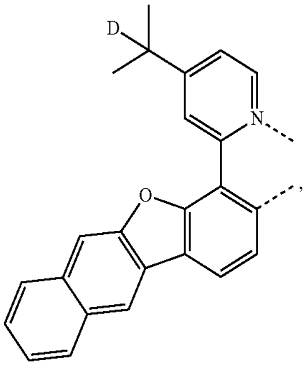

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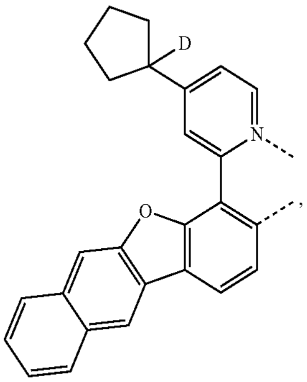

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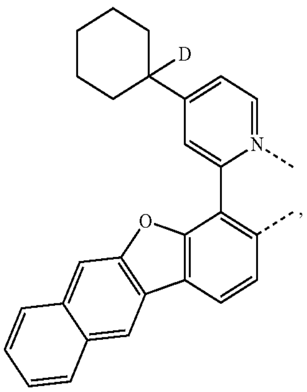

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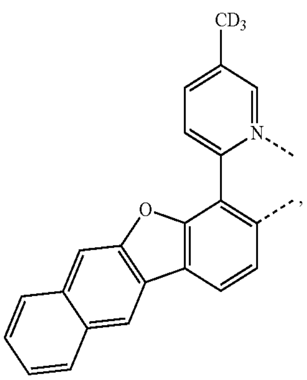

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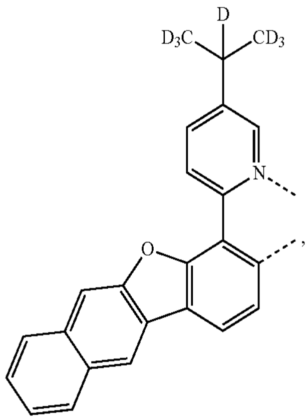

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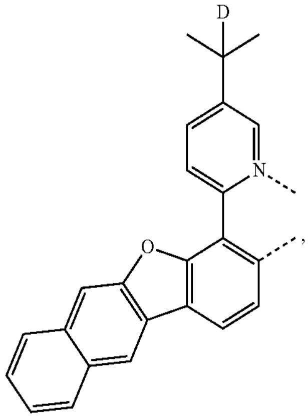

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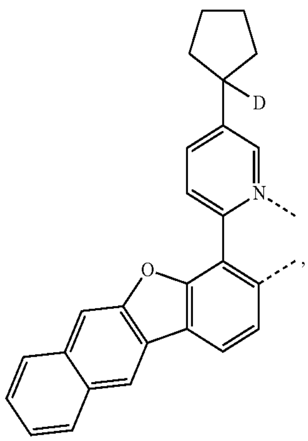

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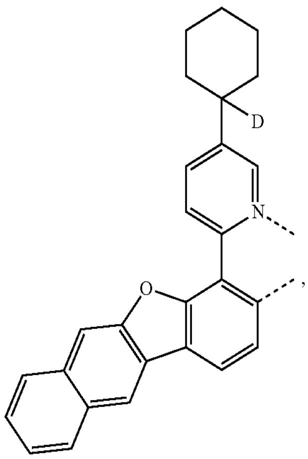

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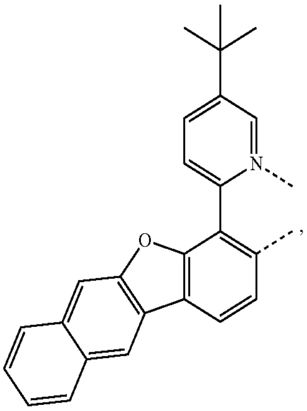

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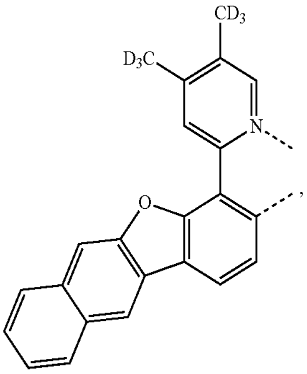

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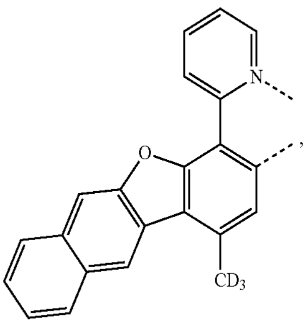

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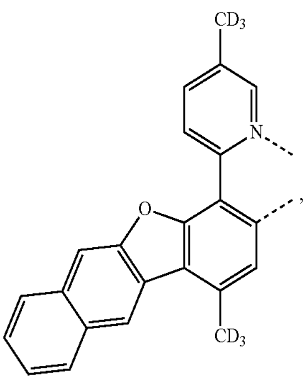

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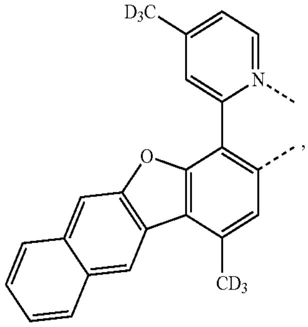

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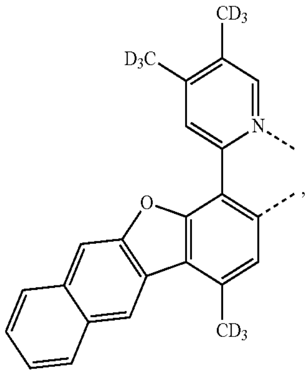

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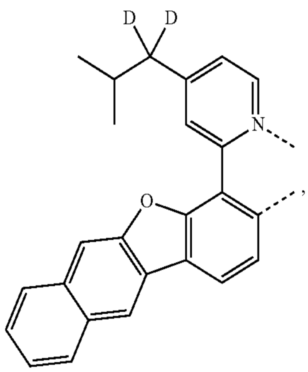

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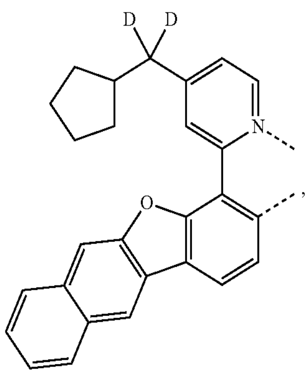

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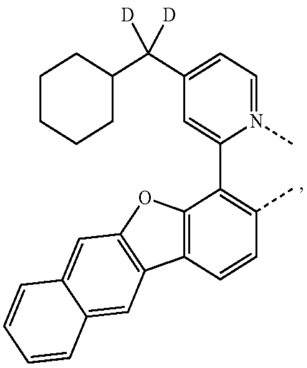

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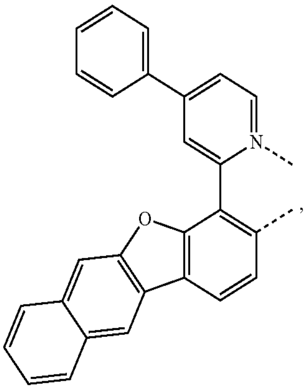

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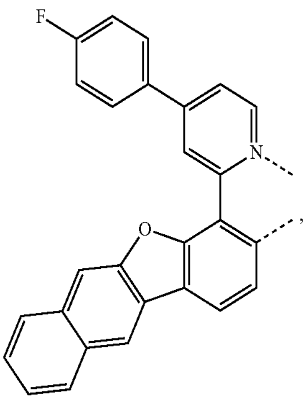

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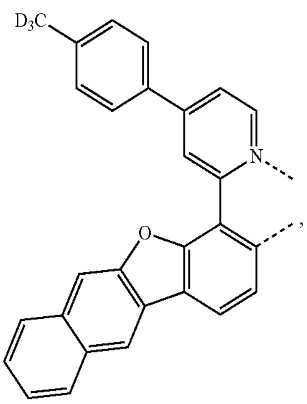

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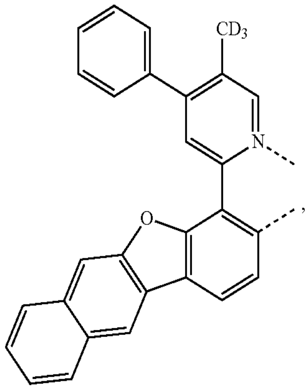

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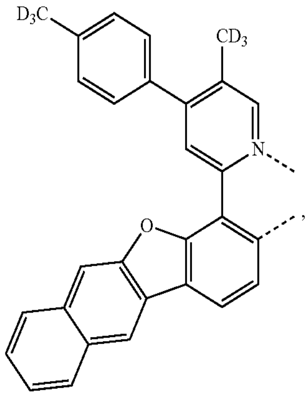

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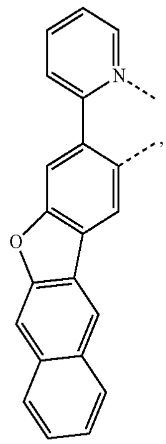

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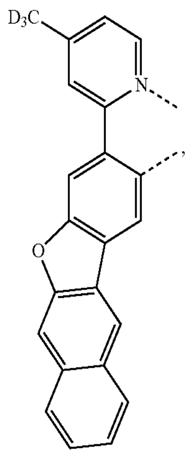

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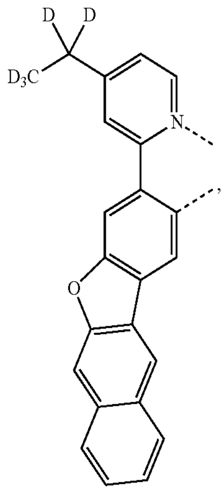

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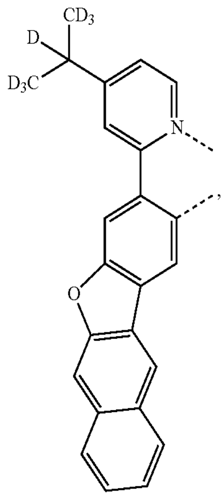

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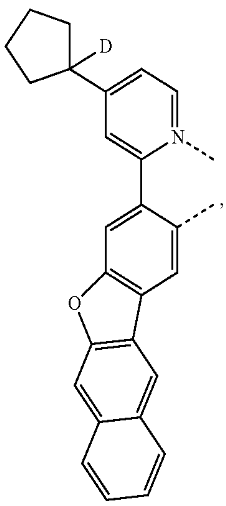

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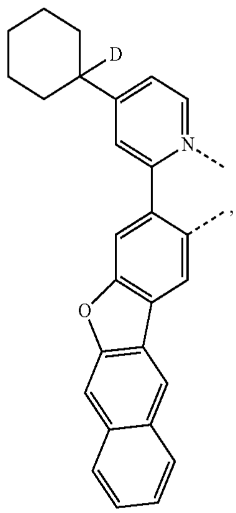

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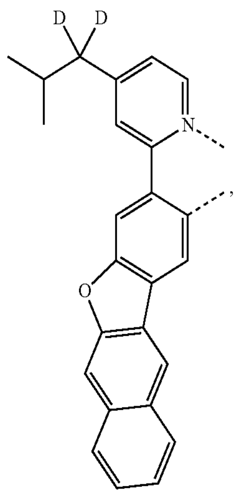

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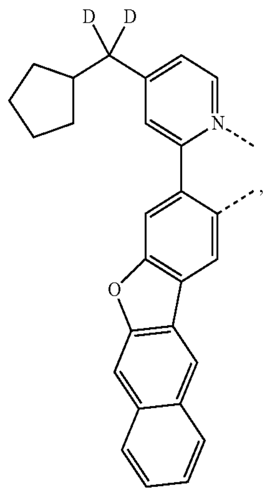

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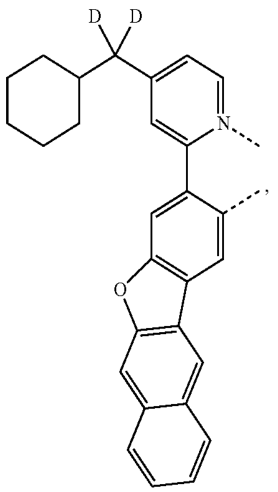

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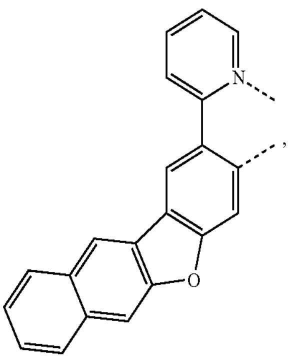

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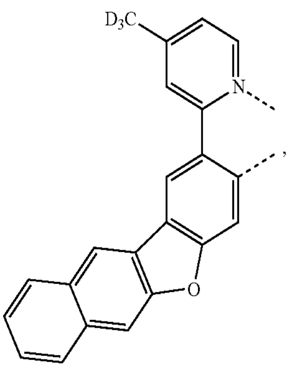

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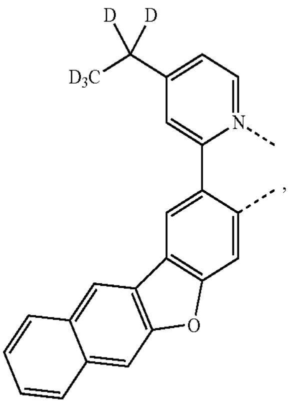

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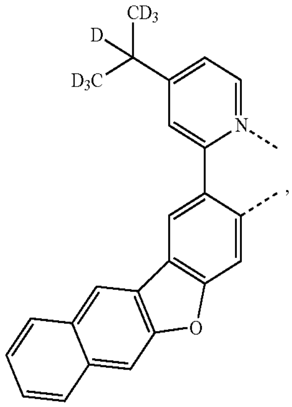

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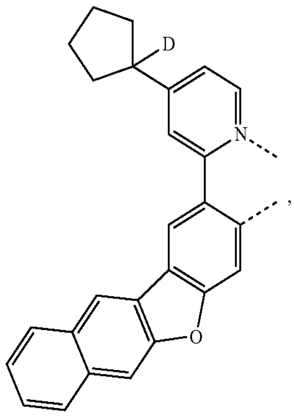

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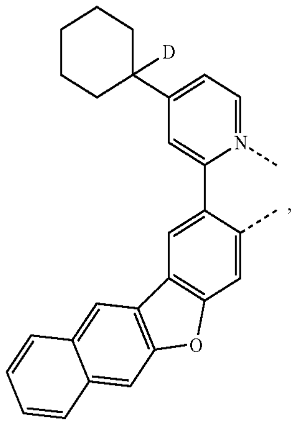

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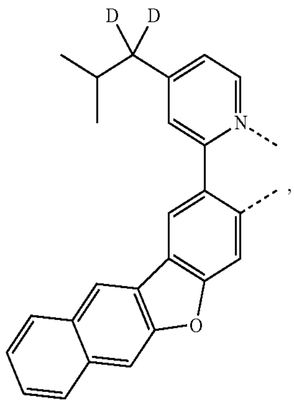

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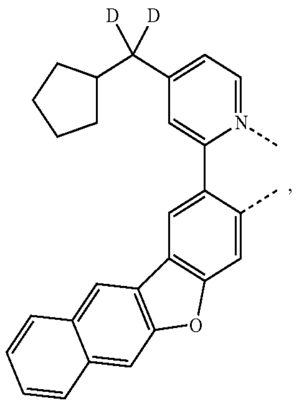

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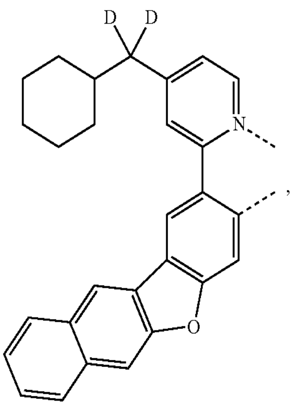

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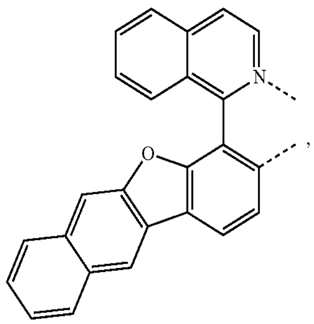

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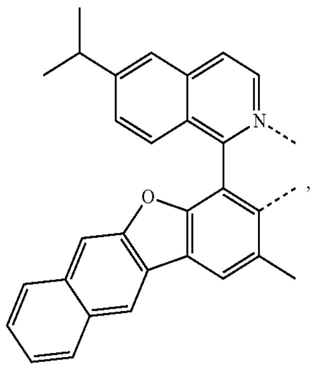

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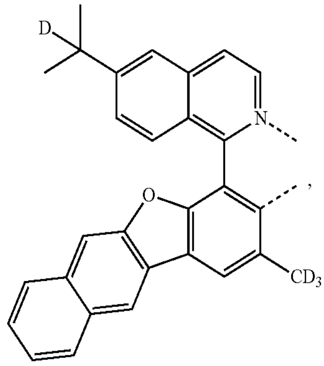

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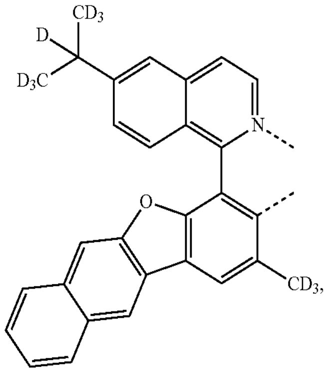

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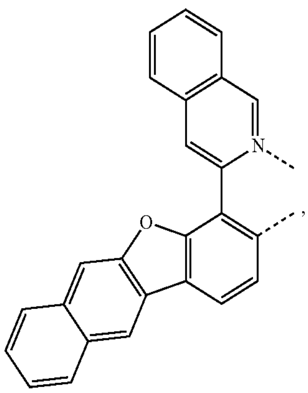

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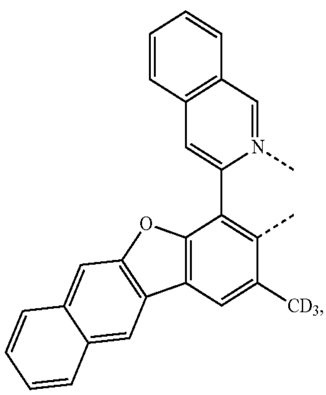

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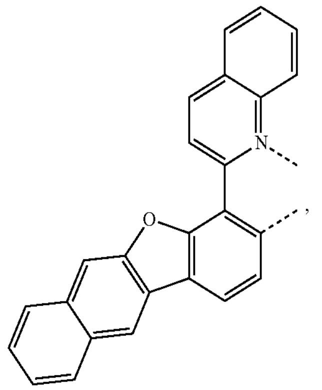

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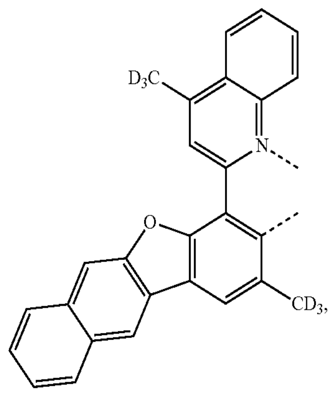

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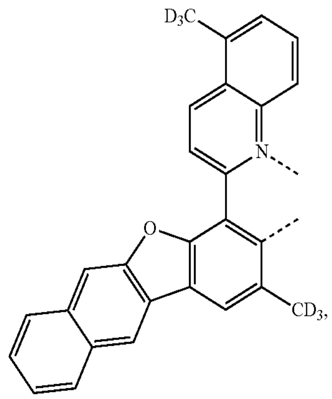

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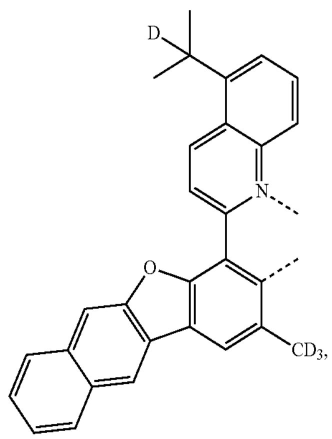

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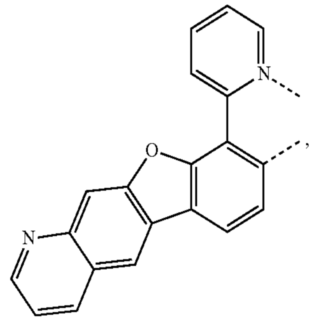

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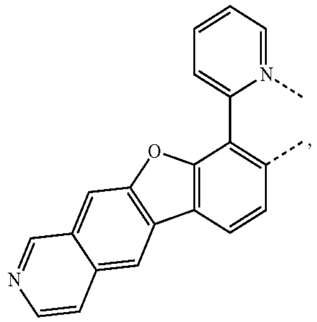

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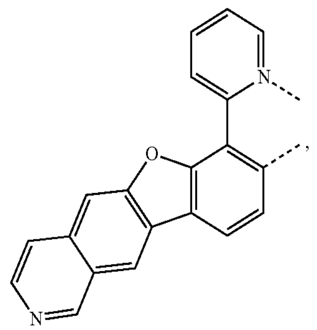

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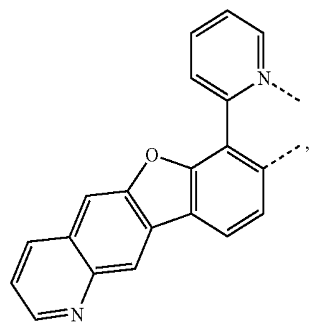

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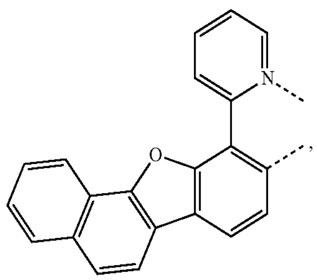

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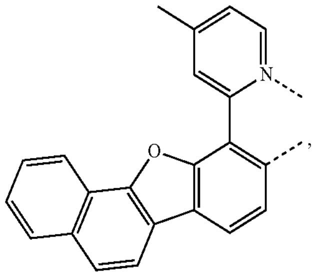

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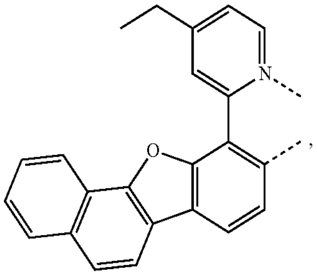

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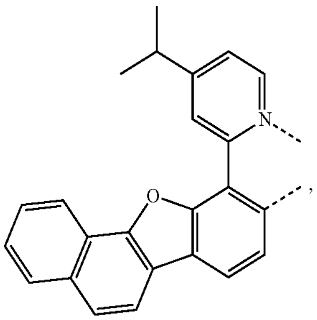

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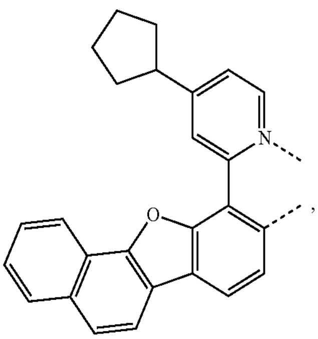

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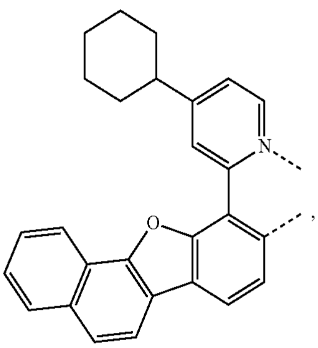

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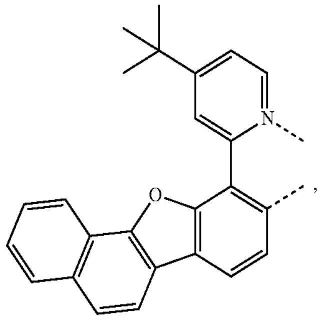

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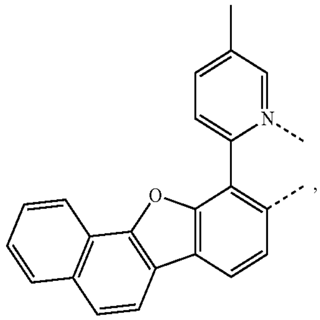

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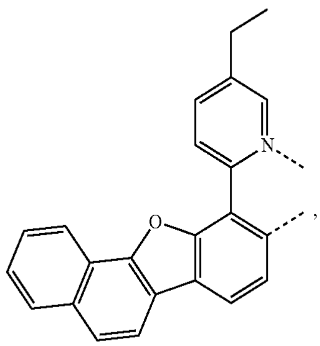

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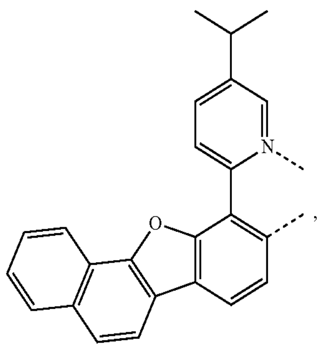

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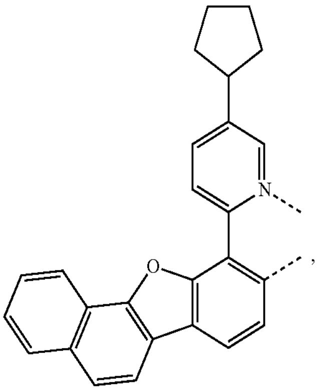

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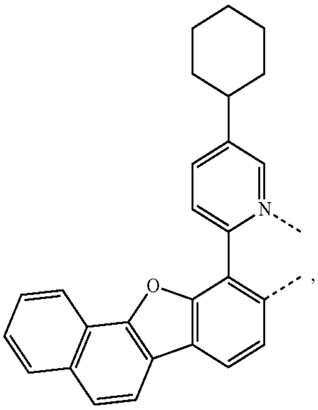

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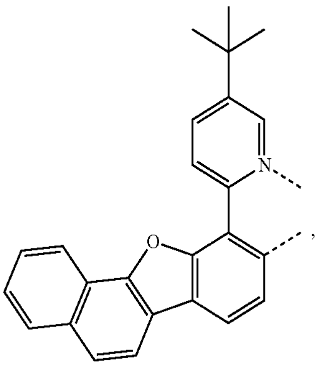

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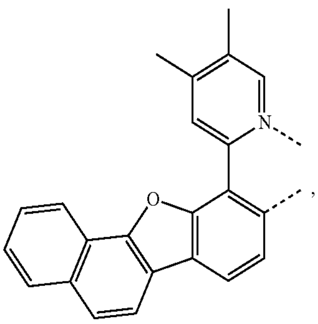

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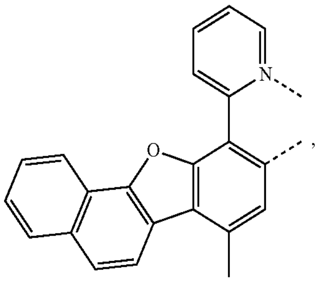

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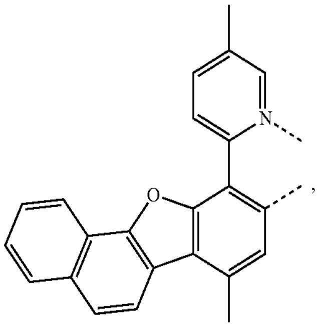

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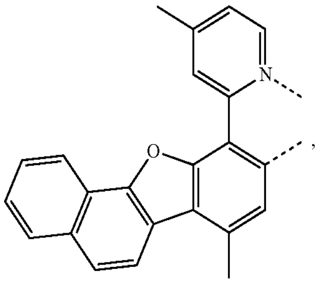

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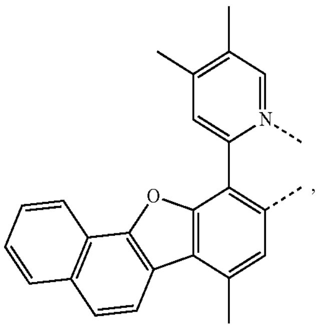

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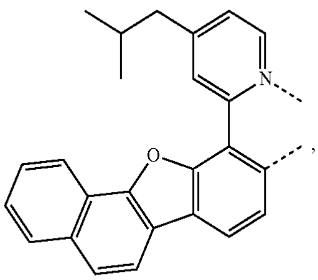

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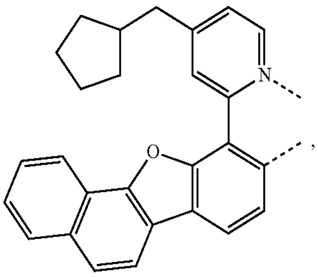

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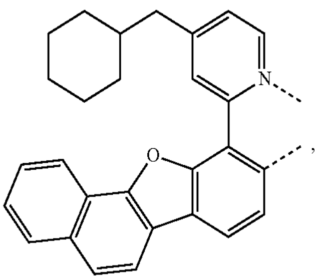

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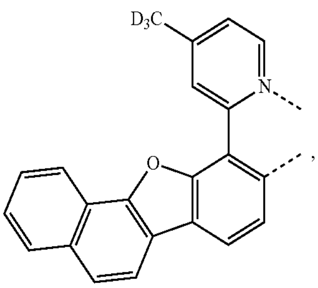

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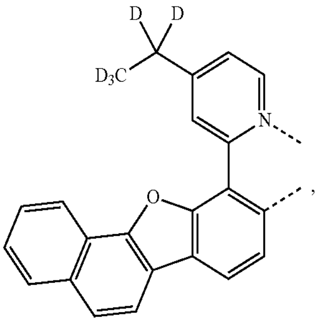

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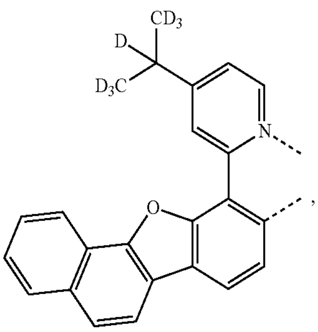

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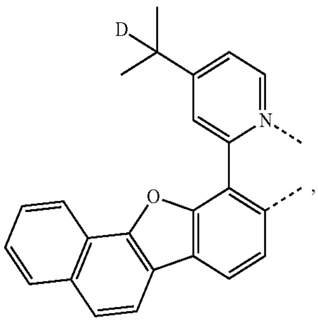

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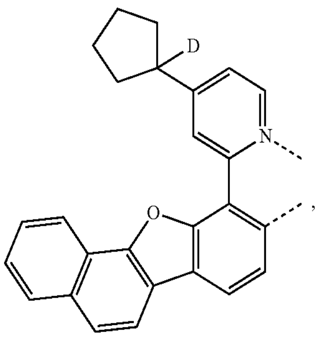

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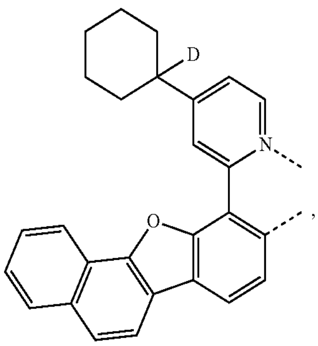

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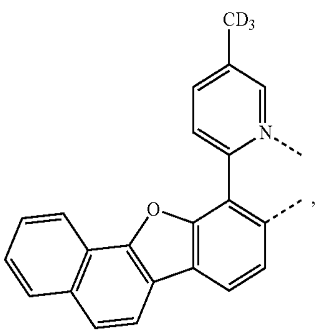

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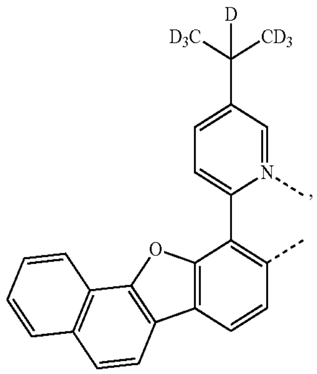

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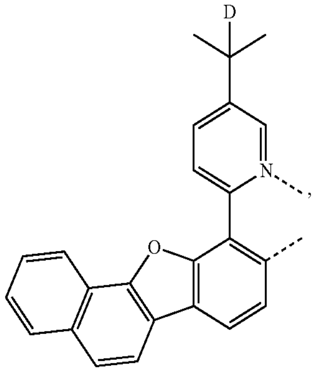

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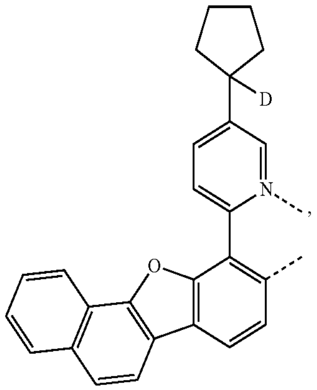

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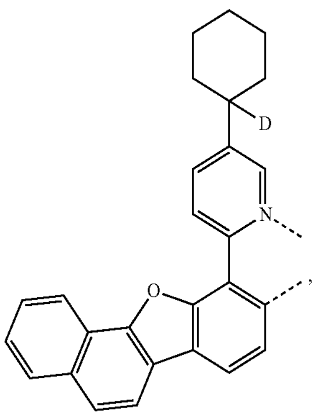

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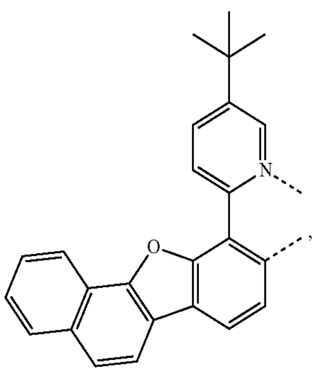

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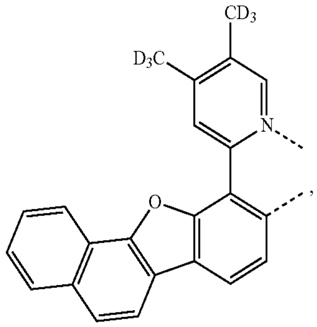

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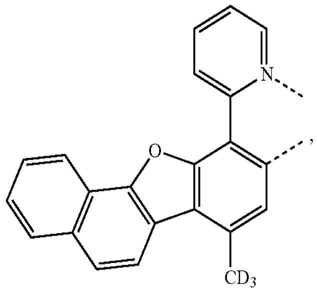

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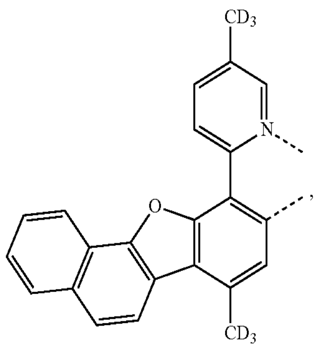

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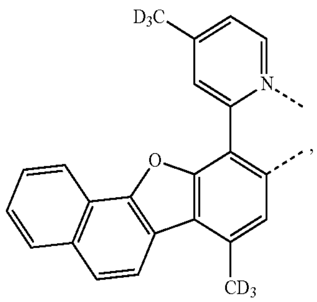

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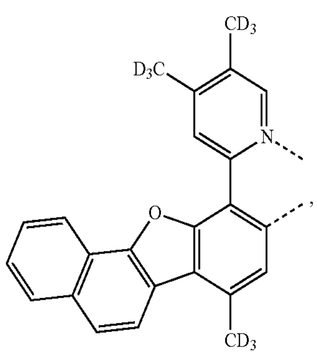

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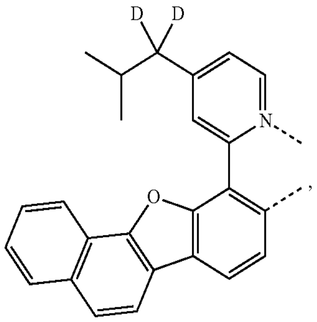

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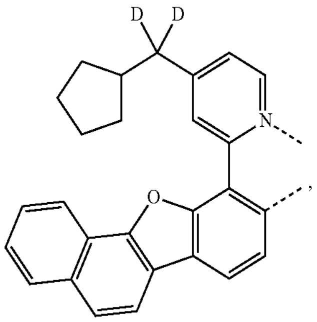

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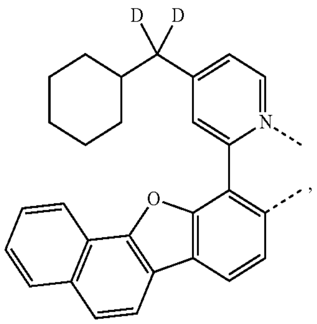

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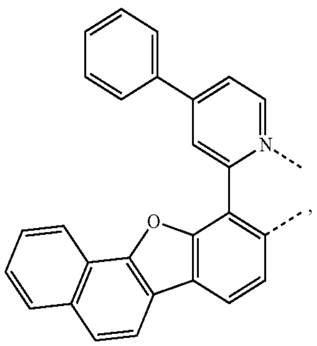

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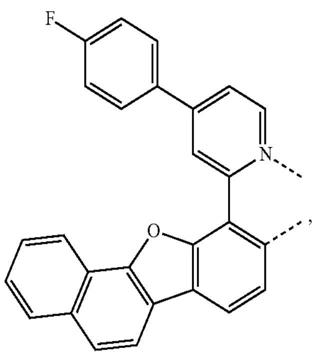

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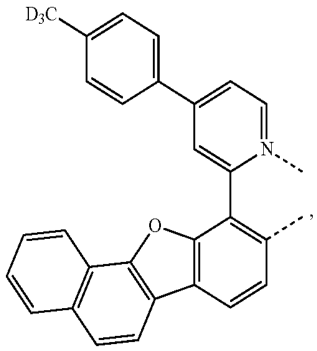

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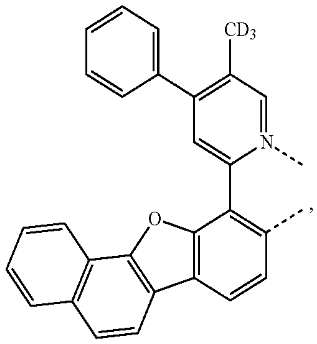

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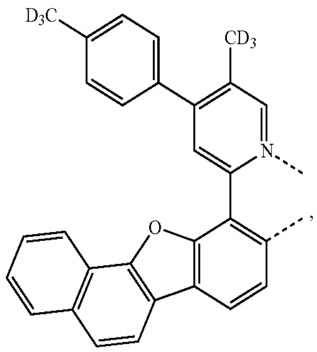

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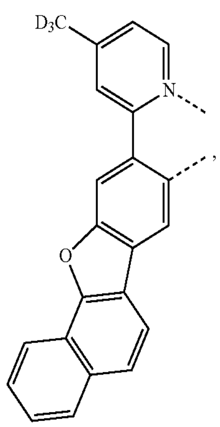

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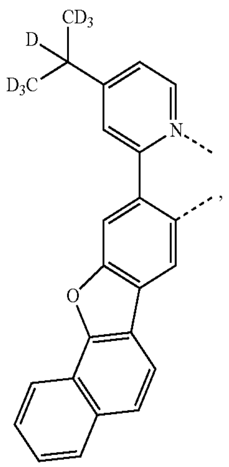
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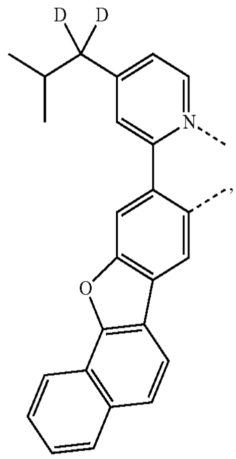
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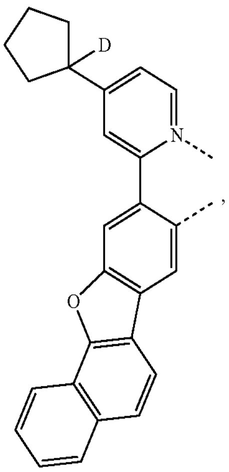
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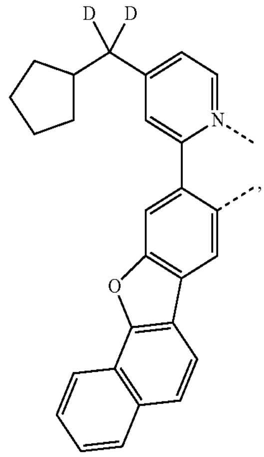
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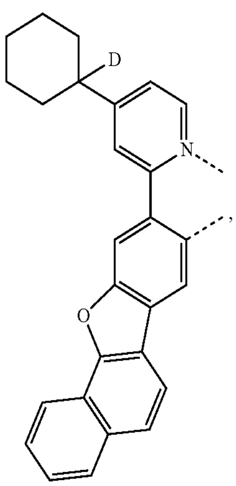
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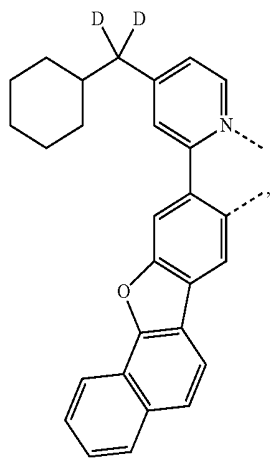
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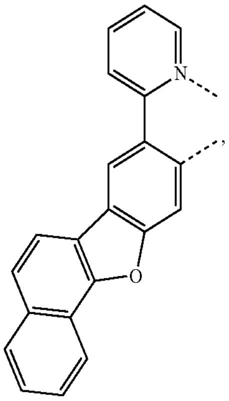

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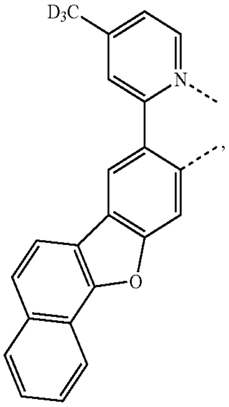

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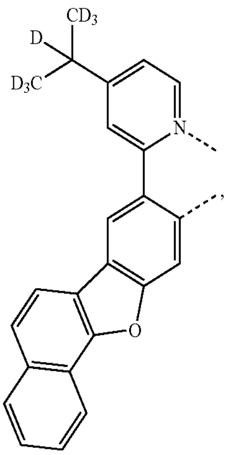

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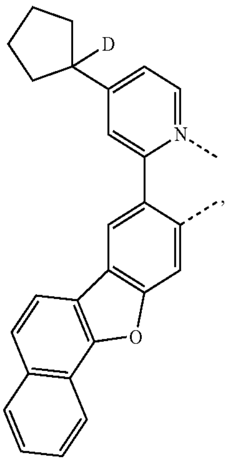

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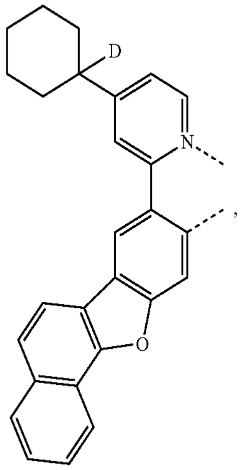

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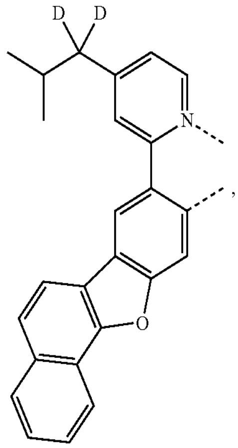

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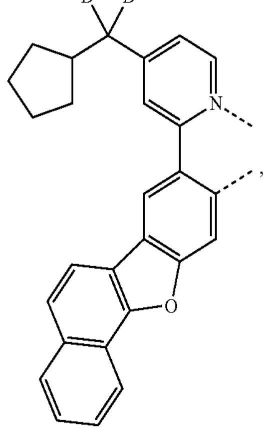

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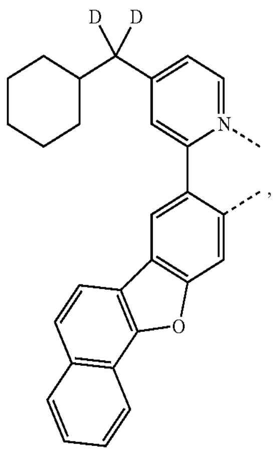

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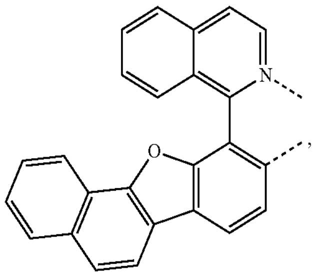

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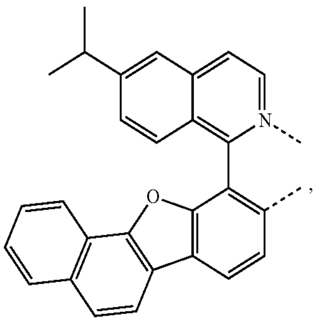

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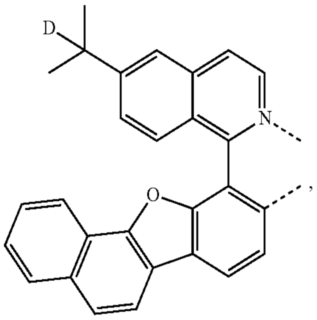

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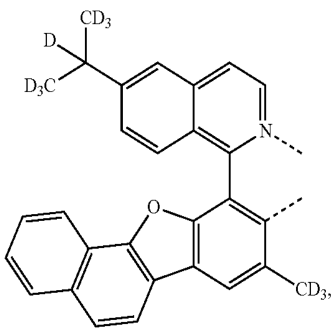

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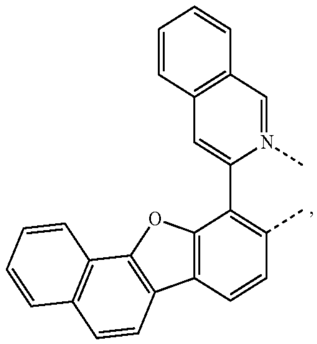

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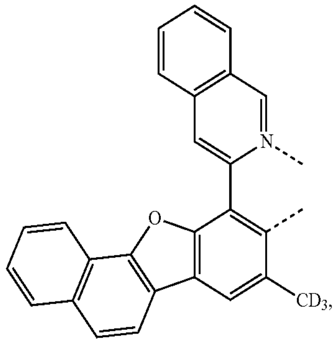

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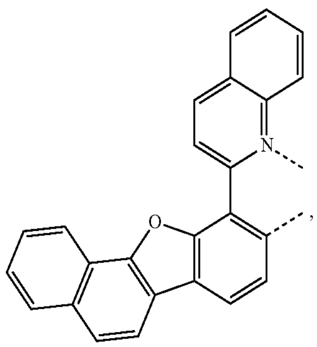

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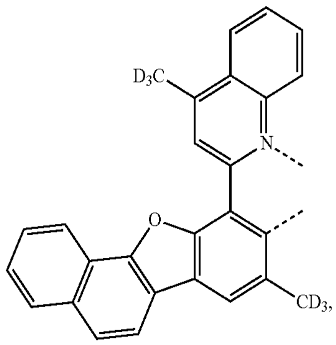

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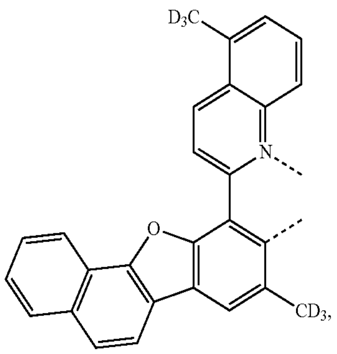

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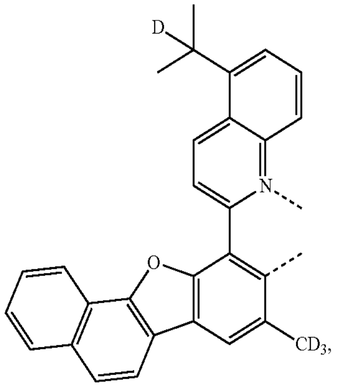

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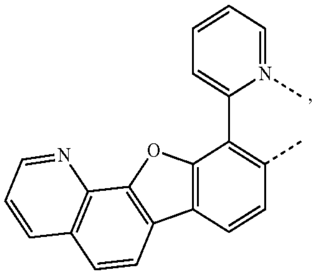

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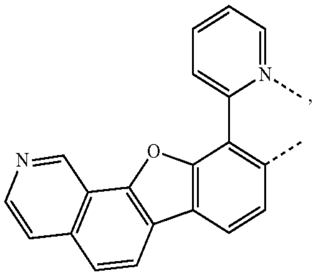

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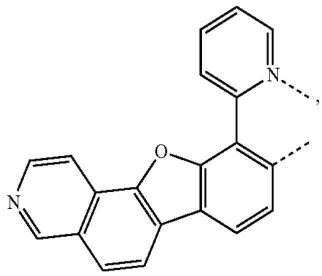

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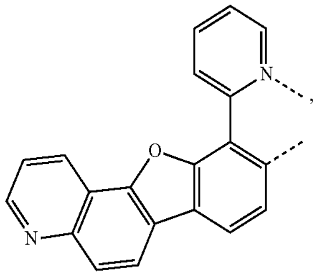

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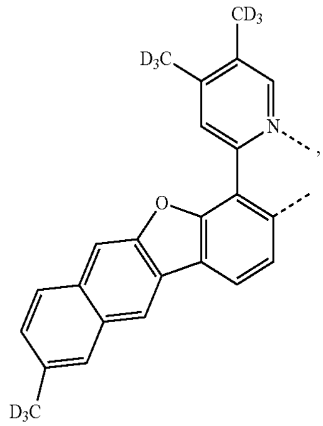

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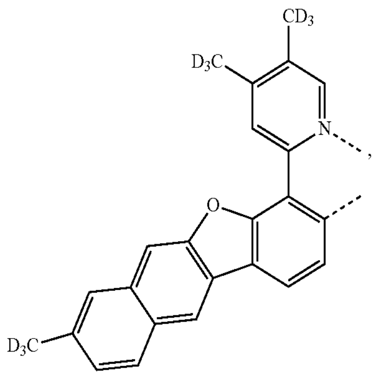

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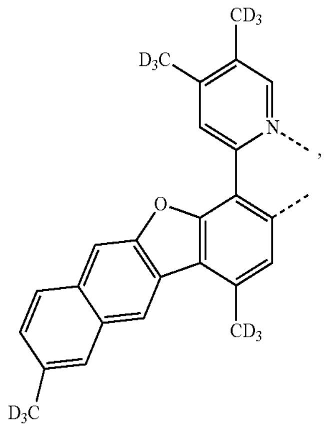

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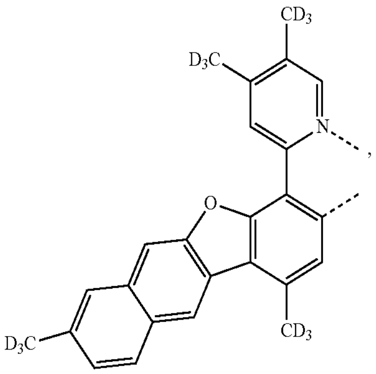

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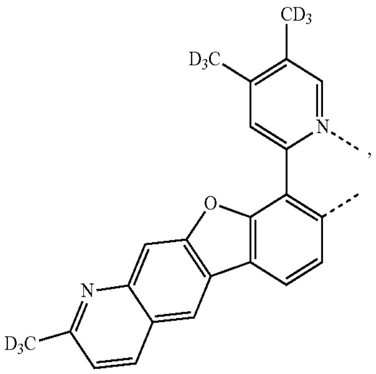

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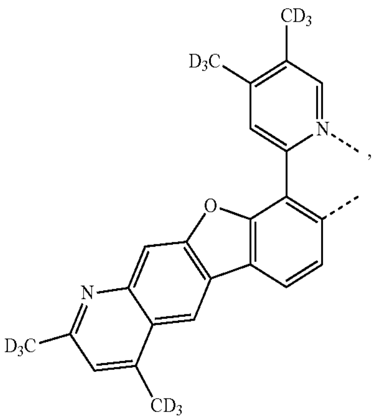

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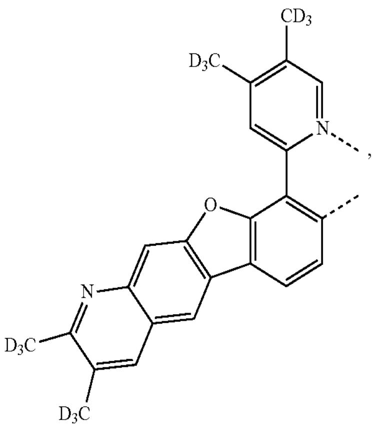

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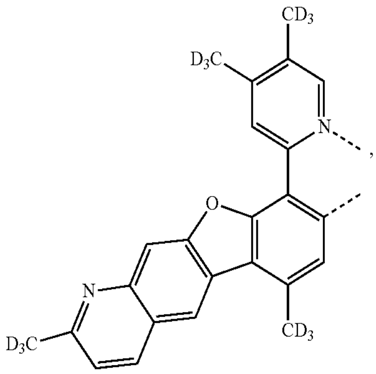

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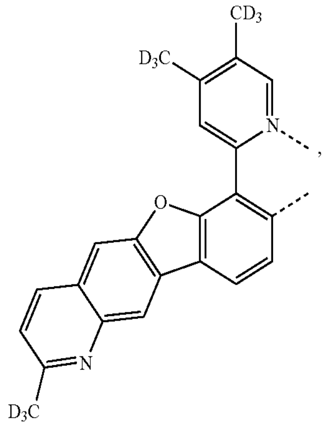

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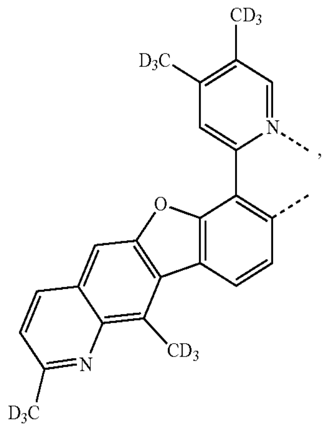

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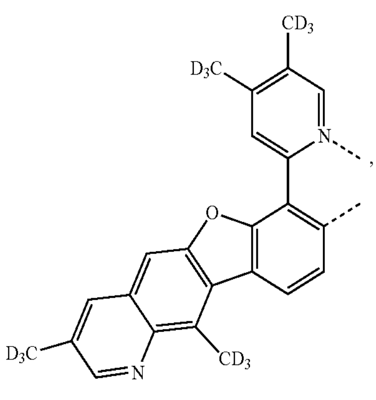

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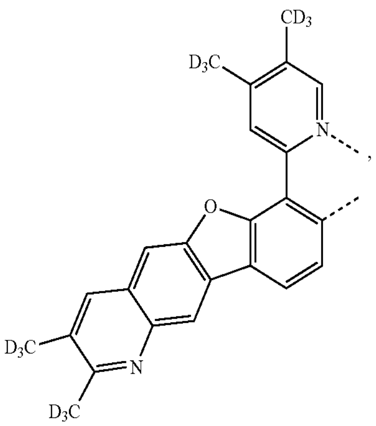

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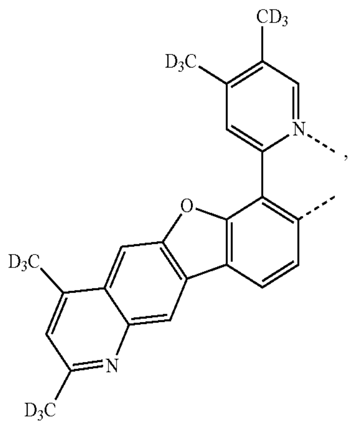

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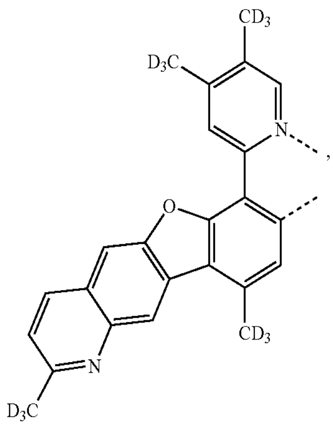

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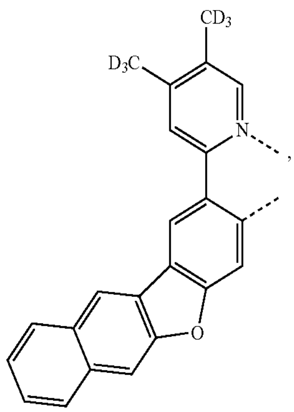

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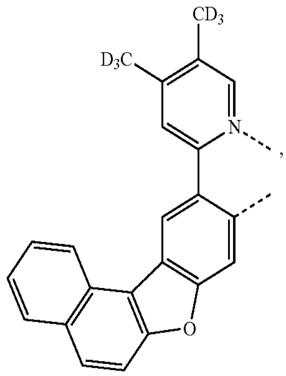

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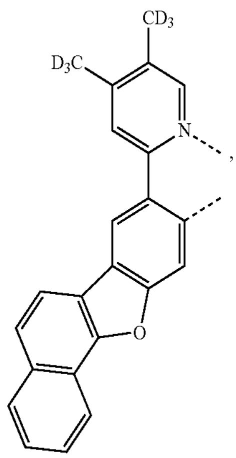

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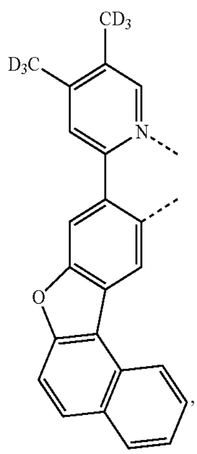

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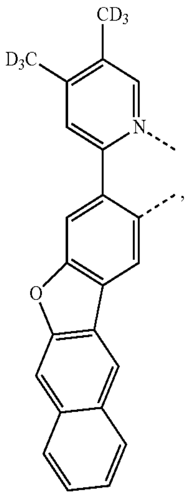

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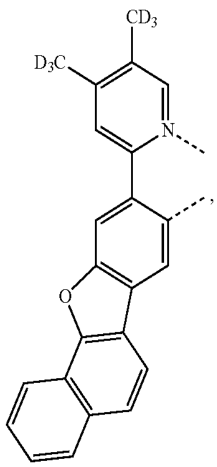

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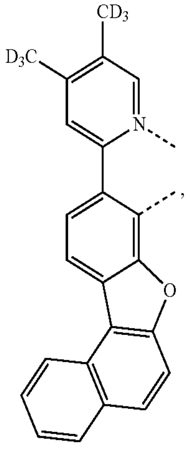

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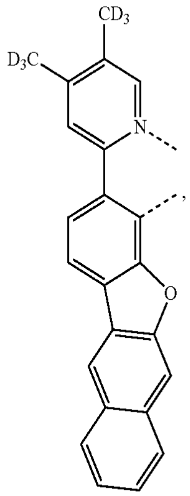

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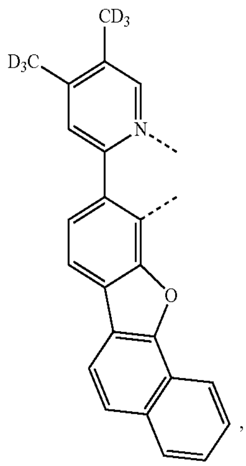

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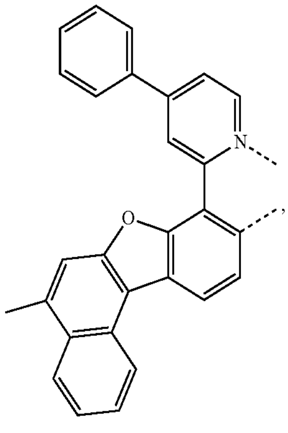

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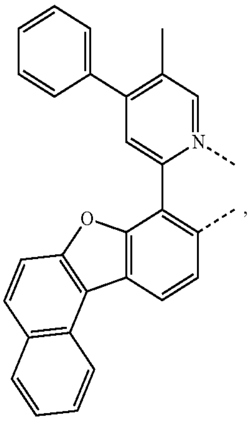

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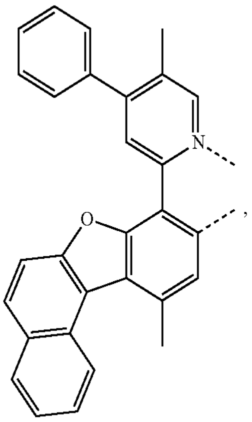

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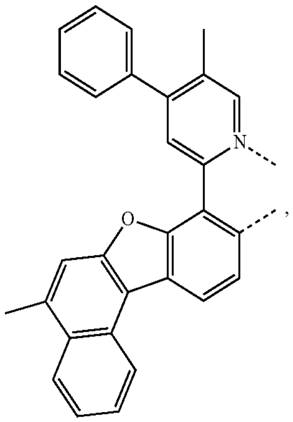

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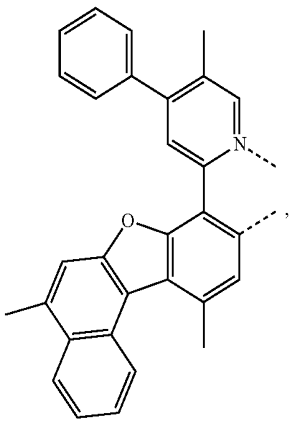

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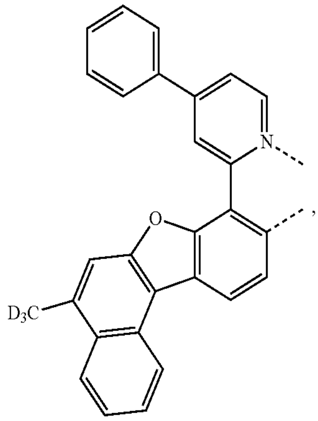

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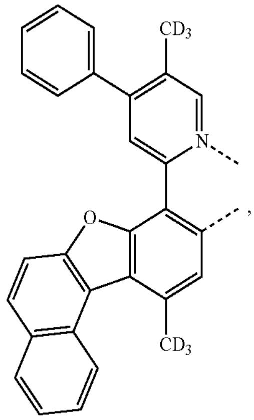

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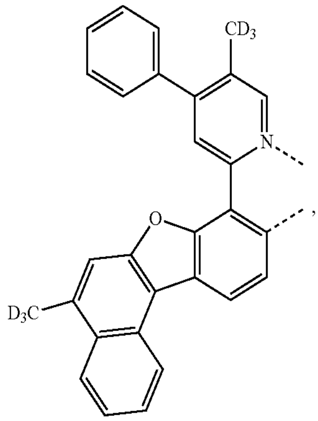

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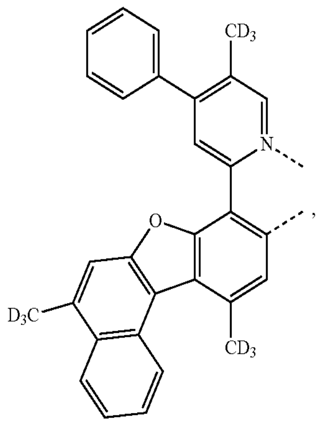

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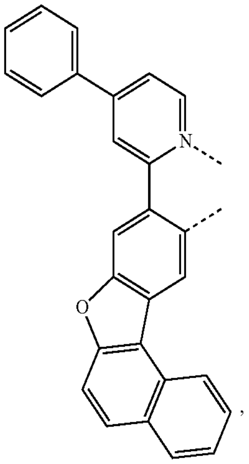

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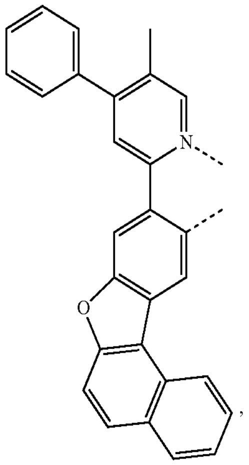

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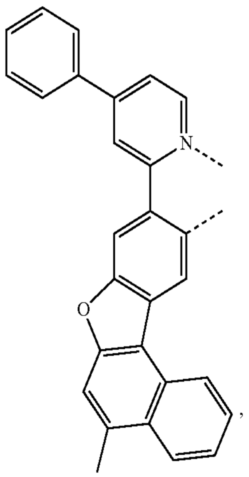

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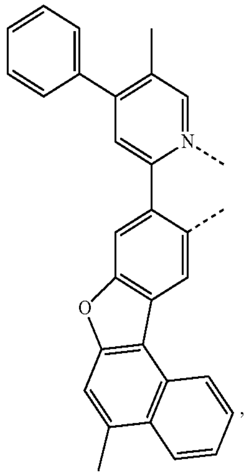

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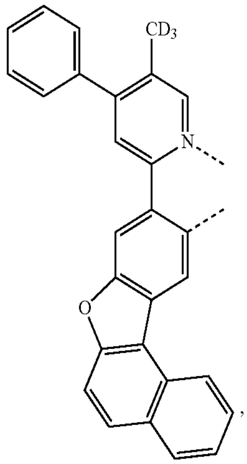

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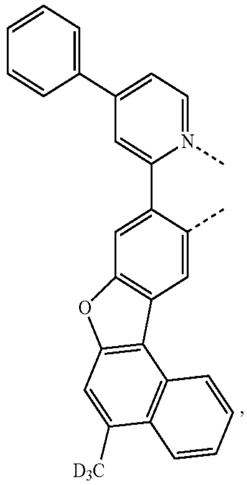

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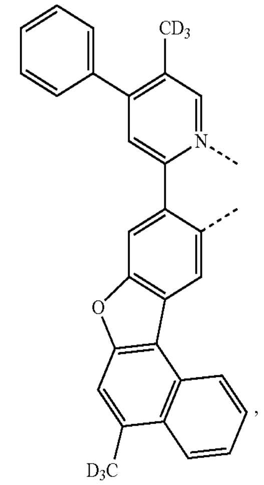

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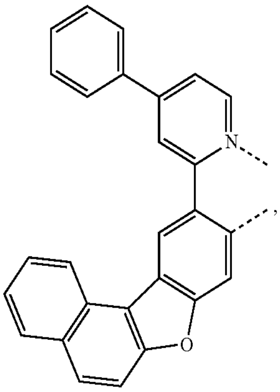

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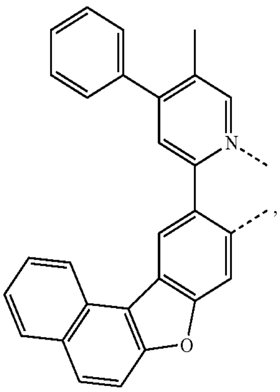

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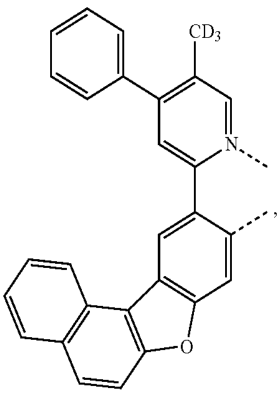

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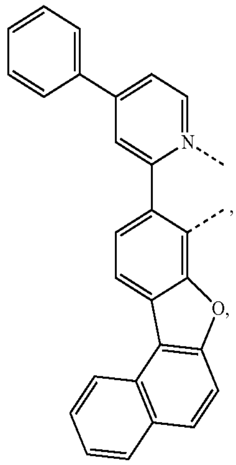

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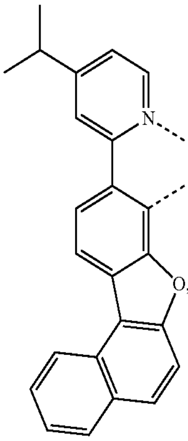

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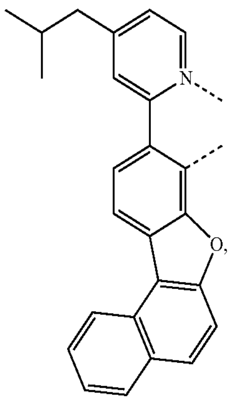

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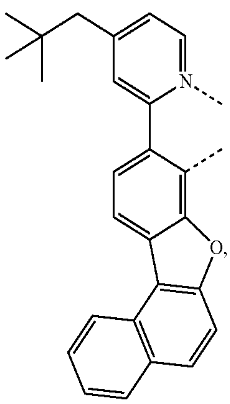

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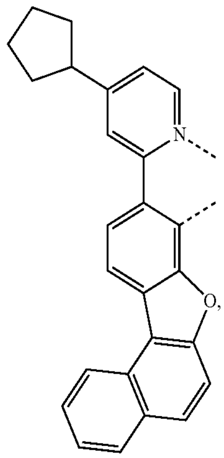

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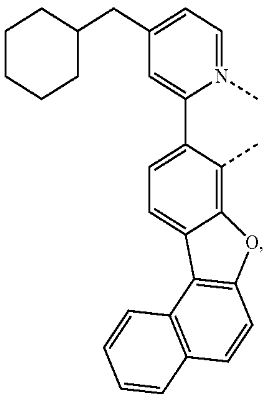

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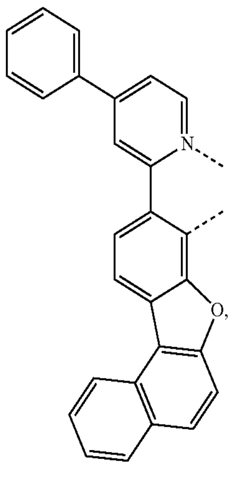

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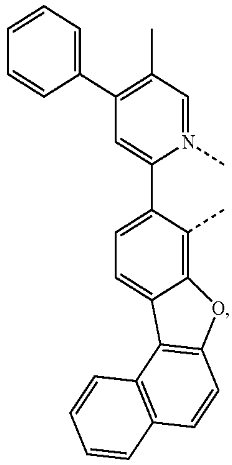

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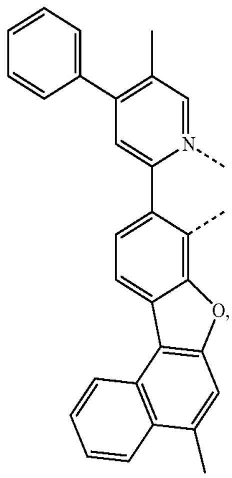

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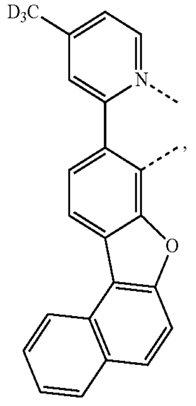

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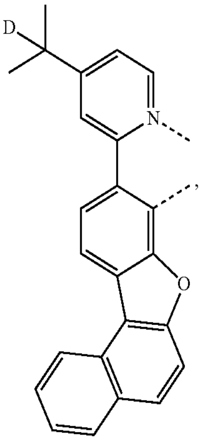

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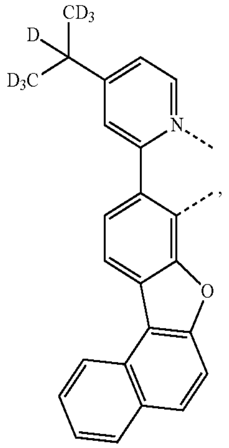

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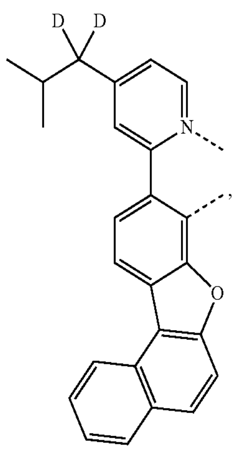

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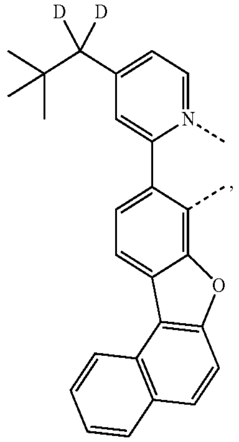

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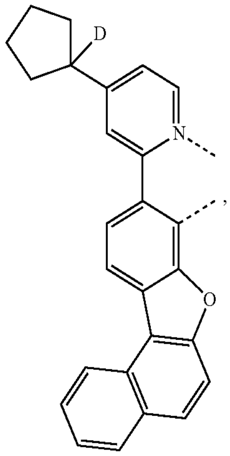

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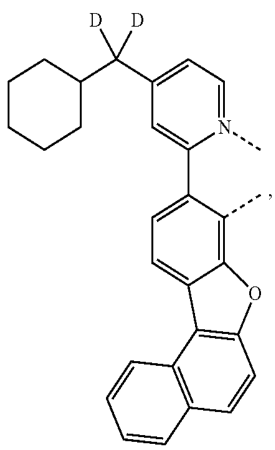

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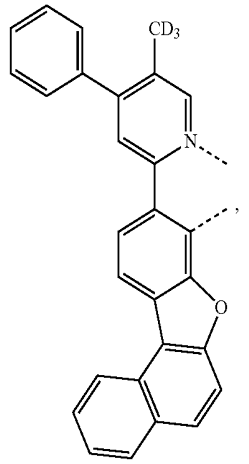

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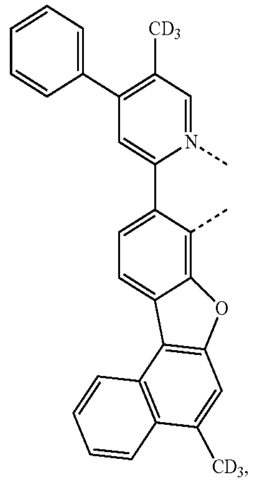

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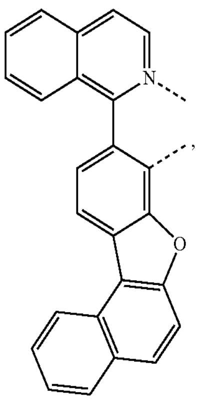

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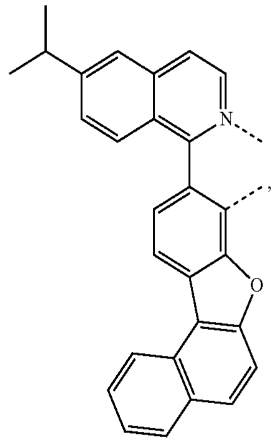

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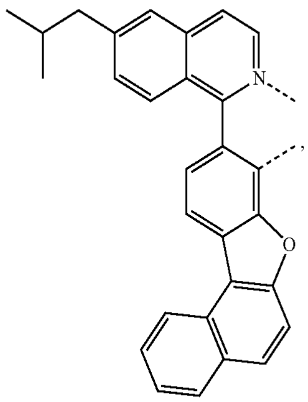

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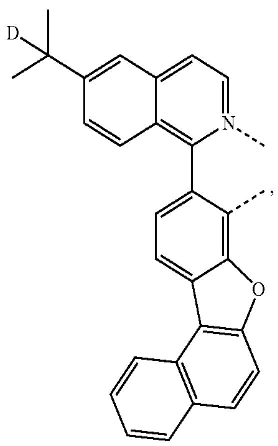

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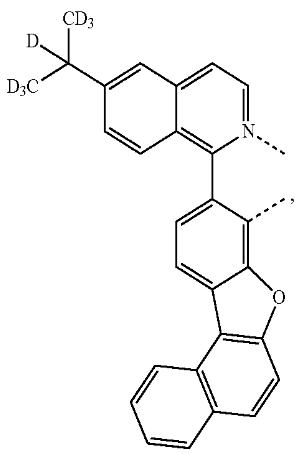

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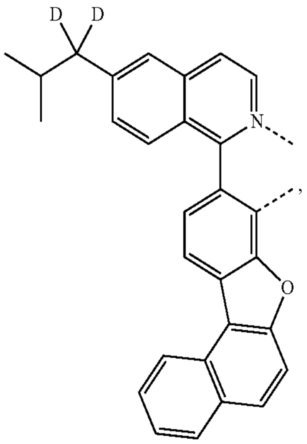

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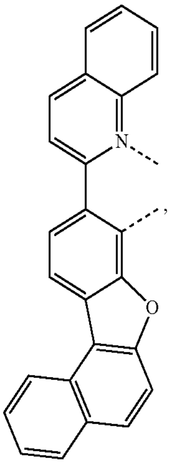

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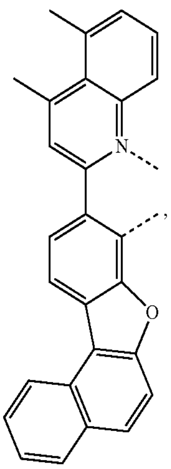

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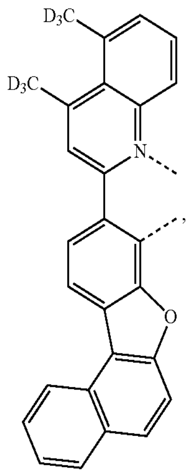

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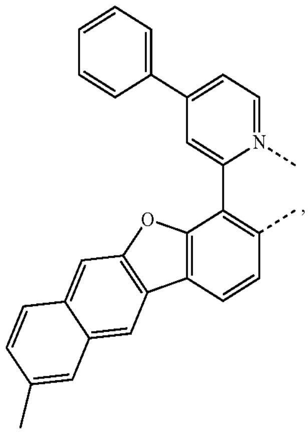

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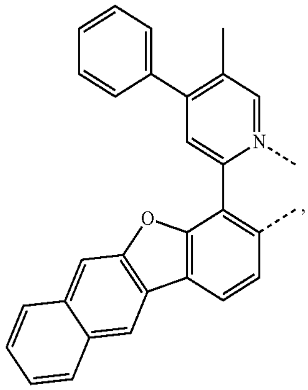

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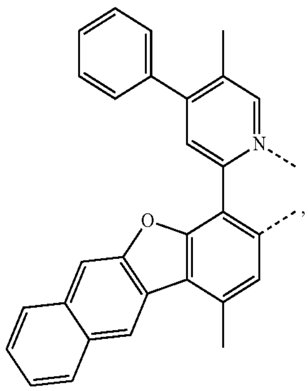

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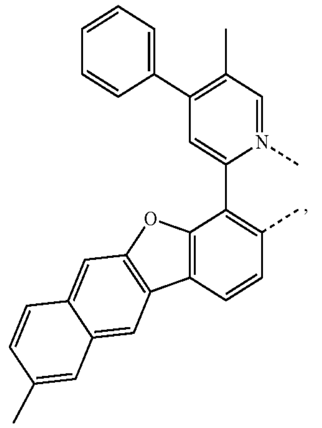

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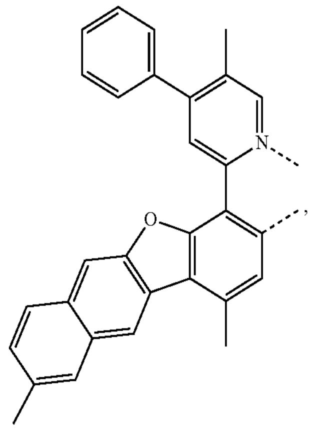

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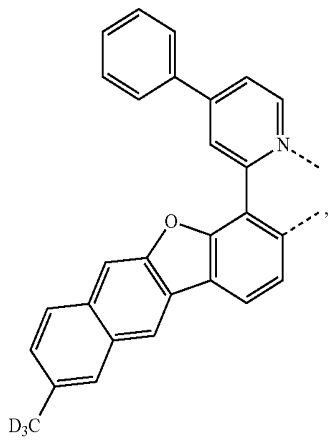

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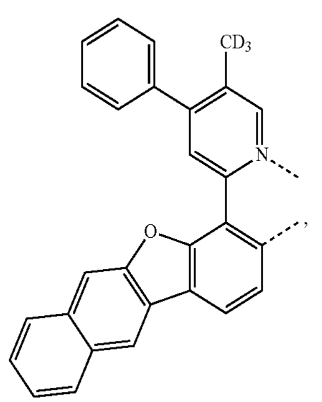

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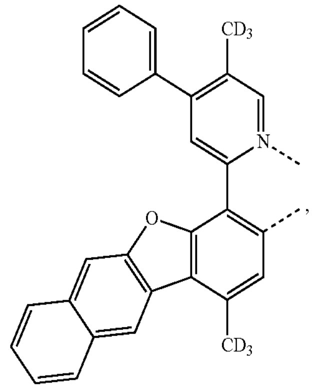

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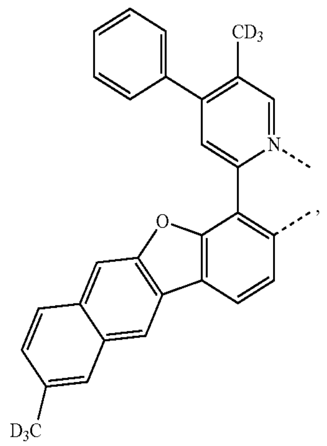

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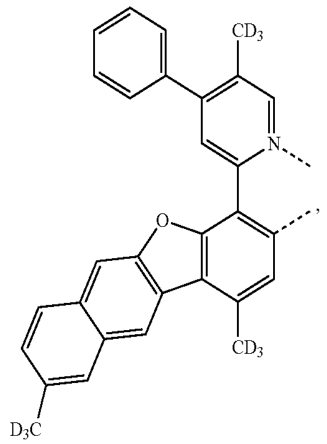

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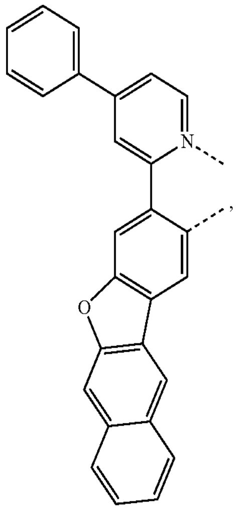

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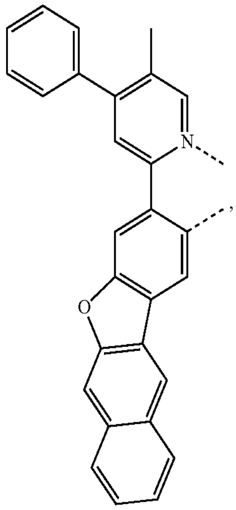

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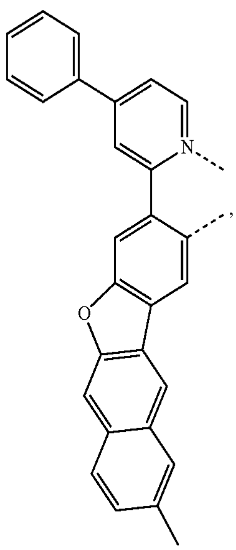

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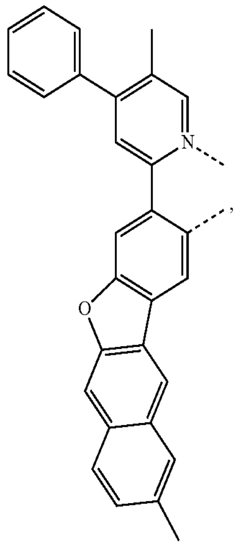

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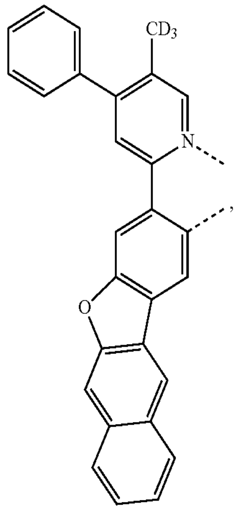

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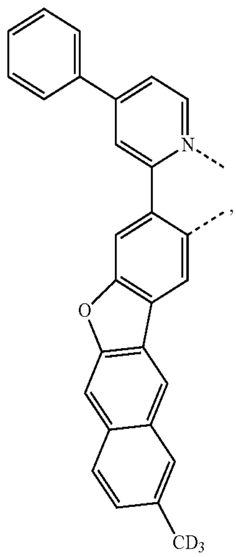

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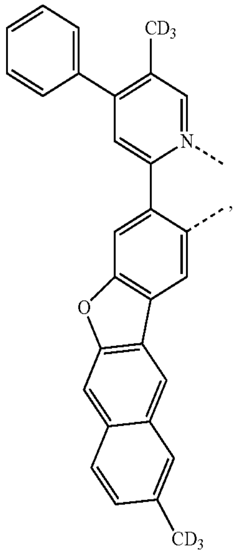

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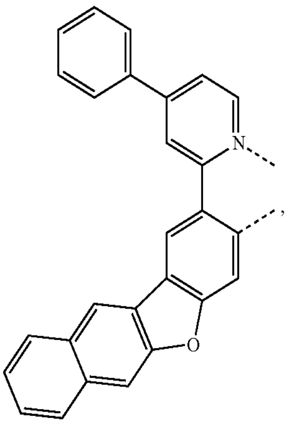

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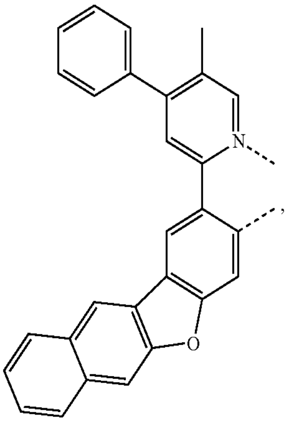

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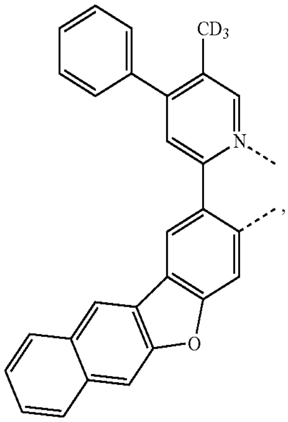

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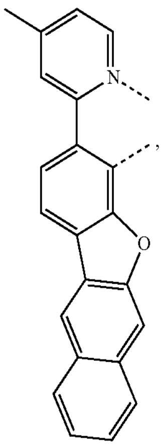

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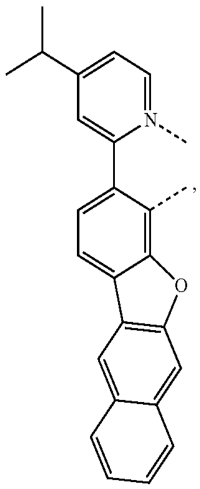

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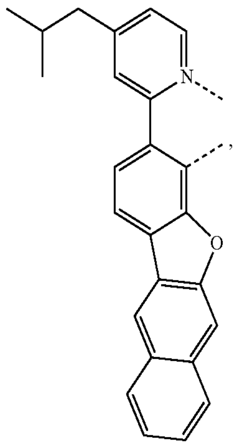

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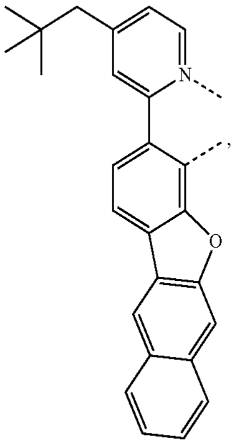

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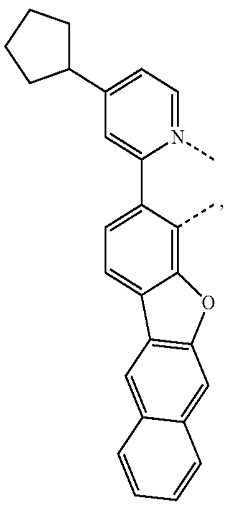

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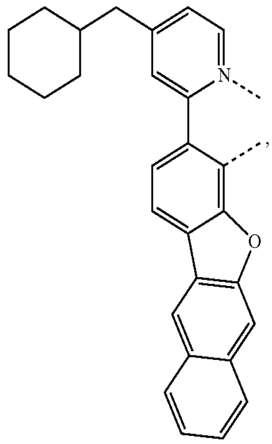

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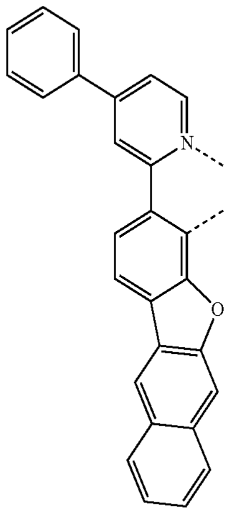

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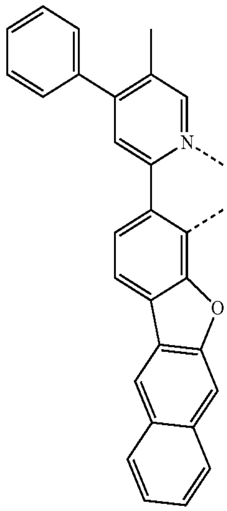

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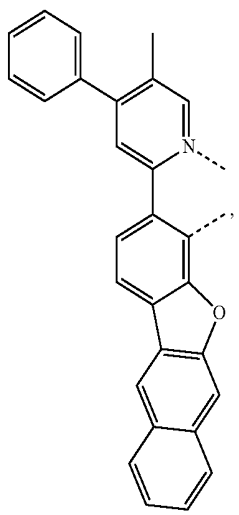

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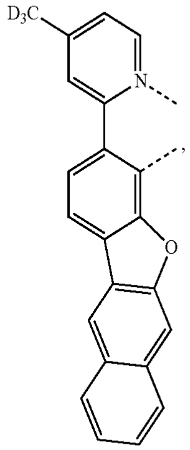

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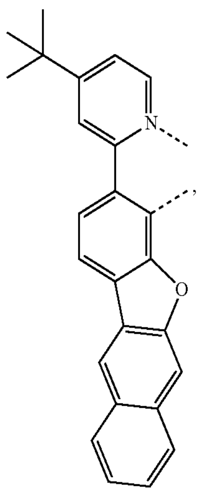

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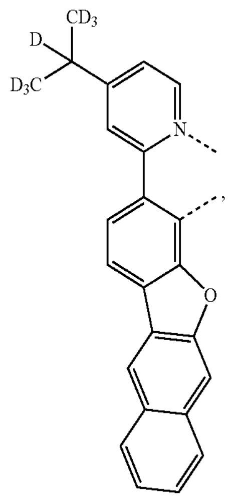

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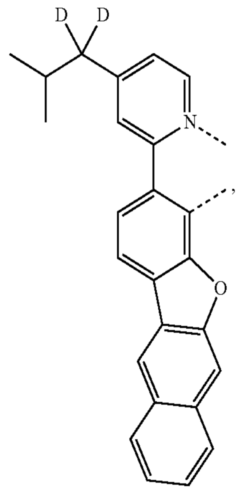

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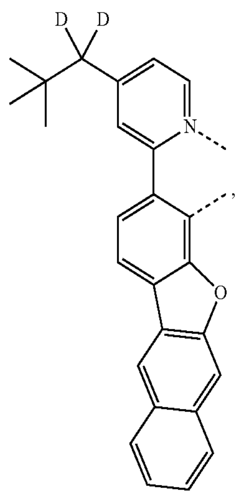

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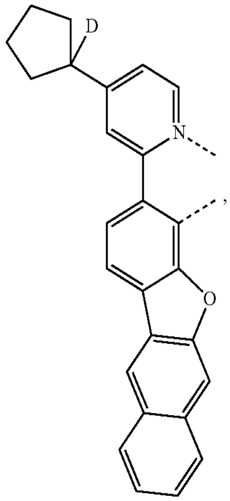

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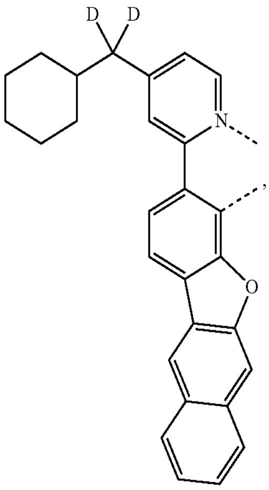

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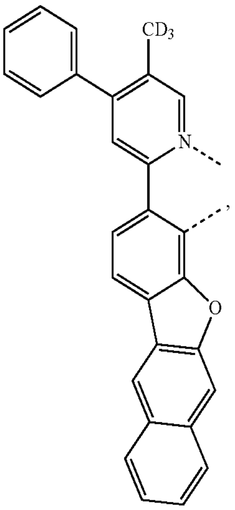

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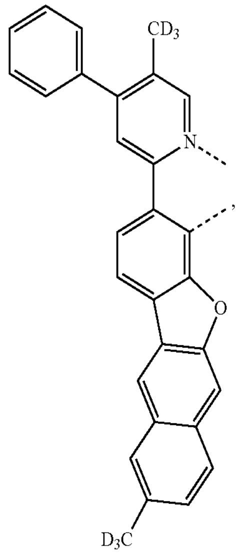

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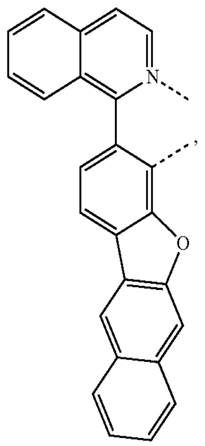

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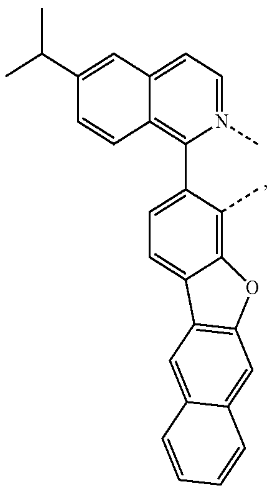

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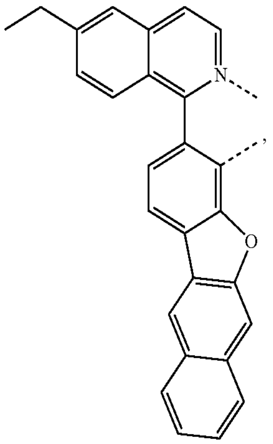

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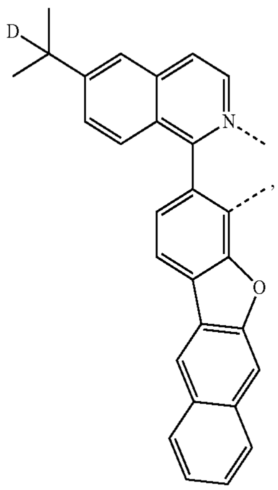

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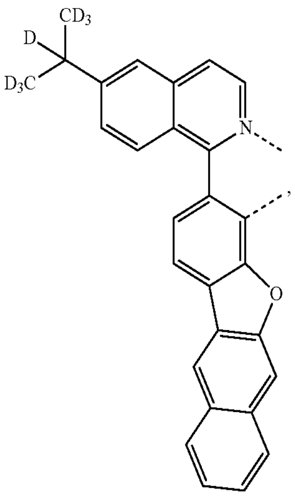

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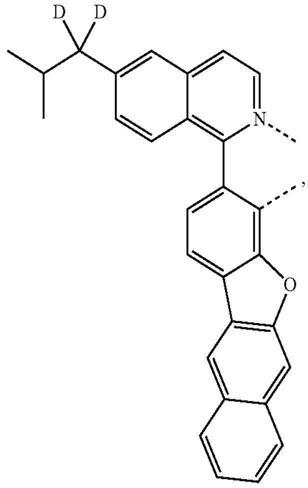

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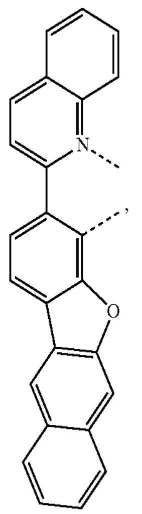

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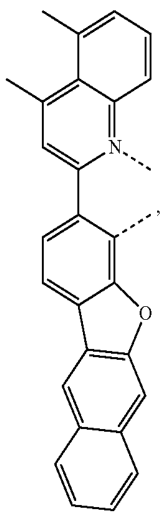

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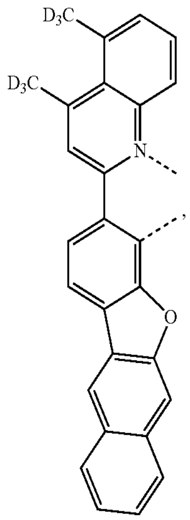

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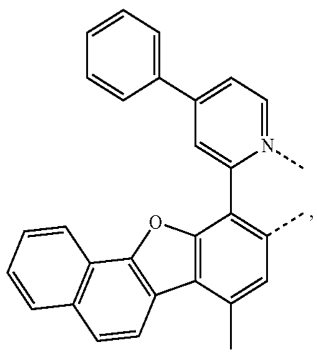

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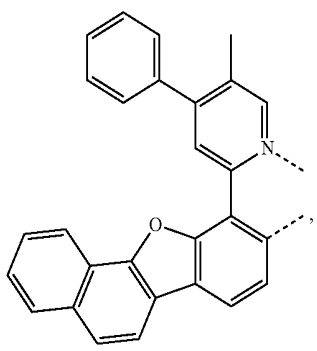

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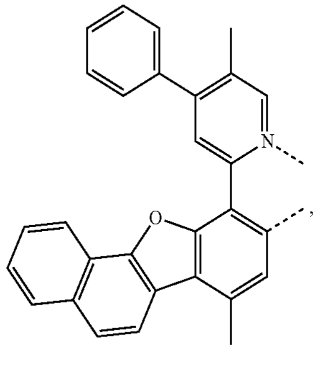

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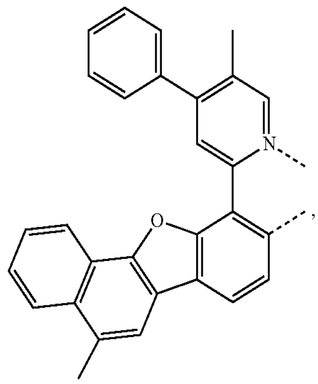

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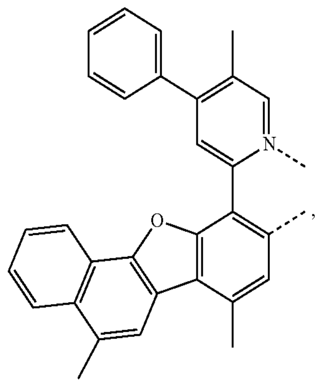

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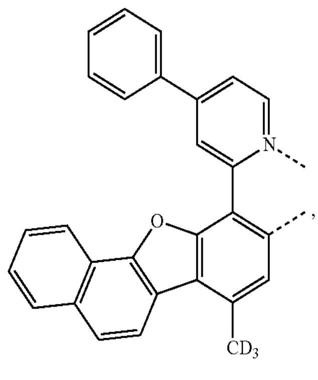

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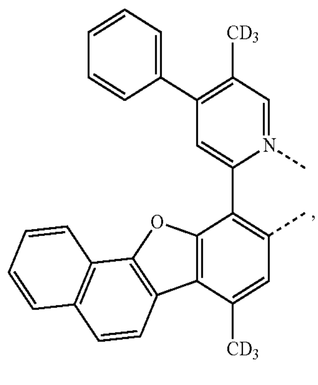

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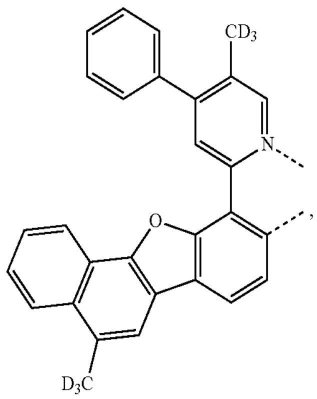

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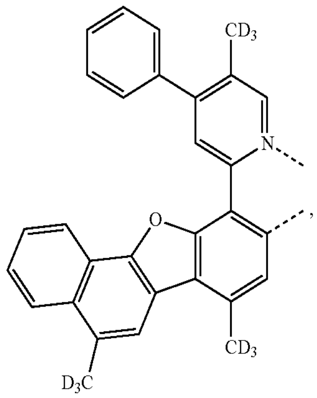

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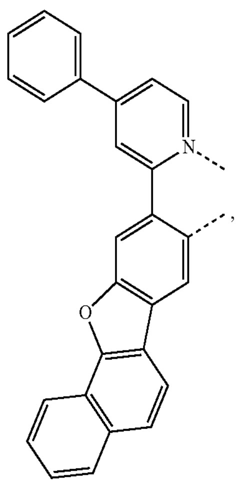

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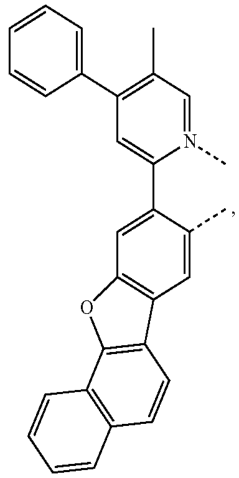

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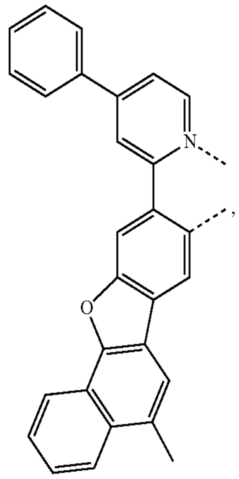

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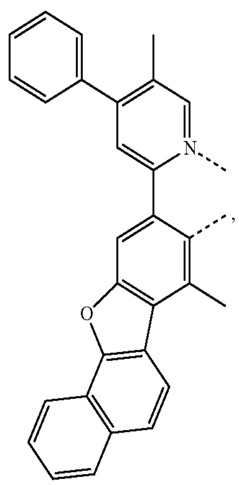

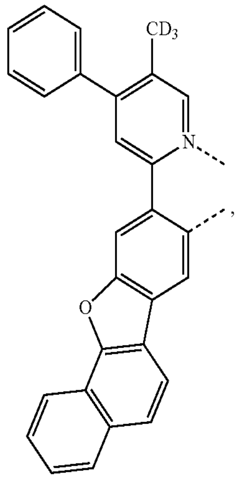

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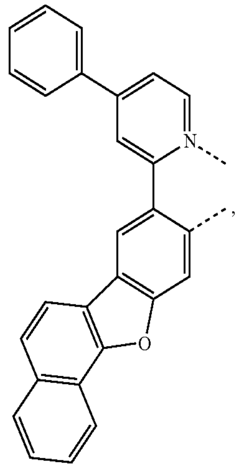

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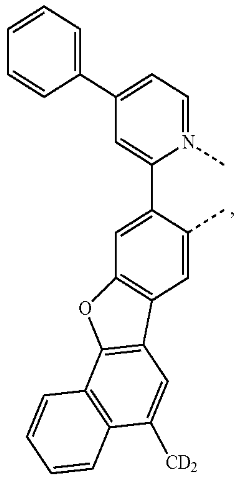

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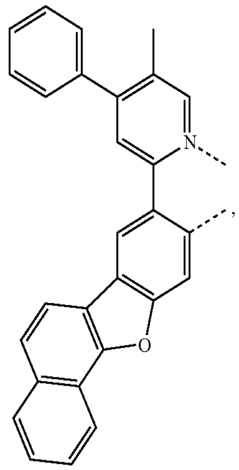

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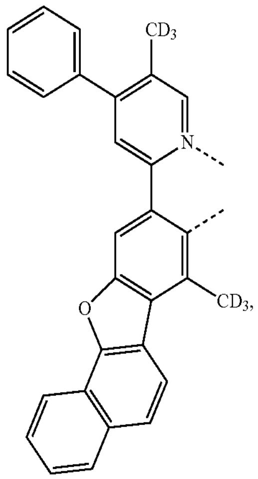

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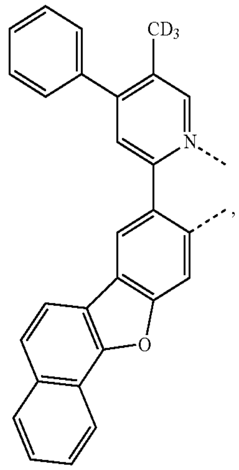

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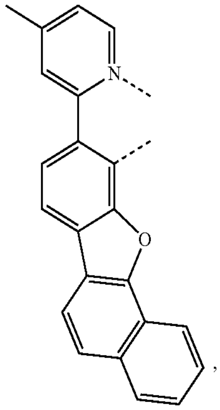

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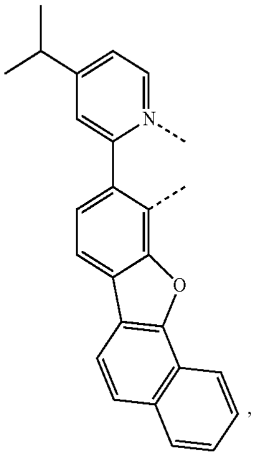

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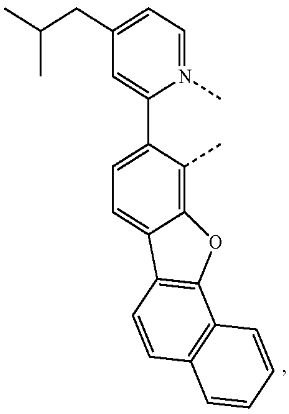

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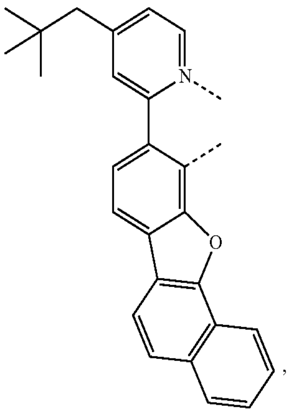

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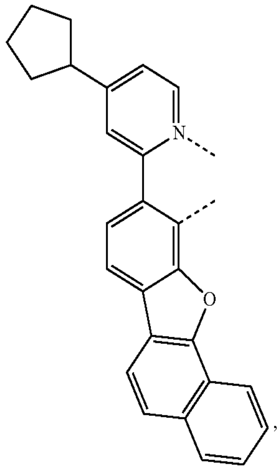

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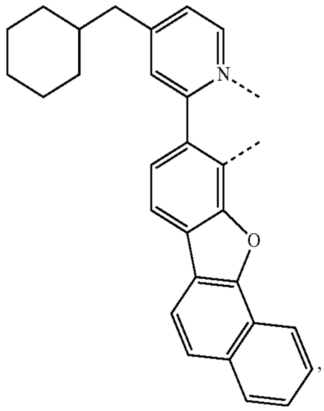

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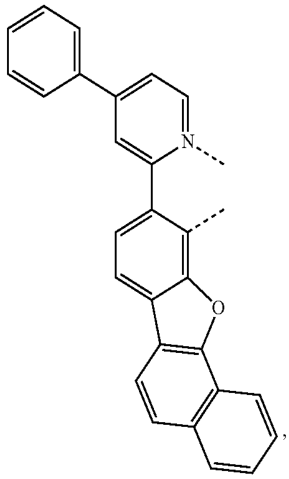

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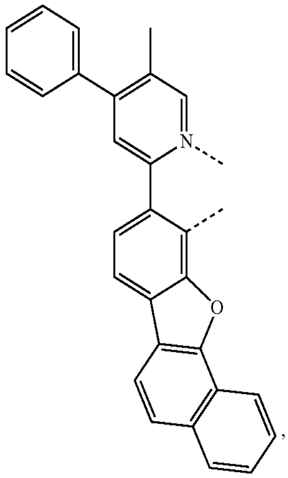
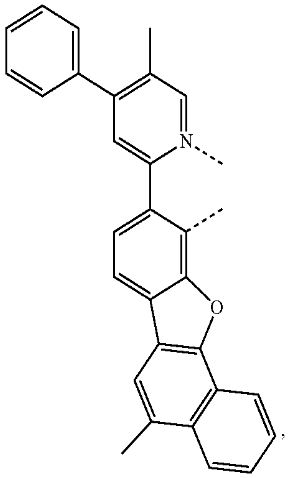
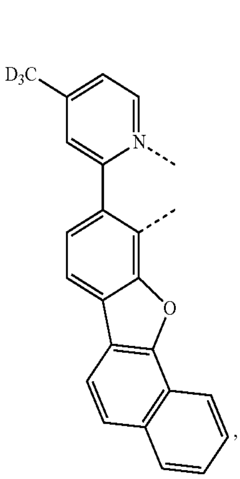


L_{A1079}



L_{A1080}



L_{A1081}

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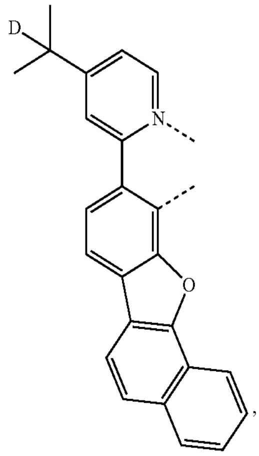
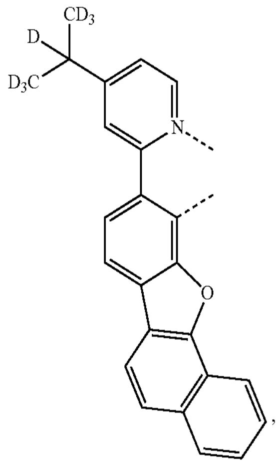
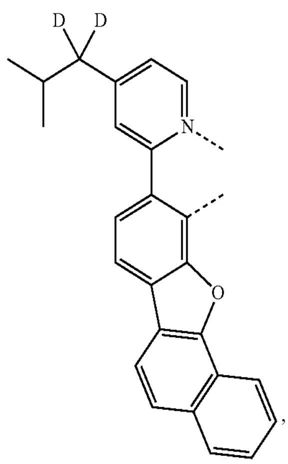


L_{A1082}



L_{A1083}



L_{A1084}

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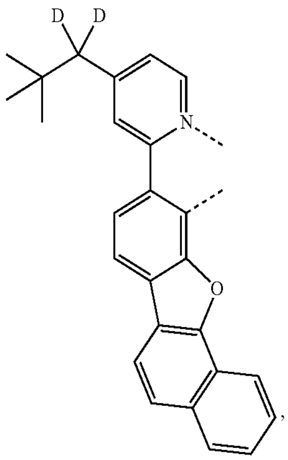
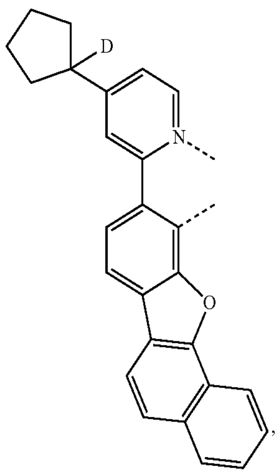
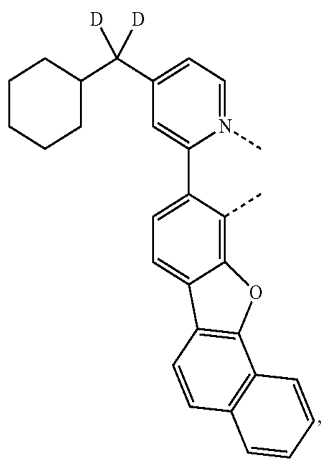


L_{A1085}



L_{A1086}



L_{A1087}

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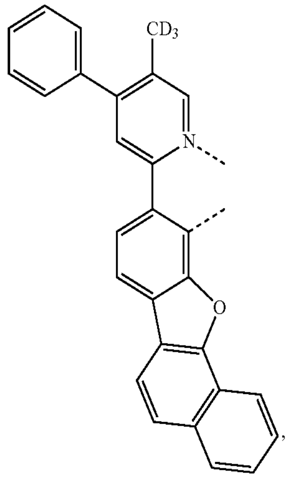
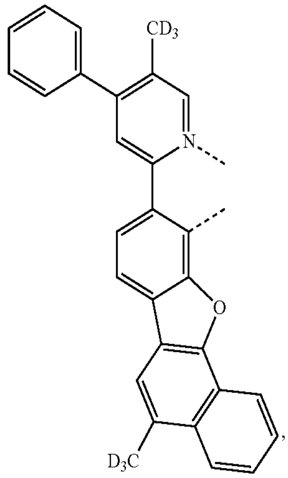
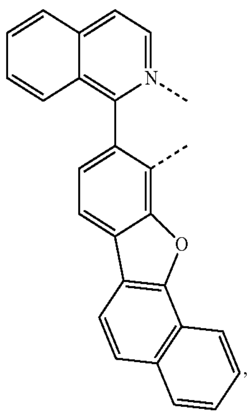


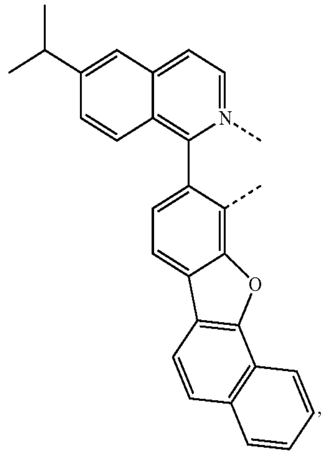
L_{A1088}



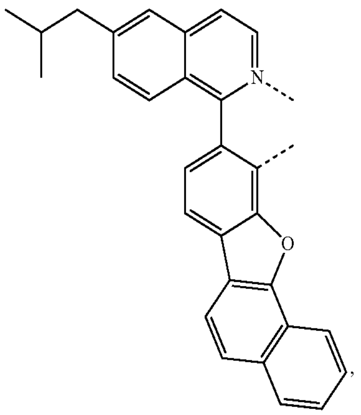
L_{A1089}



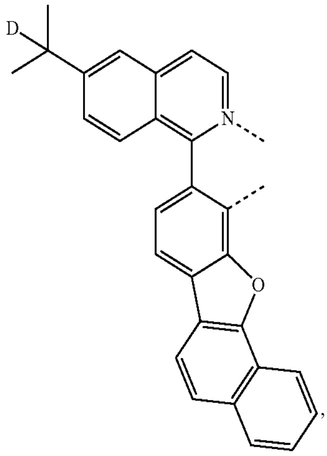
L_{A1094}



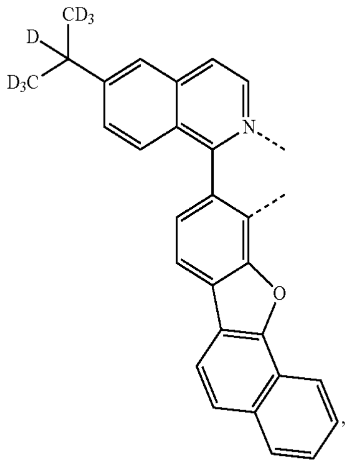
L_{A1095}



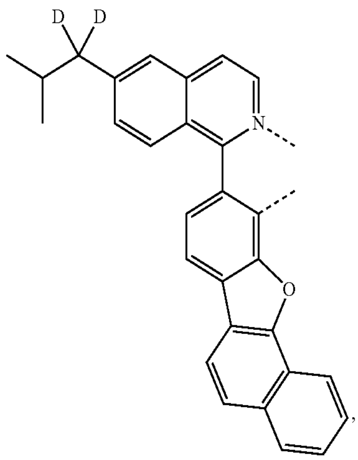
L_{A1096}



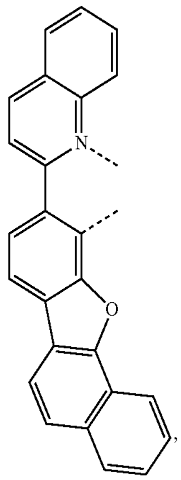
L_{A1097}



L_{A1098}

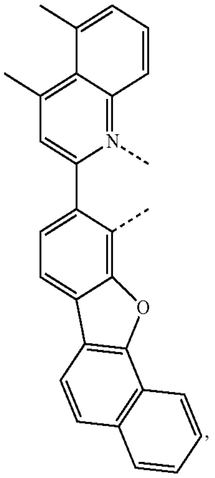


L_{A1099}

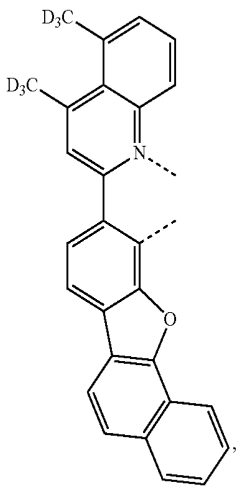


L_{A1102}

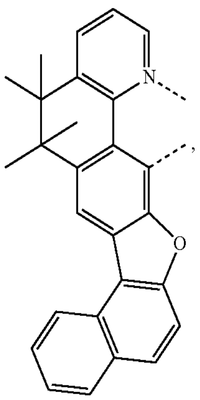
L_{A1103}



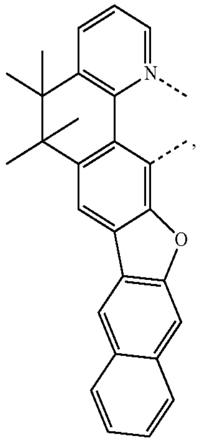
L_{A1104}



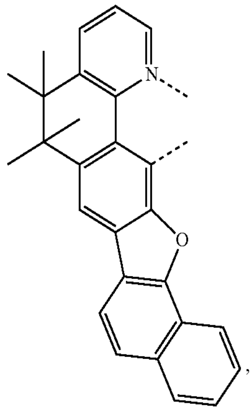
L_{A1117}



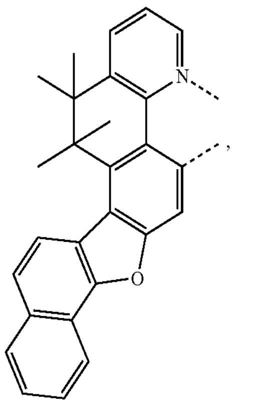
L_{A1118}



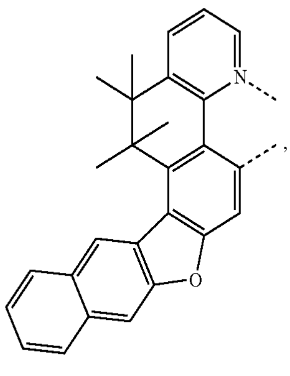
L_{A1119}



L_{A1120}



L_{A1121}



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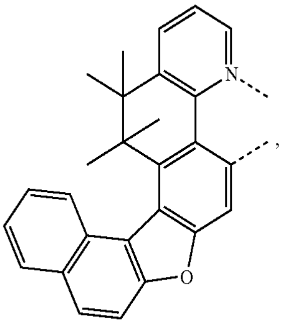
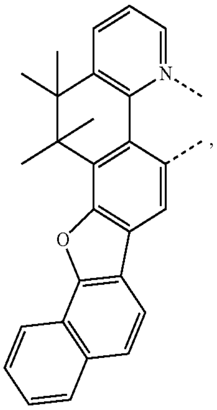
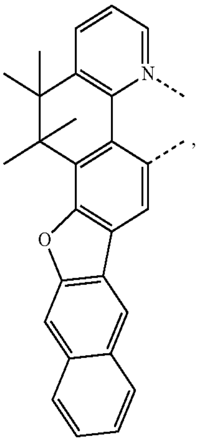
L_{A1122}



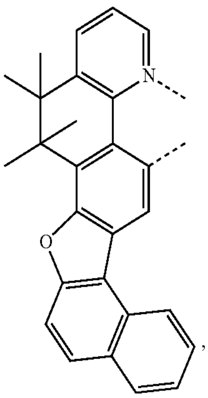
L_{A1123}



L_{A1124}



L_{A1125}



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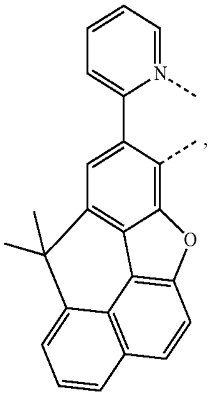
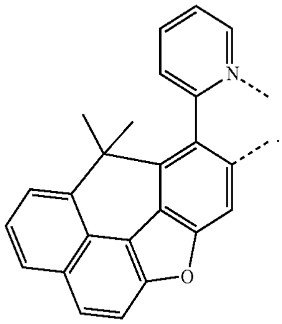
L_{A1126}



and

L_{A1127}

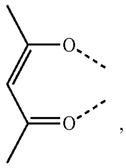


7. The compound of claim **6**, wherein the compound has the formula $Ir(L_{Ai})_2(L_{Ck})$;

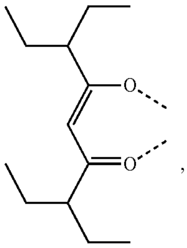
and

wherein L_{Ck} has the following formula:

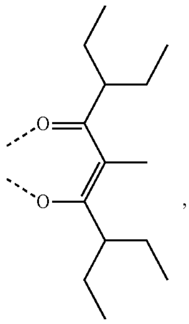
L_{C1}



L_{C2}



L_{C3}



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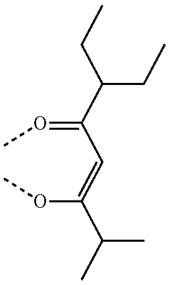
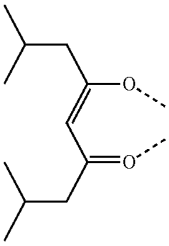
L_{C4}



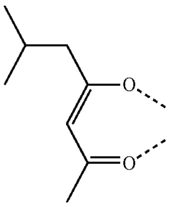
,

L_{C5}



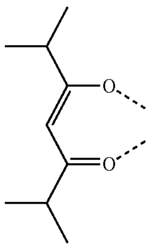
,

L_{C6}



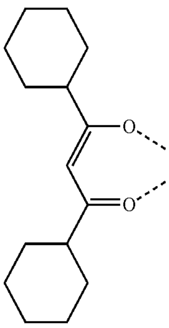
,

L_{C7}



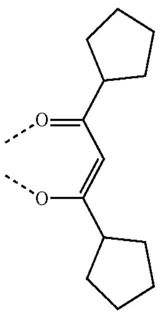
,

L_{C8}



,

L_{C9}



,

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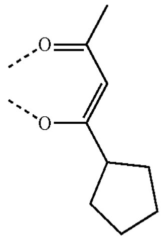
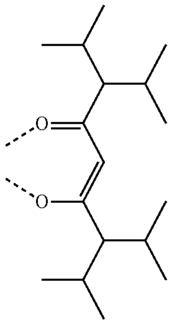
L_{C10}



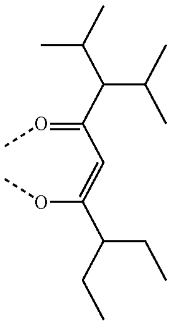
,

L_{C11}



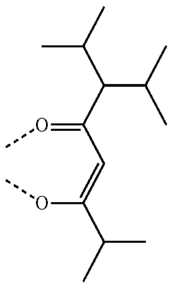
,

L_{C12}



, and

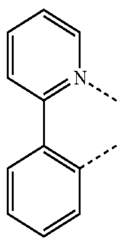
L_{C13}



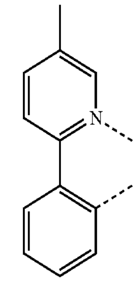
.

8. The compound of claim **6**, wherein the compound has the formula $Ir(L_{Ai})(L_{Bj})_2$; and wherein L_{Bi} has the following formula:

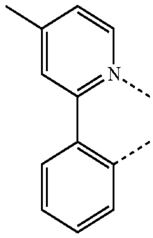
L_{B1}



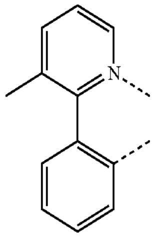
L_{B2}



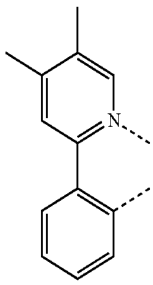
L_{B3}



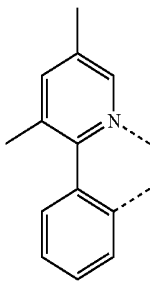
L_{B4}



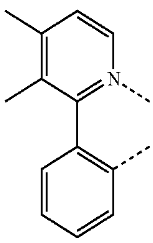
L_{B5}



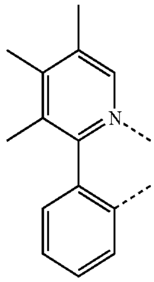
L_{B6}



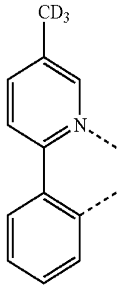
L_{B7}



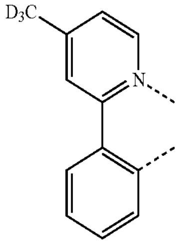
L_{B8}



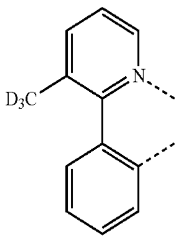
L_{B9}



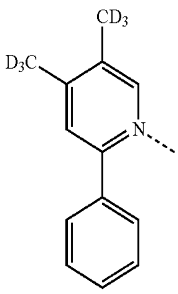
L_{B10}



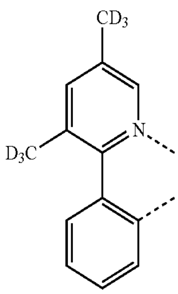
L_{B11}



L_{B12}



L_{B13}



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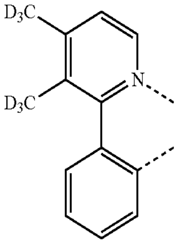
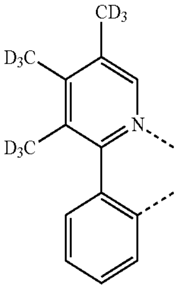
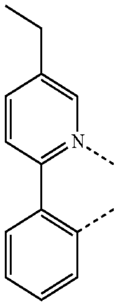
L$_{B14}$



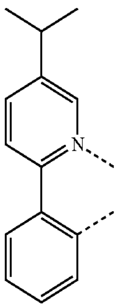
L$_{B15}$



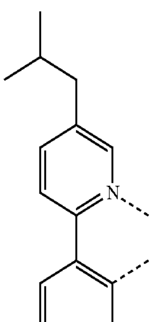
L$_{B16}$



L$_{B17}$



L$_{B18}$



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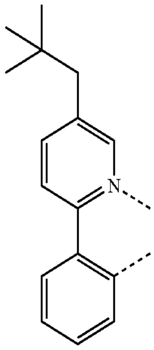
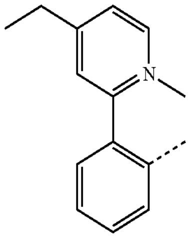
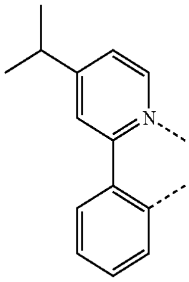
L$_{B19}$



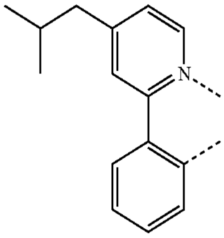
L$_{B20}$



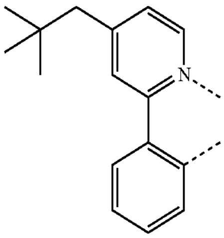
L$_{B21}$



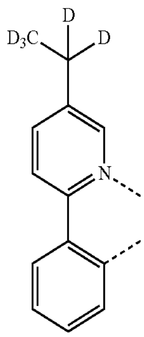
L$_{B22}$



L$_{B23}$



L$_{B24}$



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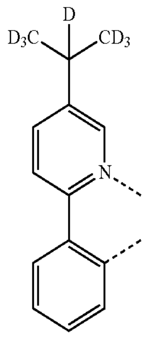
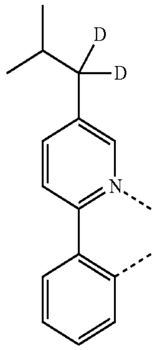
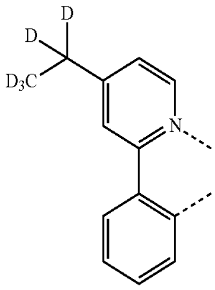


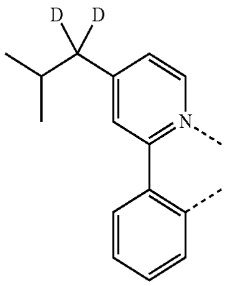
L_{B25}



L_{B26}



L_{B27}



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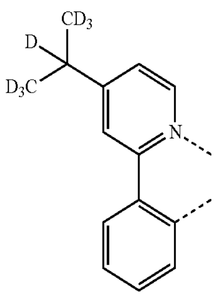

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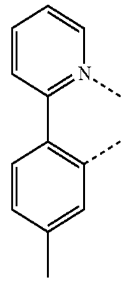

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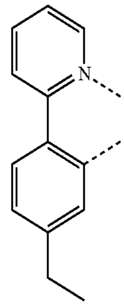

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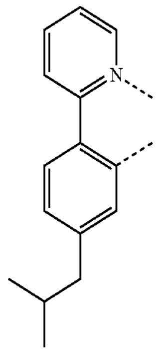

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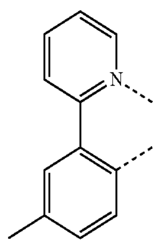

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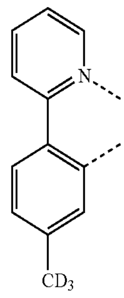

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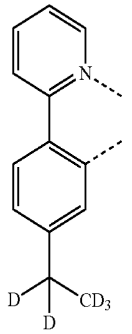

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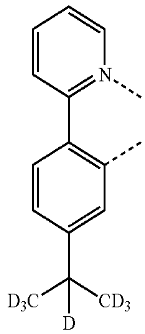

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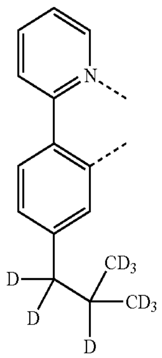

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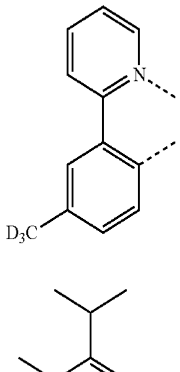

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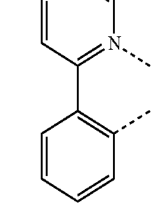

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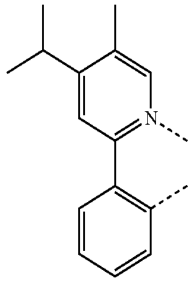

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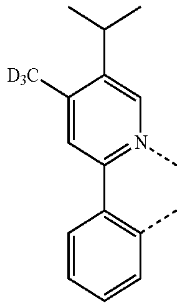

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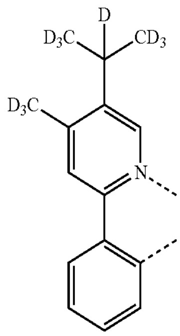

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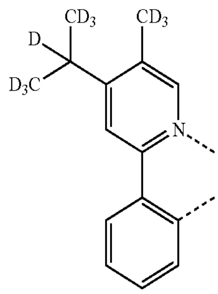

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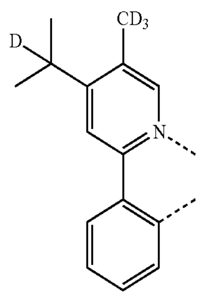

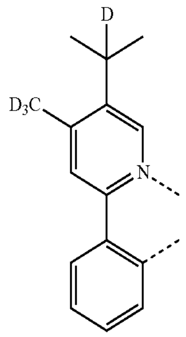

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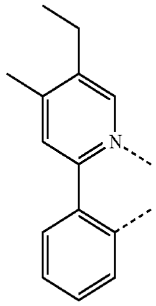

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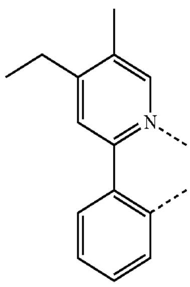

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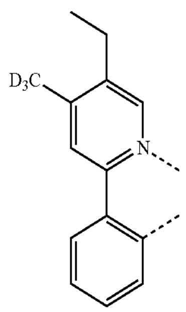

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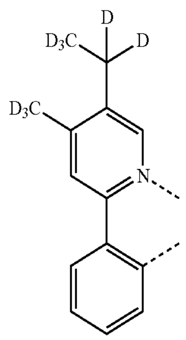

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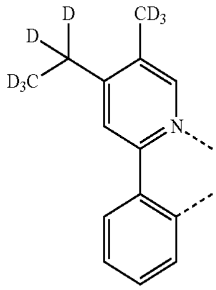

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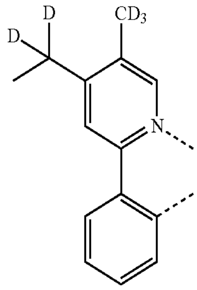

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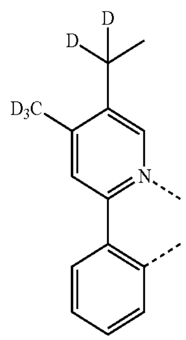

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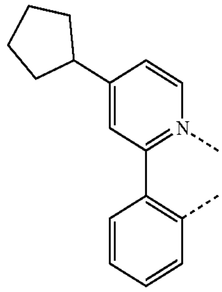

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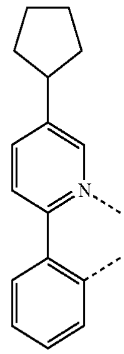

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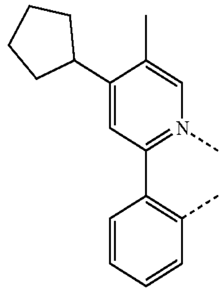

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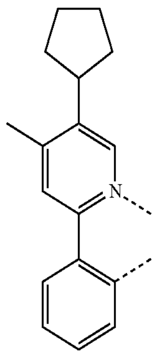

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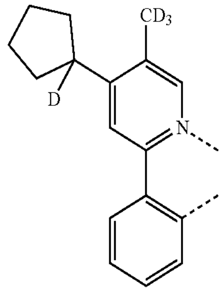

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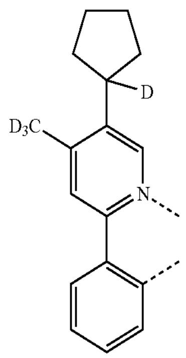

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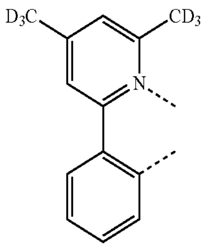

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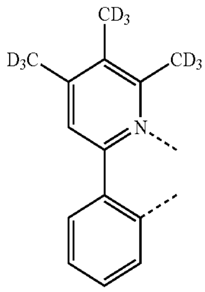

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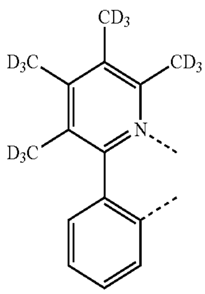

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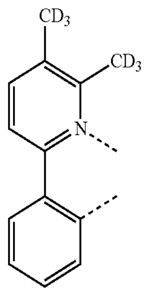

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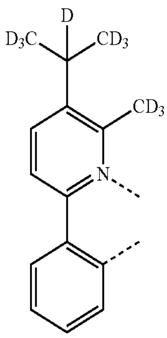

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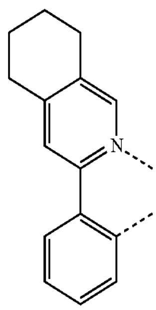

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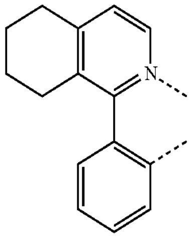

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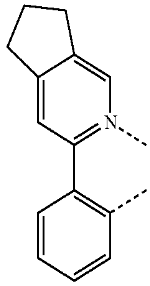

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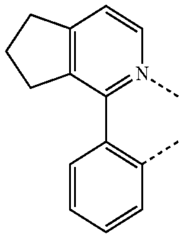

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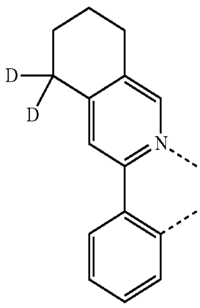

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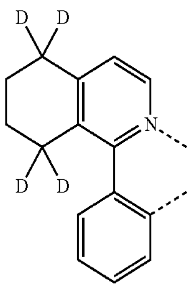

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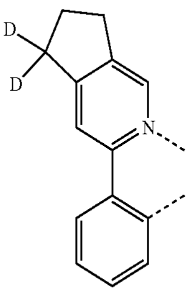

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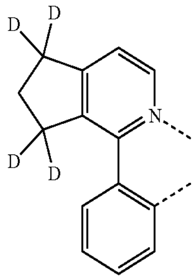

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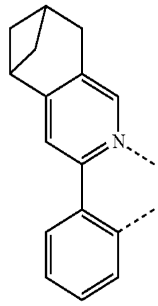

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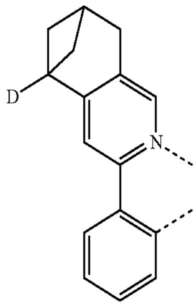

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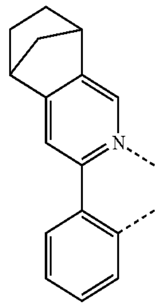

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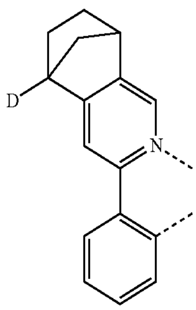

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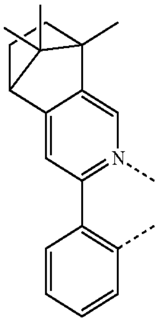
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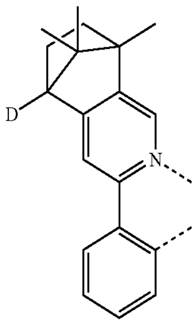
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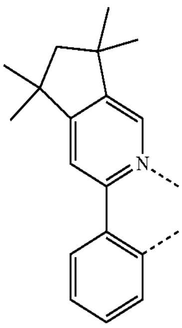
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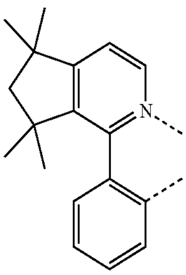
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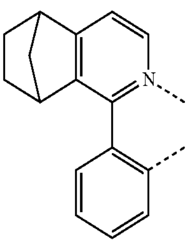
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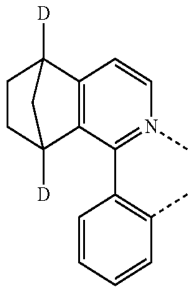
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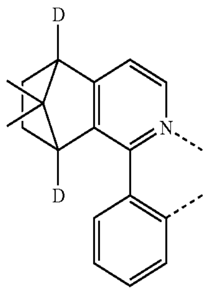
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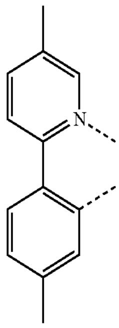
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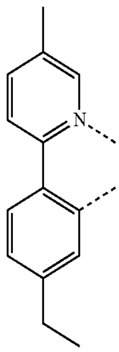
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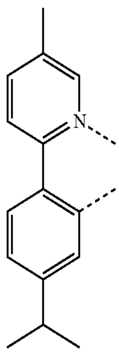
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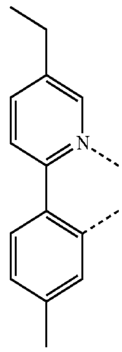

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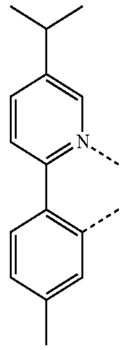

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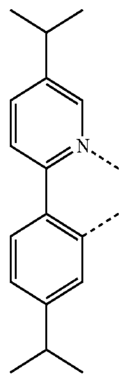

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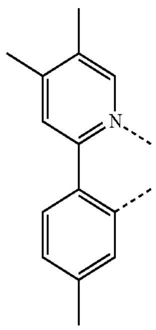

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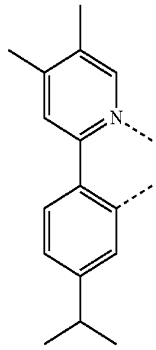

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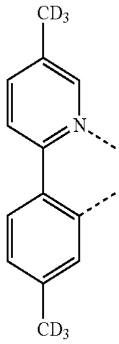

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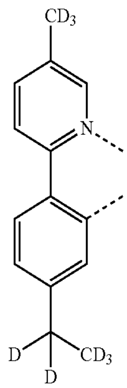

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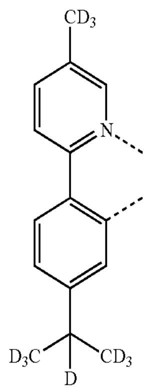

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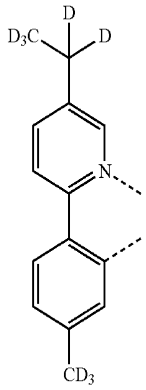

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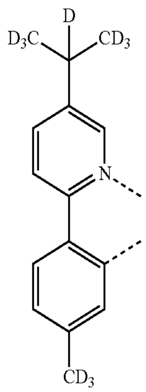

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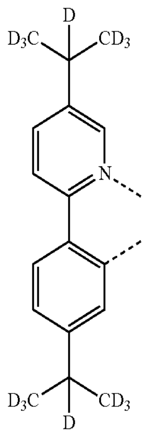

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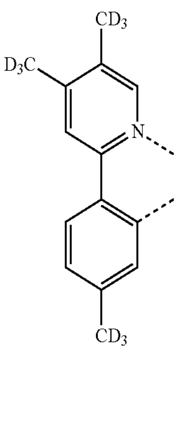

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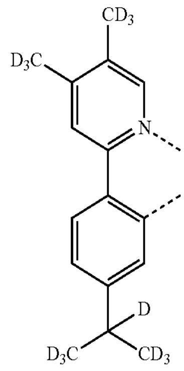

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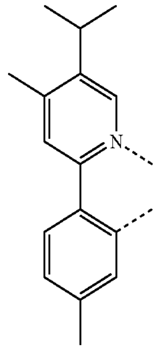

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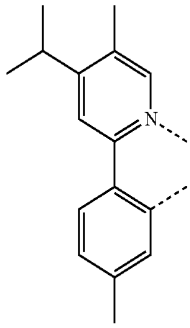

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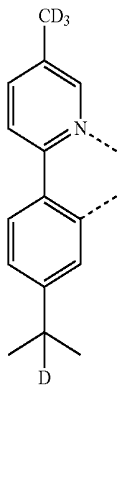

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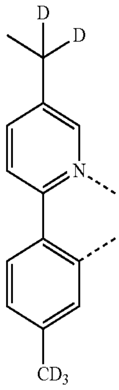

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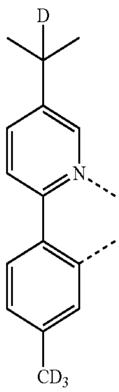

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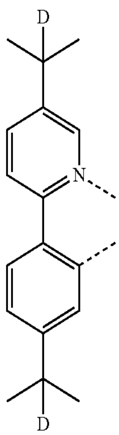

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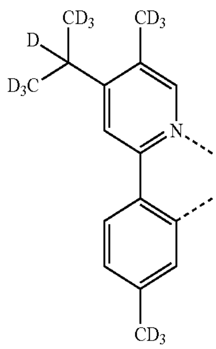

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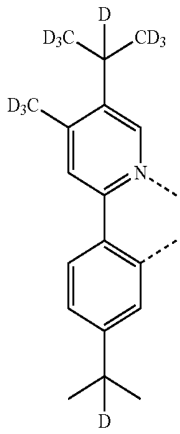

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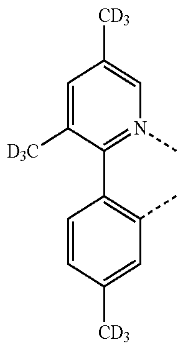

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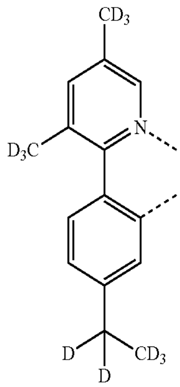

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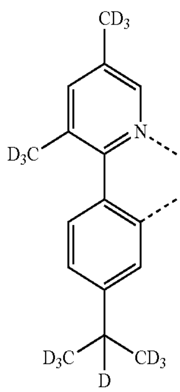

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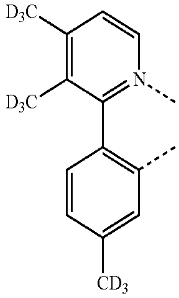

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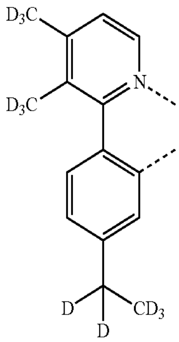

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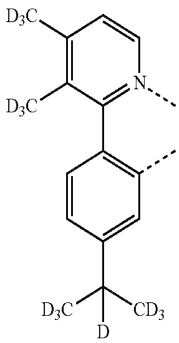

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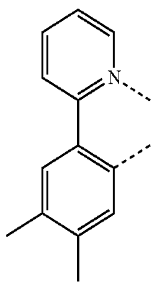

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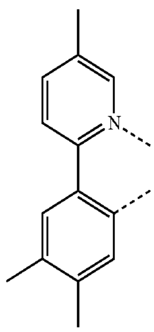

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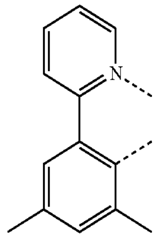

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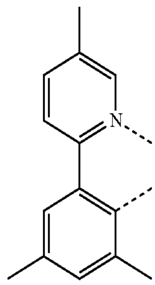

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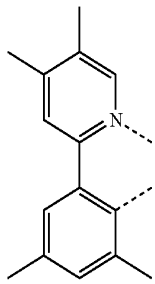

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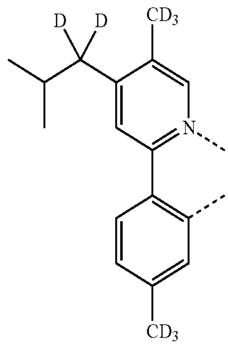

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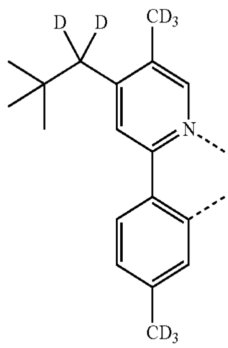

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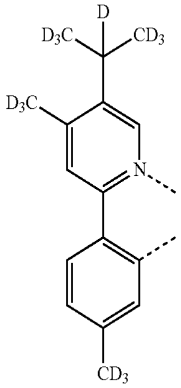

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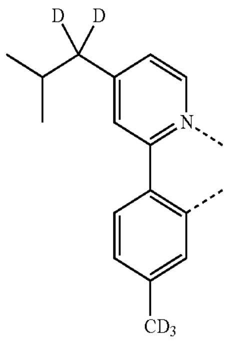

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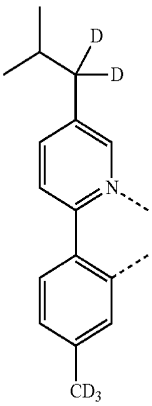

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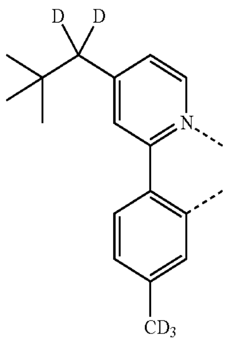

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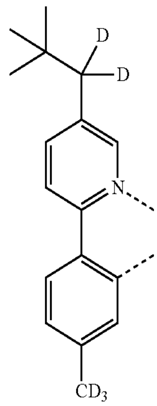

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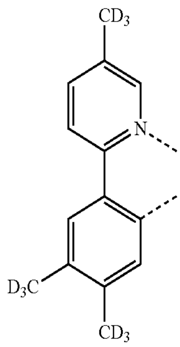

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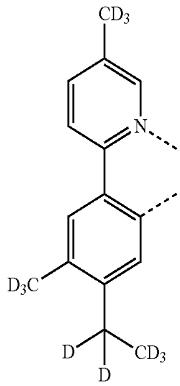

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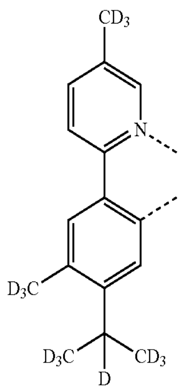

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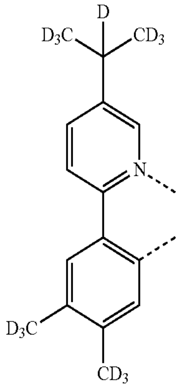

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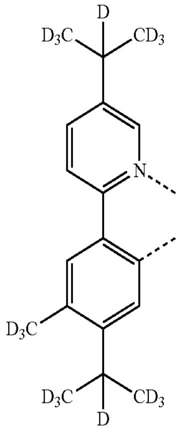

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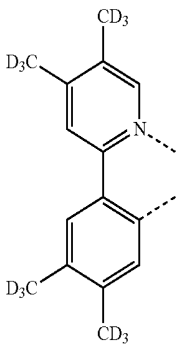

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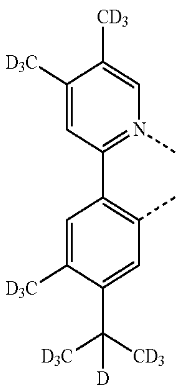

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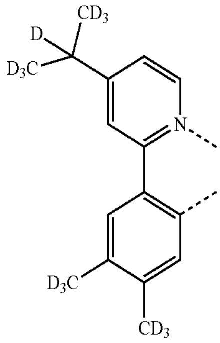

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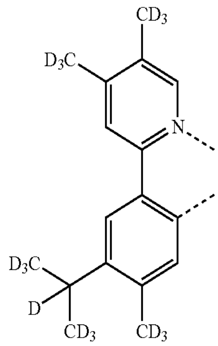

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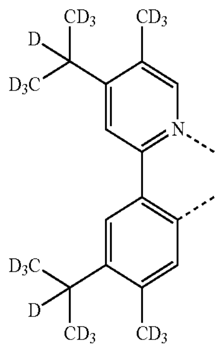

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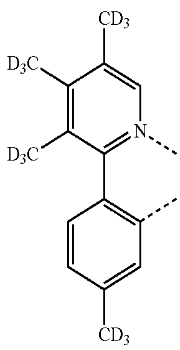

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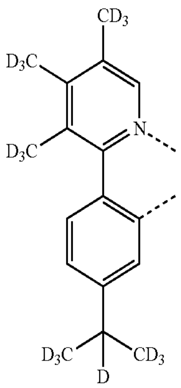

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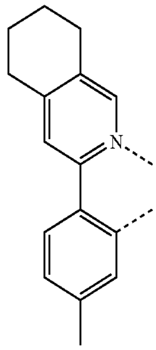

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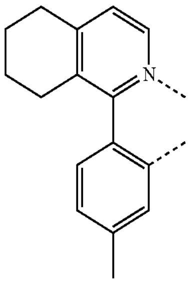

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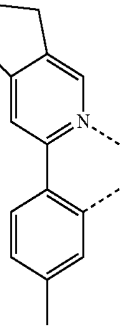

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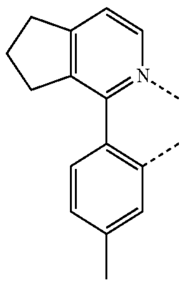

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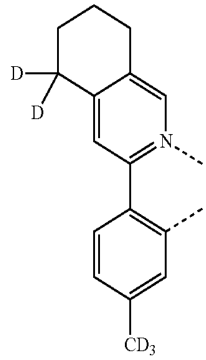

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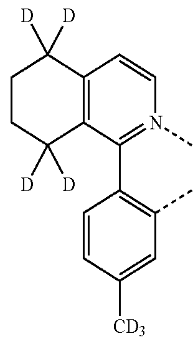

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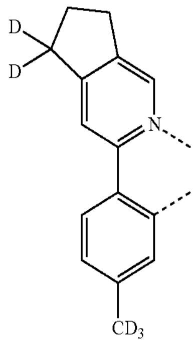

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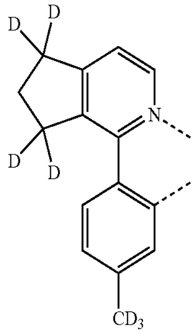

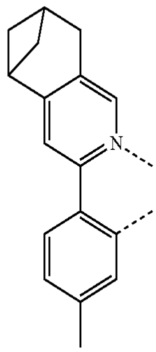
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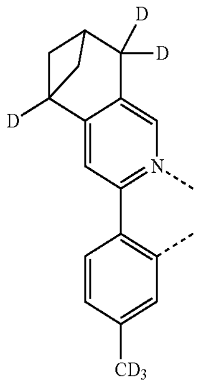
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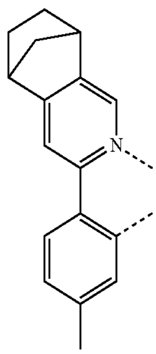
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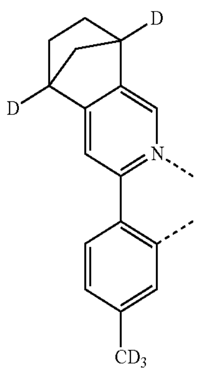
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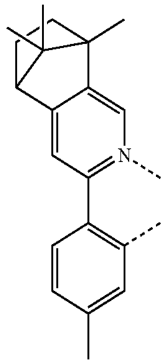
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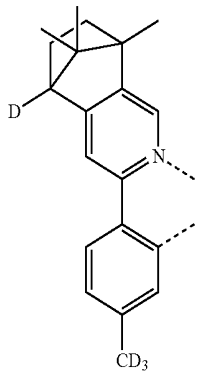
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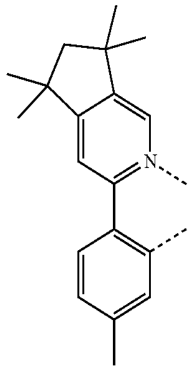
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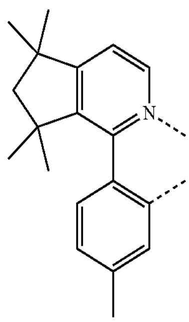
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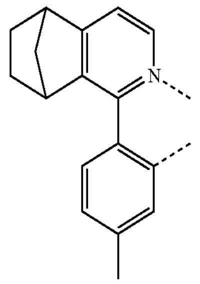

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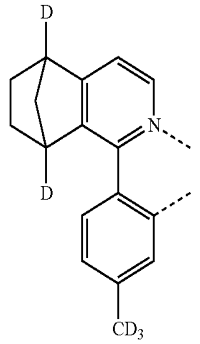

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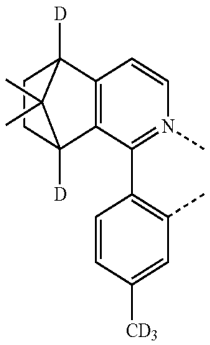

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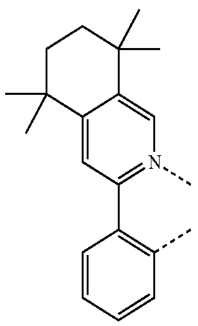

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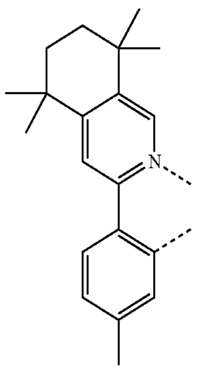

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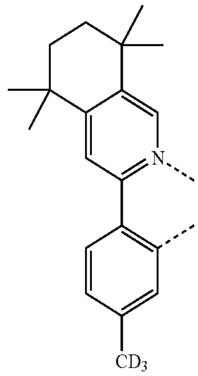

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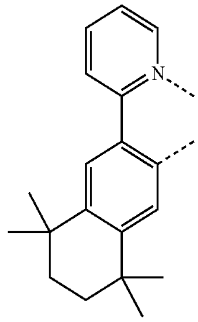

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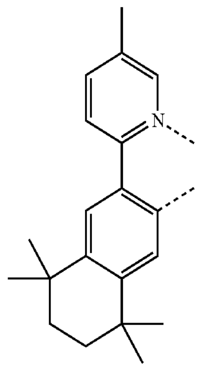

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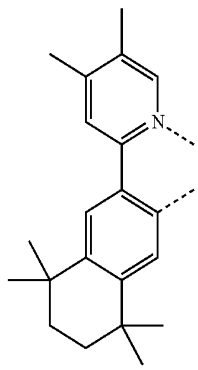

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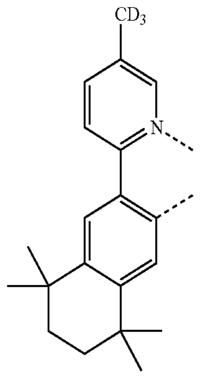

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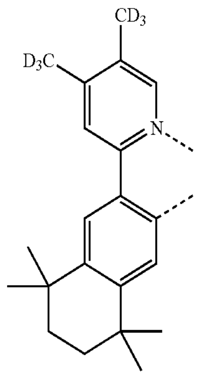

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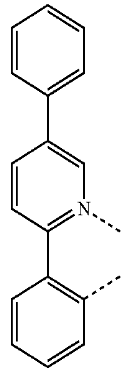

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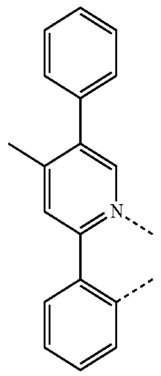

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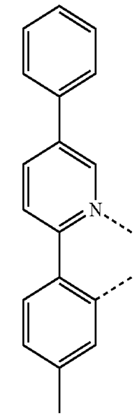

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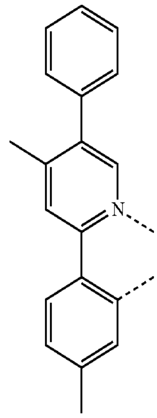

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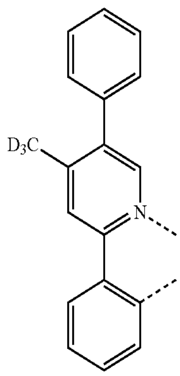

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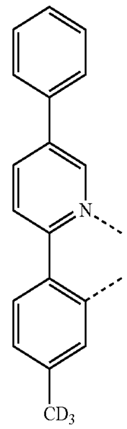

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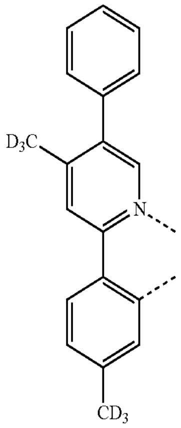

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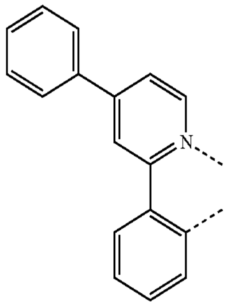

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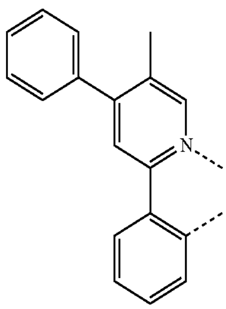

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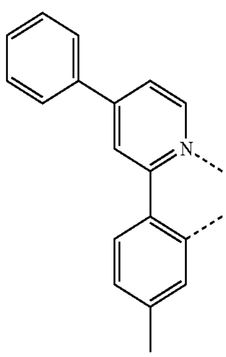

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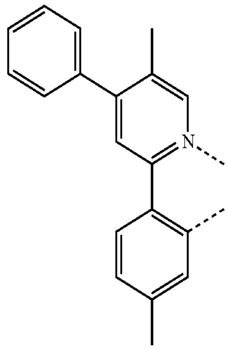

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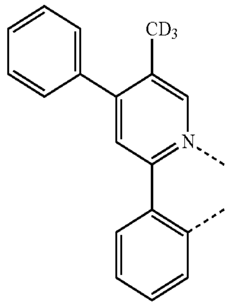

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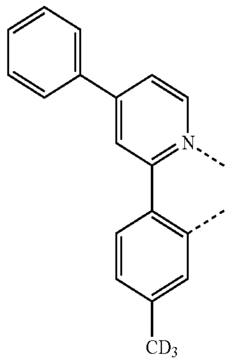

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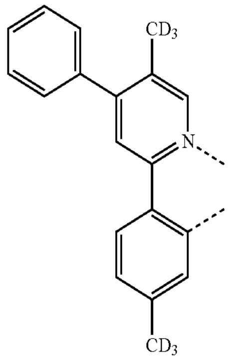

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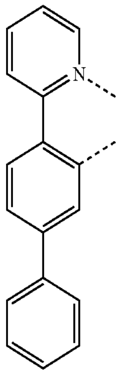

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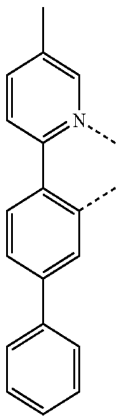

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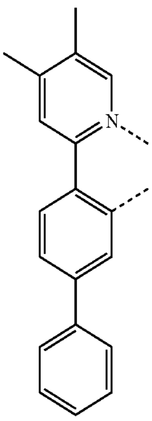

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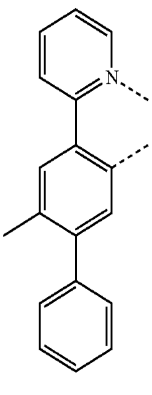

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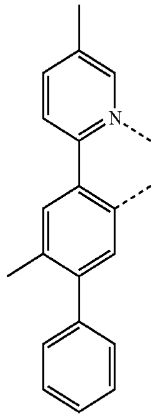

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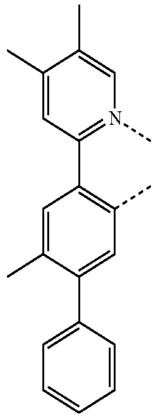

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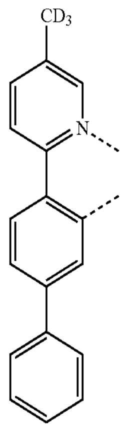

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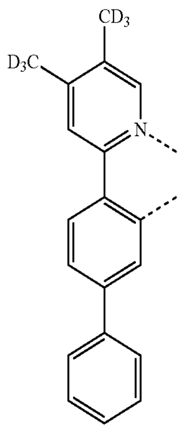

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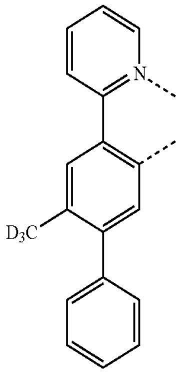

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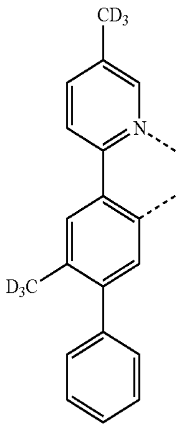

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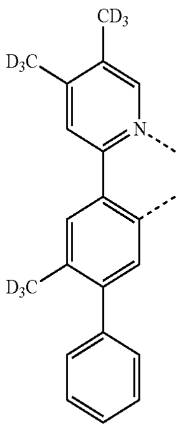

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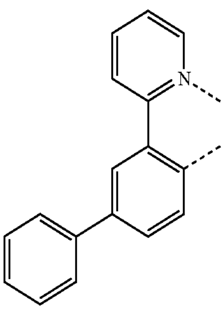

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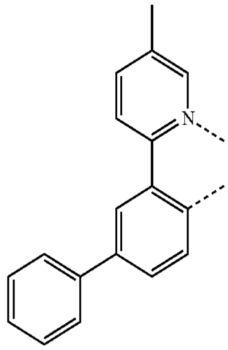

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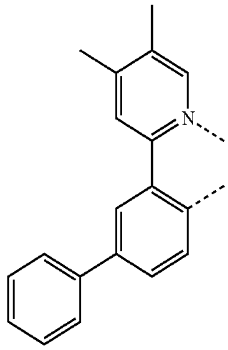

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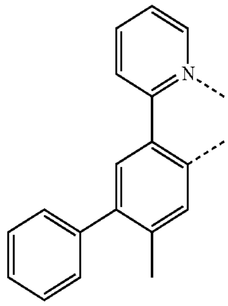

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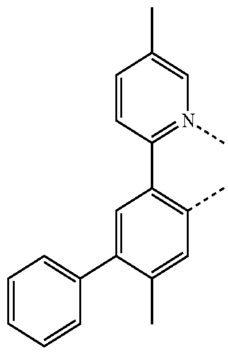

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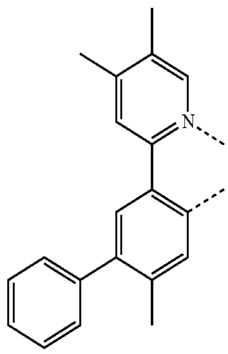

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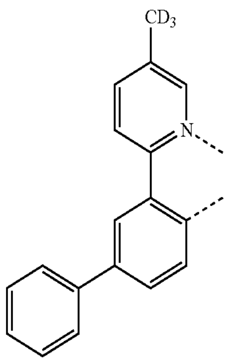

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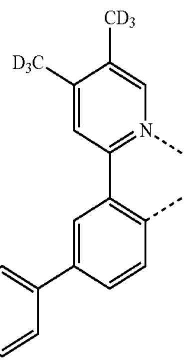

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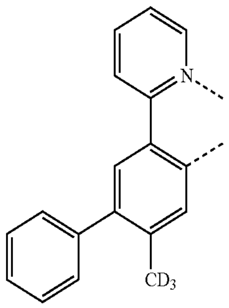

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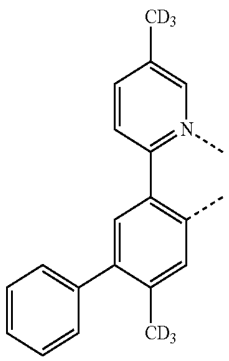

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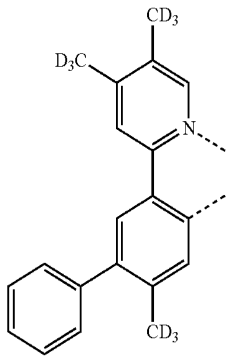

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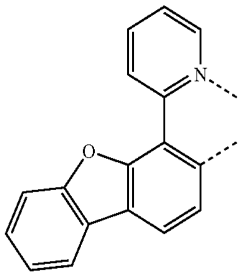

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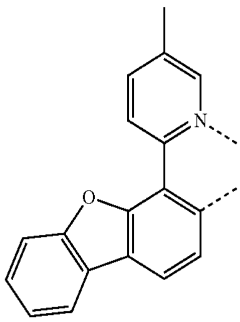

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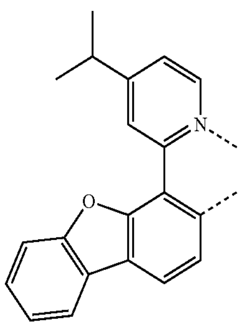

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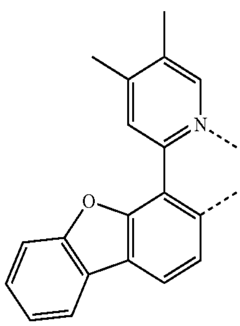

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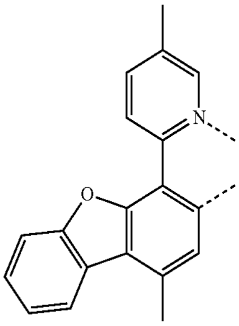

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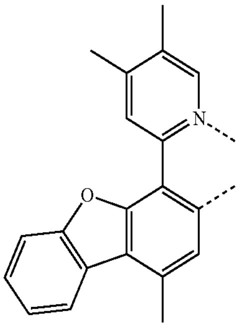

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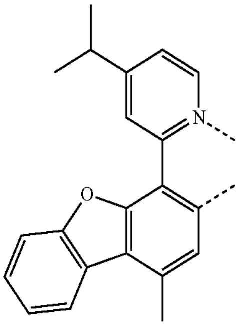

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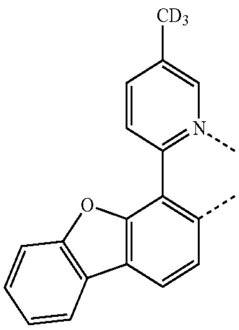

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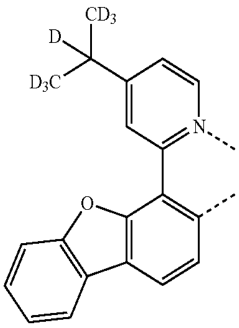

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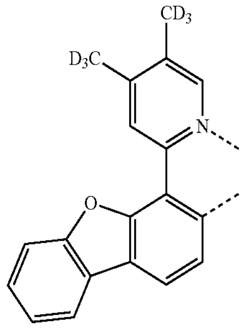

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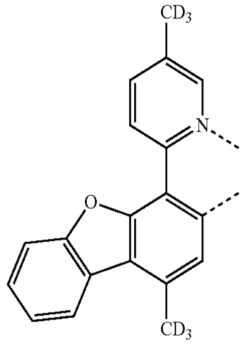

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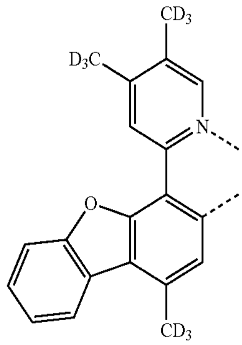

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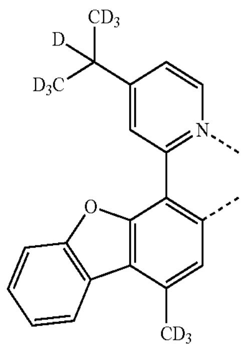

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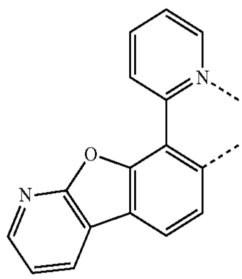

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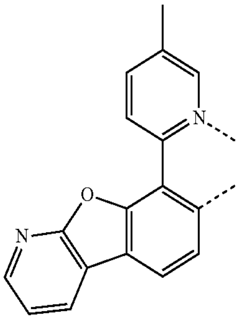

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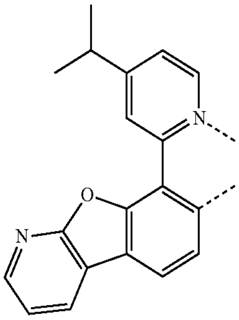

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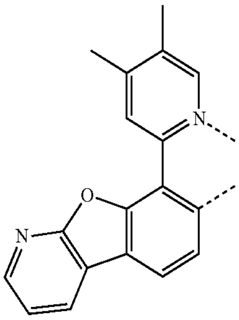

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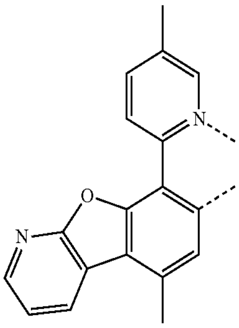

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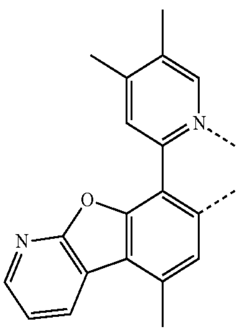

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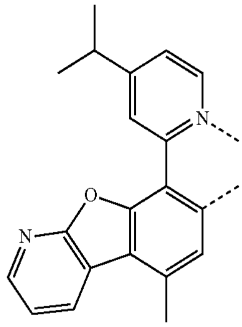

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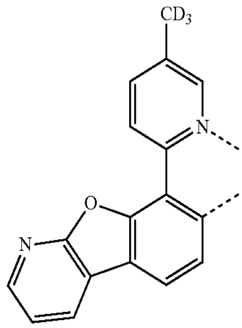

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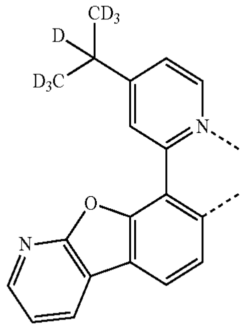

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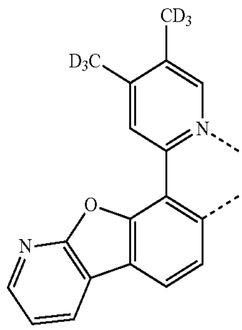

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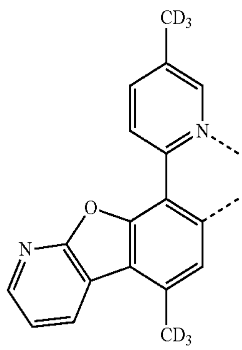

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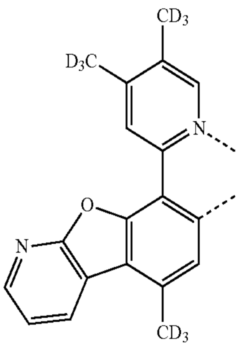

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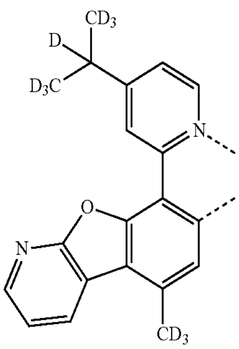

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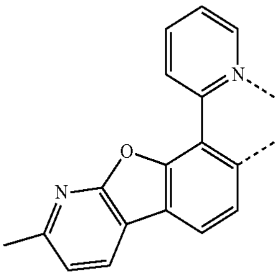

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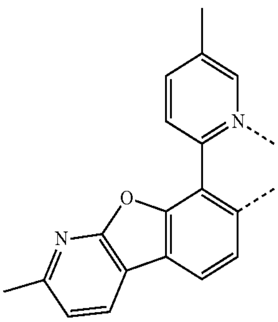

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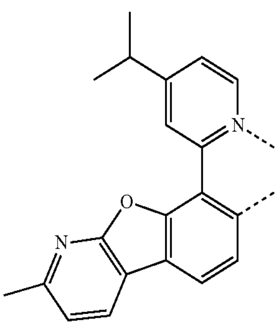

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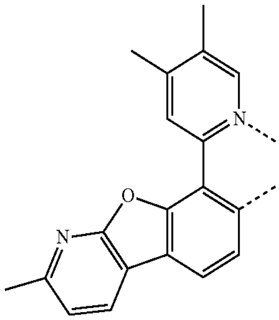

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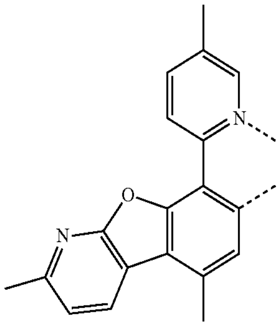

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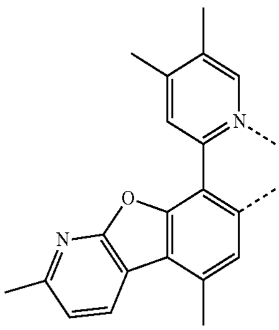

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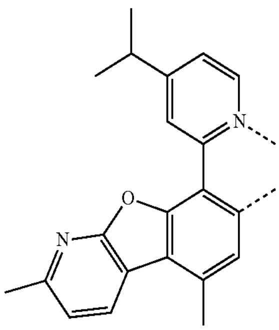

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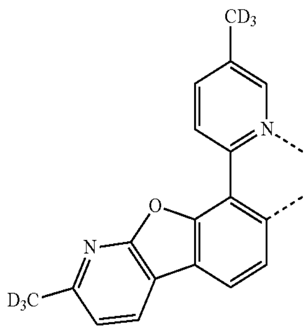

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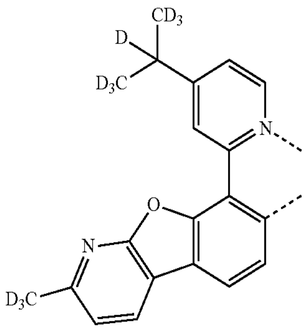

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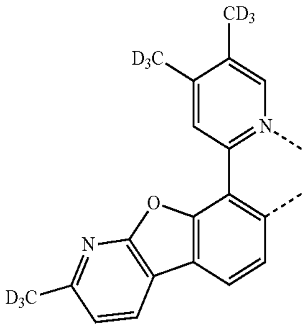

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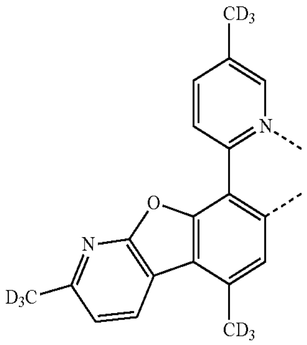

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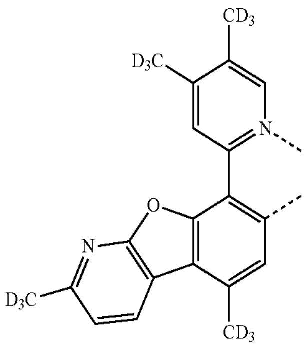

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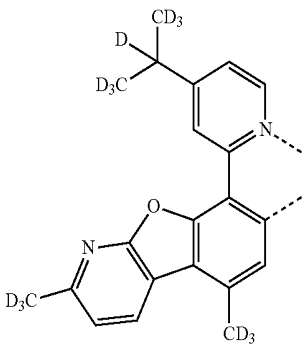

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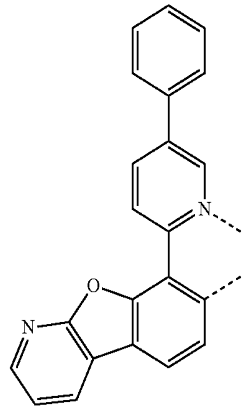

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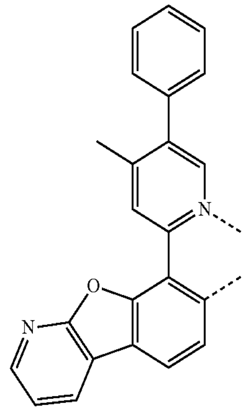

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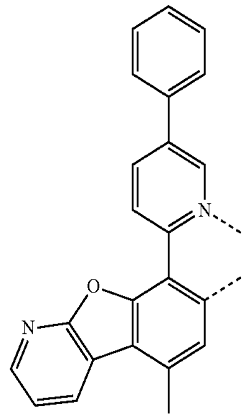

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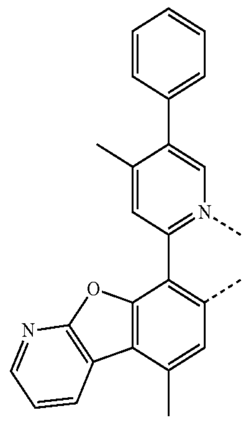

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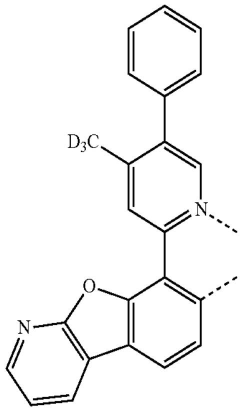

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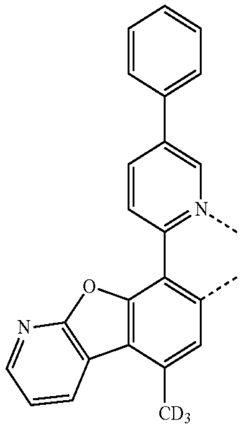
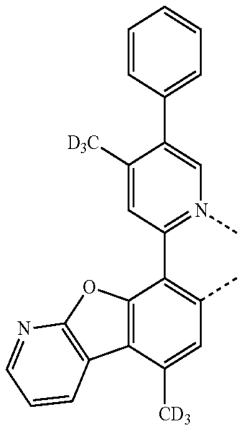
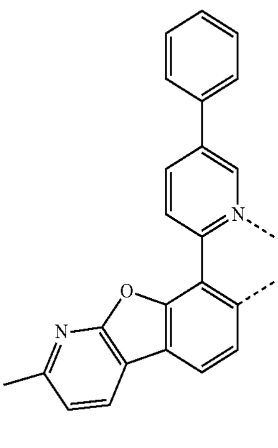


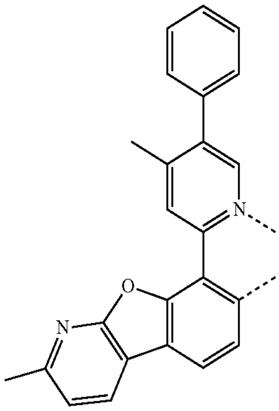
L$_{B245}$



L$_{B246}$



L$_{B247}$



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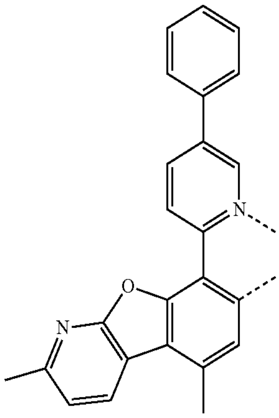

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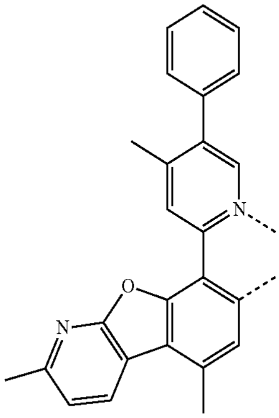
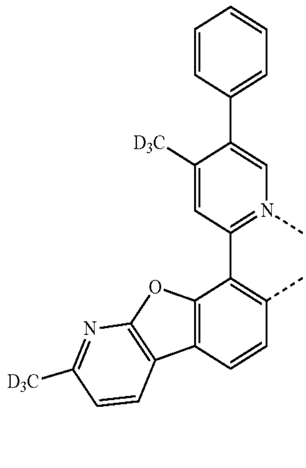


L$_{B250}$



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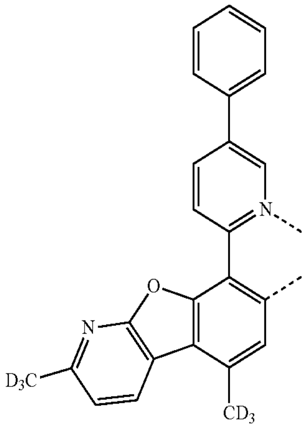
L_{B251}



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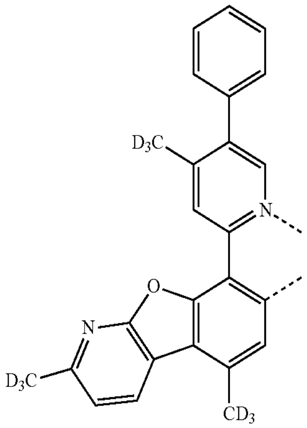

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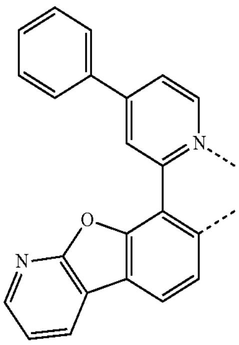

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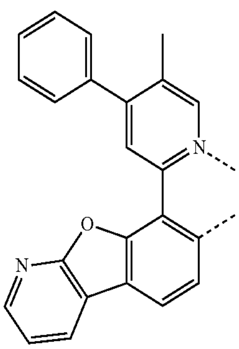

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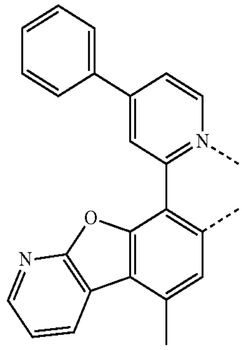
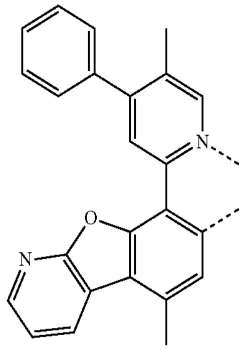
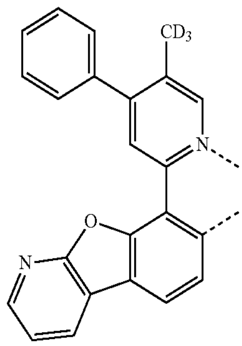
L_{B255}



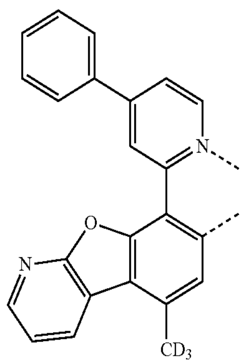
L_{B256}



L_{B257}



L_{B258}



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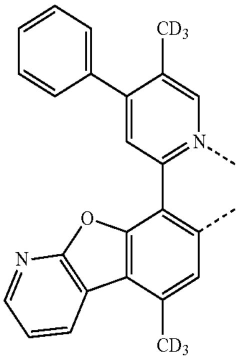
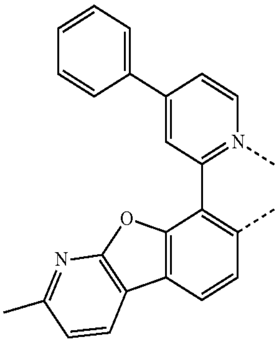
L_{B259}



L_{B260}



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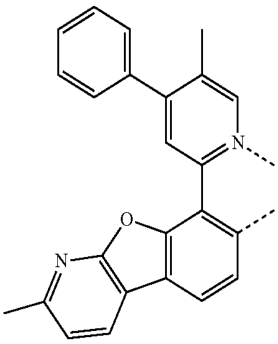
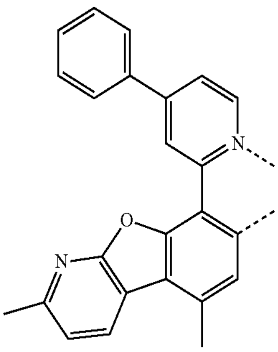


L_{B262}



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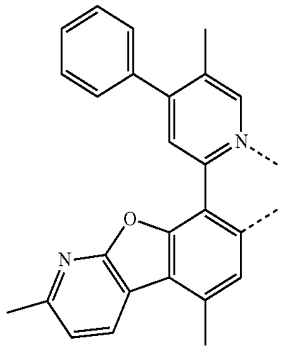
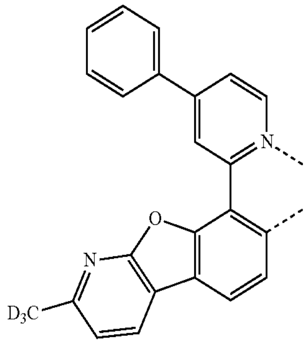
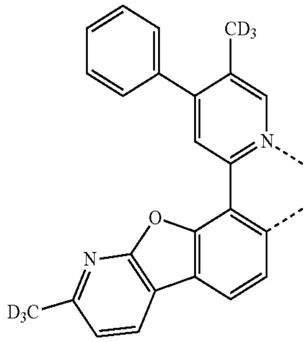
L_{B263}



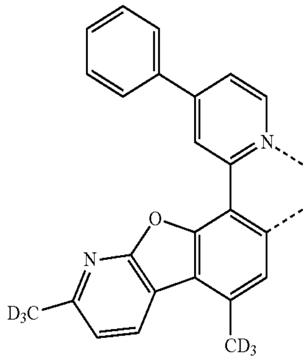
L_{B264}



L_{B265}



L_{B266}



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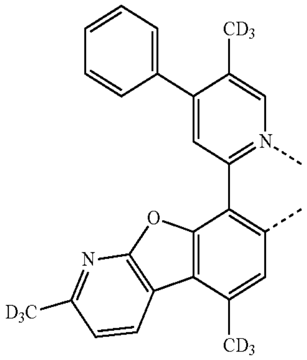
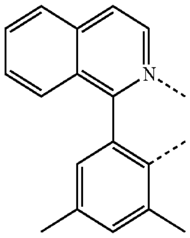
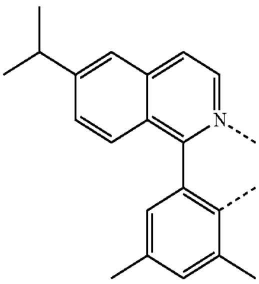
L_{B267}



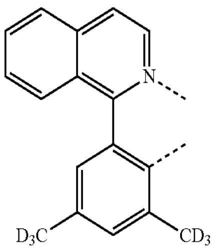
L_{B268}



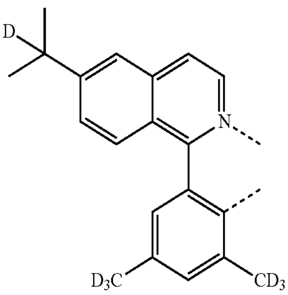
L_{B269}



L_{B270}



L_{B271}



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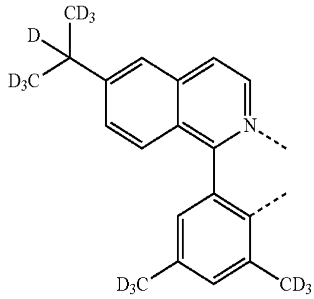
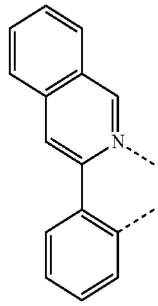
L_{B272}



L_{B273}



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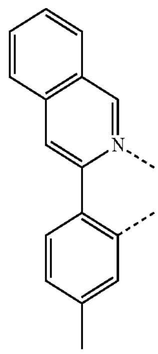
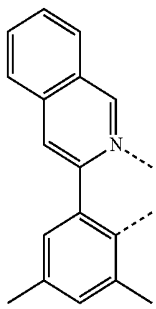
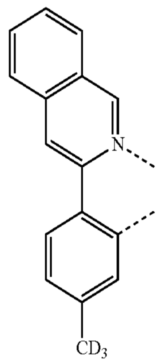


L_{B275}



L_{B276}



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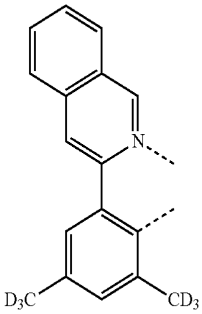
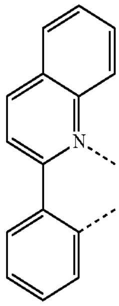
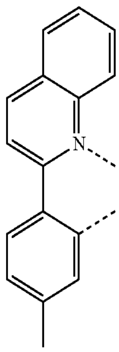


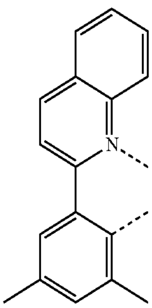
L_{B277}



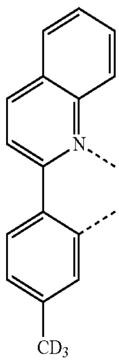
L_{B278}



L_{B279}



L_{B280}



L_{B281}

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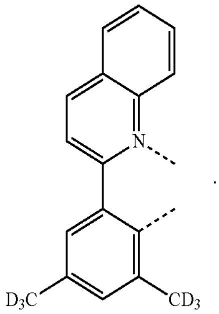
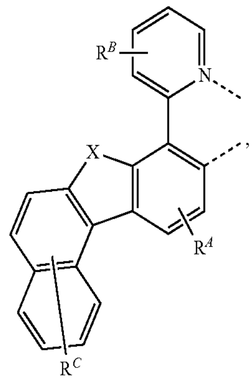
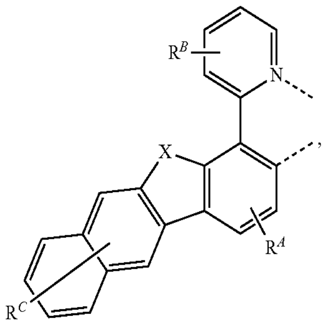
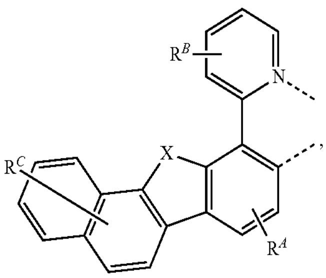


L_{B282}

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







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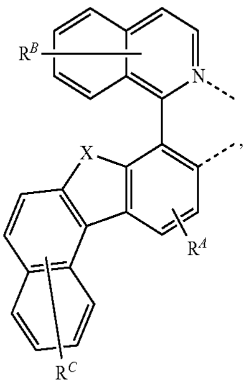

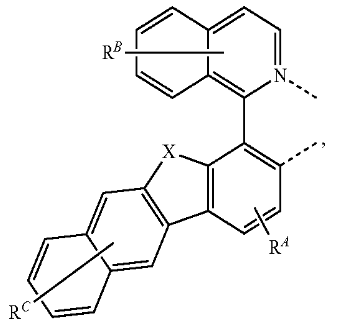

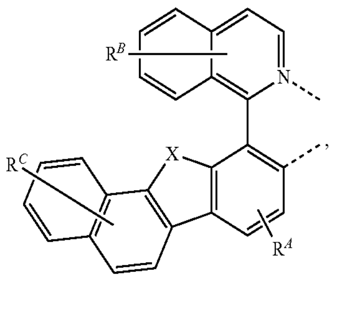

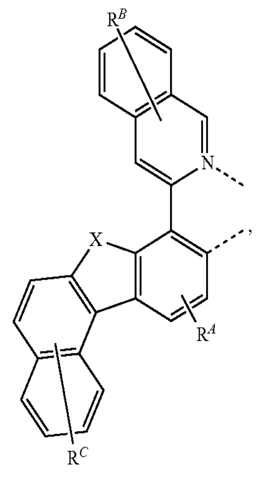

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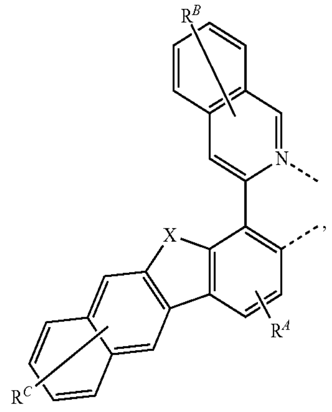

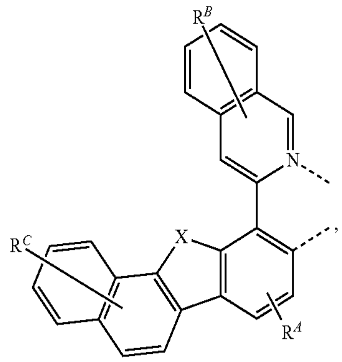

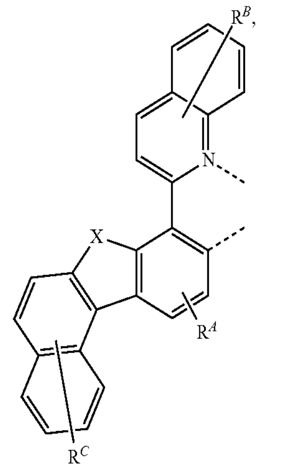

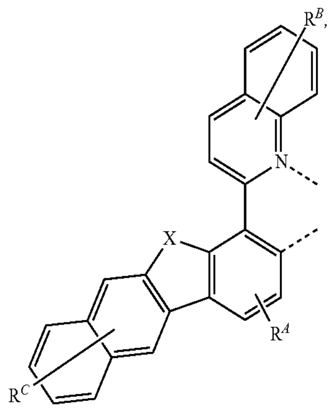

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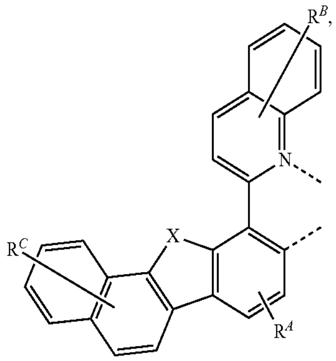

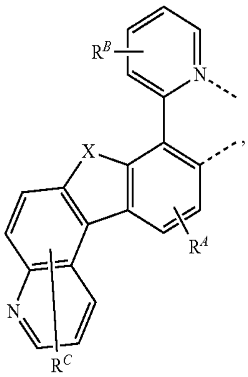

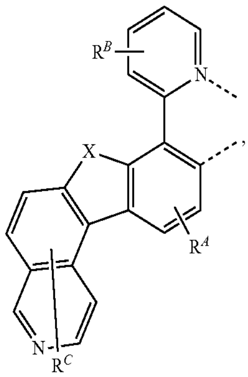

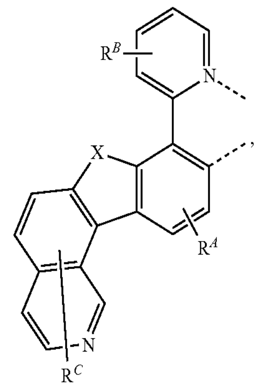

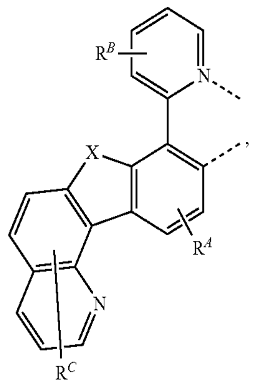

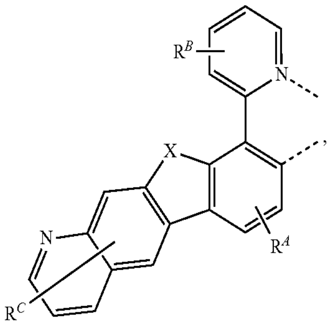

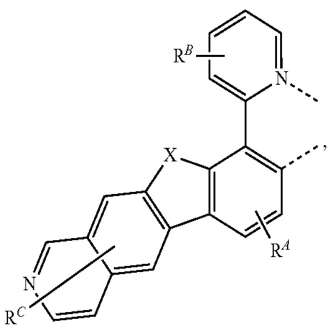

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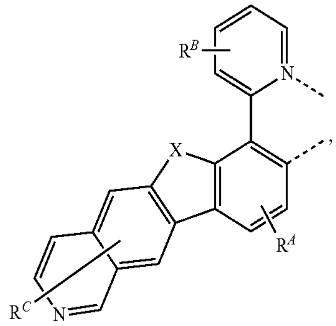
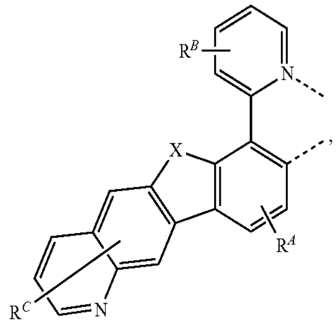
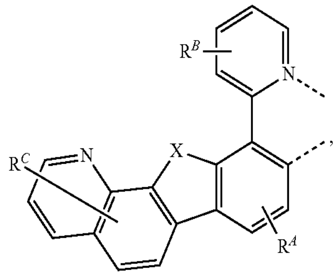
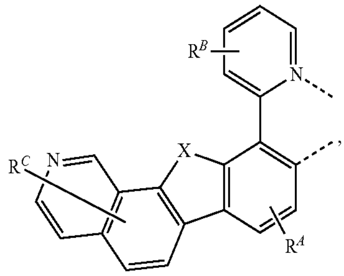
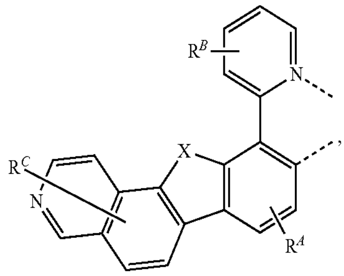
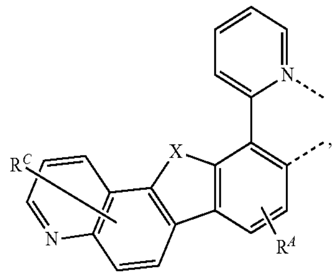










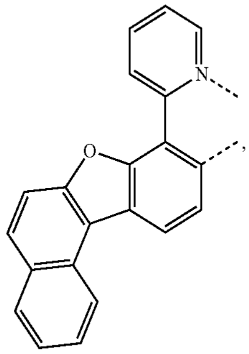


and

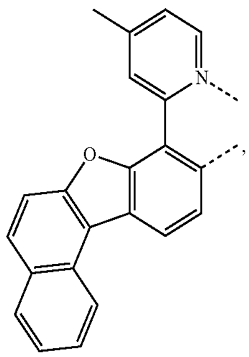
wherein R^A and R^C have the same definition as R^B.

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

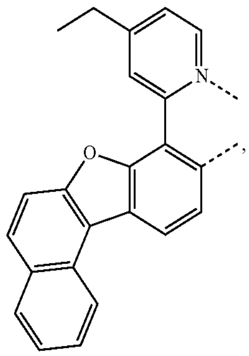
L_{A1}



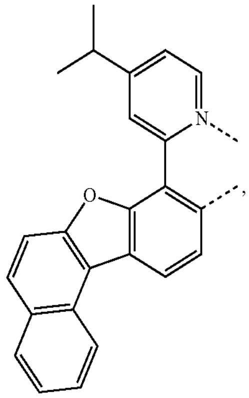
L_{A2}



L_{A3}



L_{A4}



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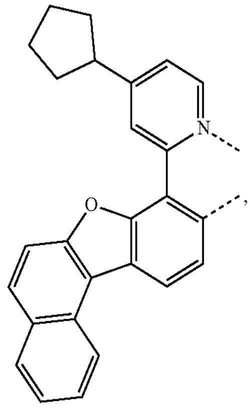
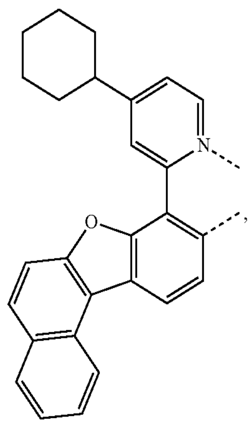
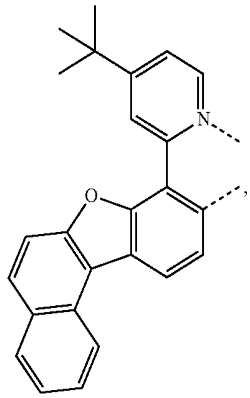
L_{A5}



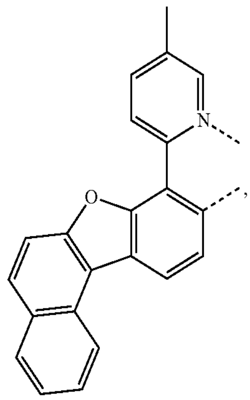
L_{A6}



L_{A7}



L_{A8}



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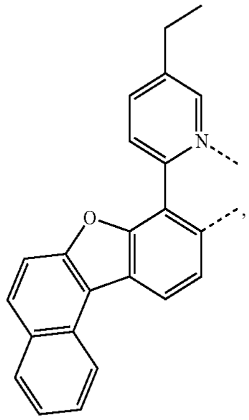
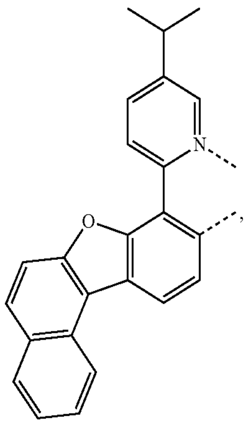
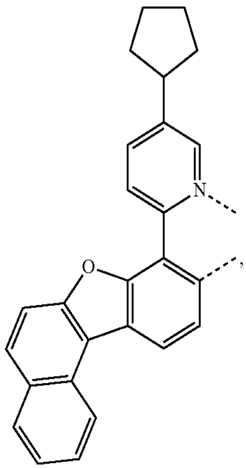
L_{A9}



L_{A10}



L_{A11}



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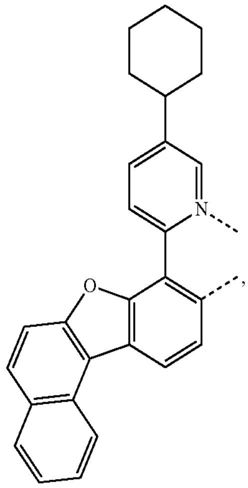

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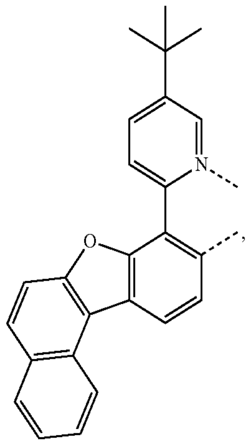

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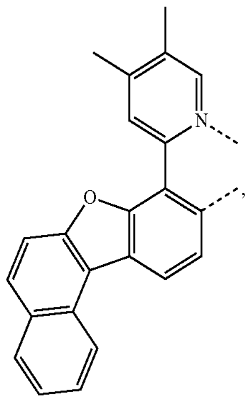

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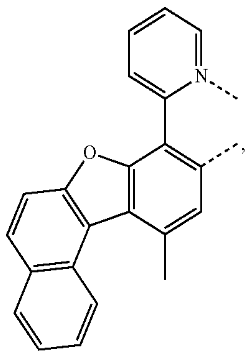

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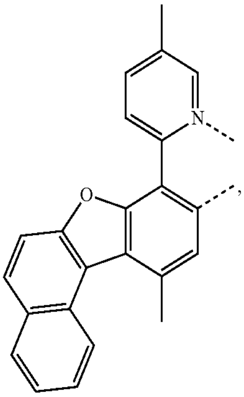

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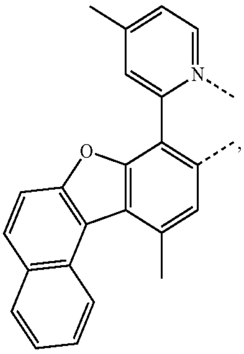

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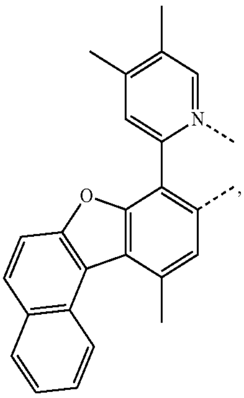

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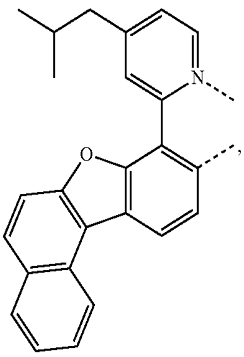

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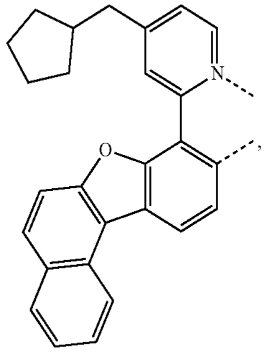

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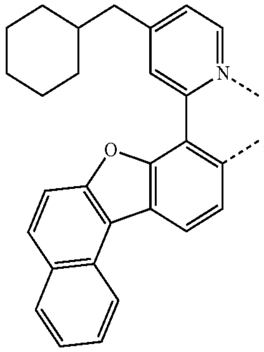

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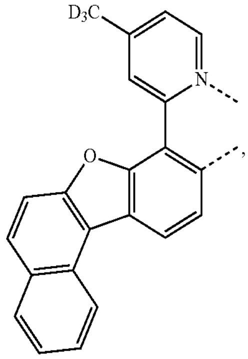

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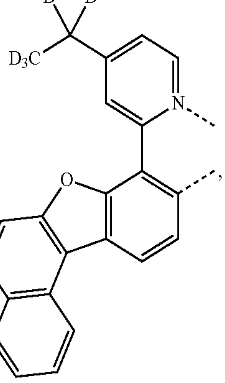

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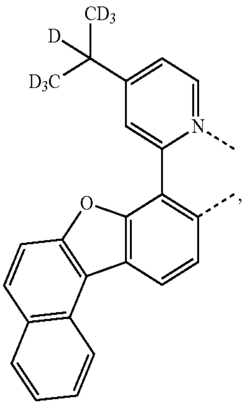

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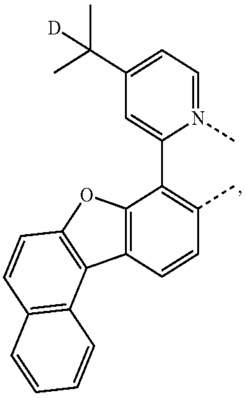

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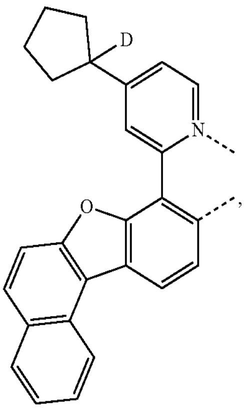

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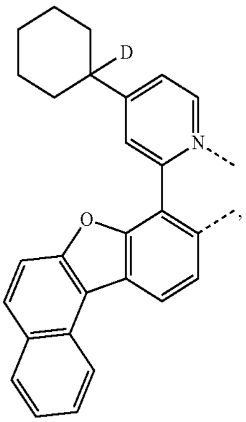

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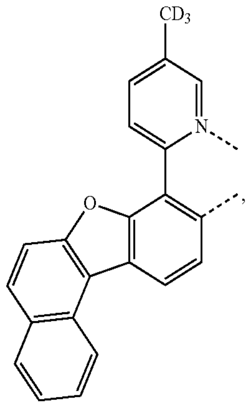

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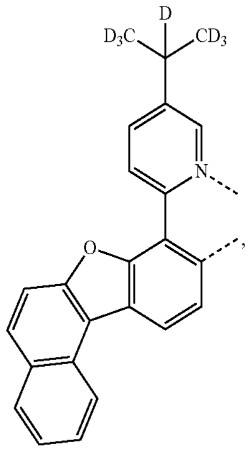

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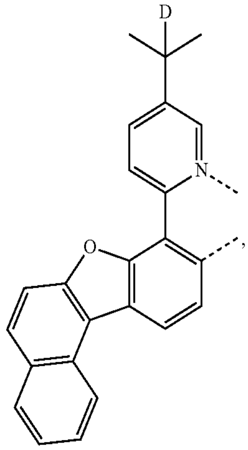

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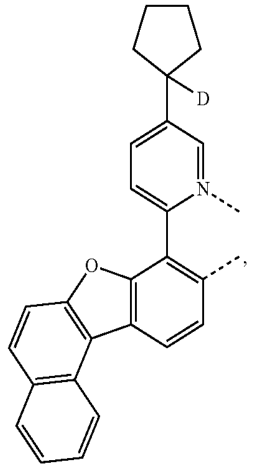

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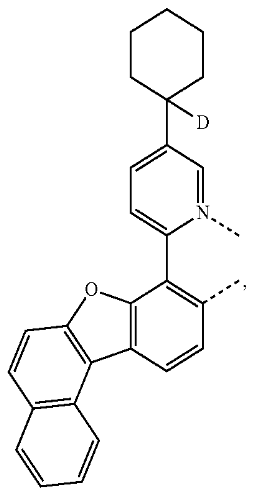

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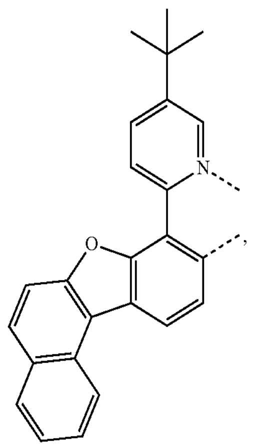

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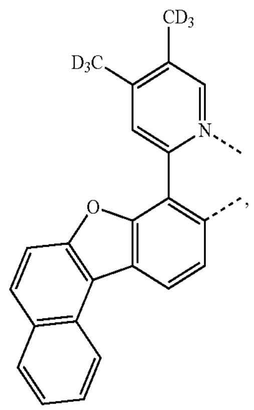

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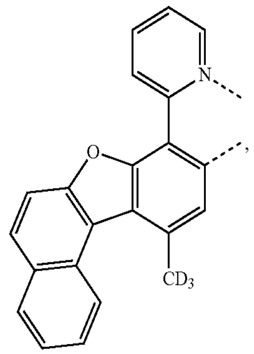

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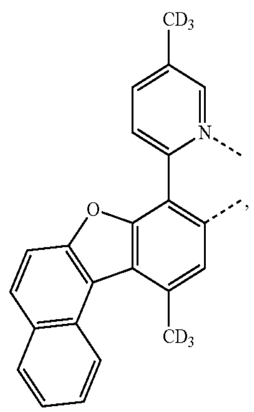

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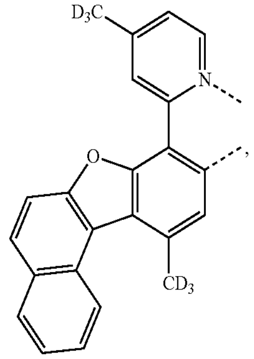

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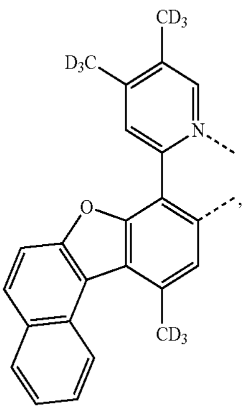

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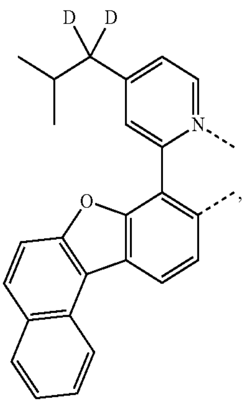

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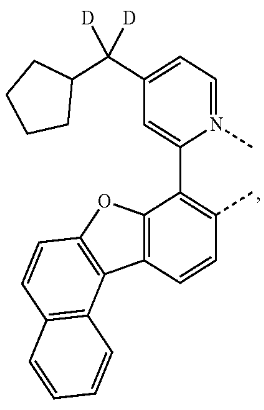

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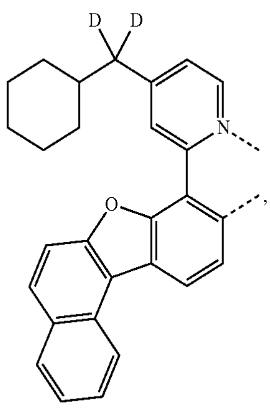

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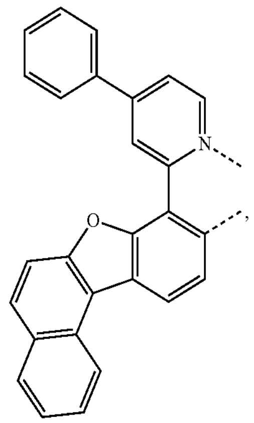

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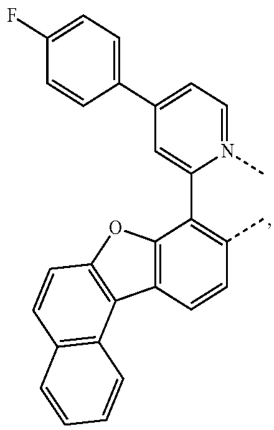

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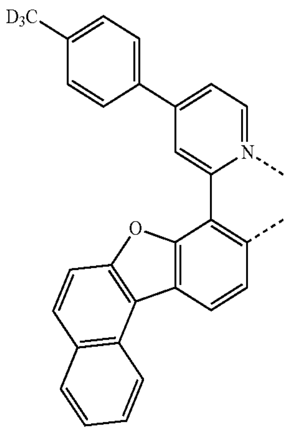

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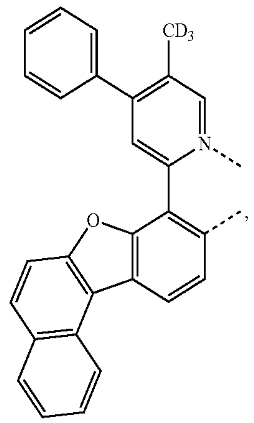

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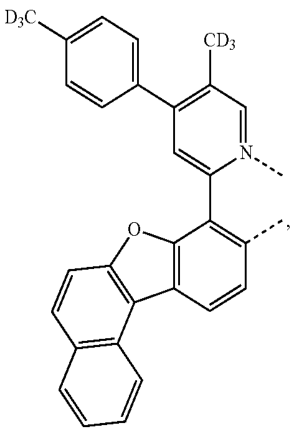

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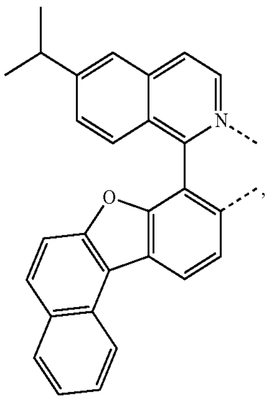

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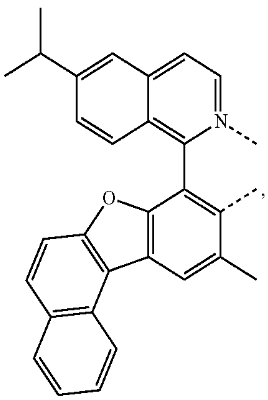

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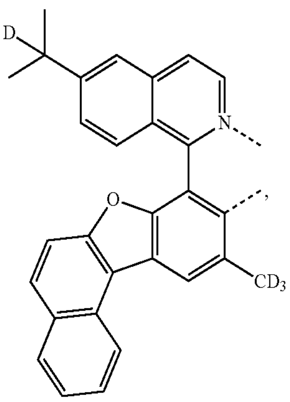

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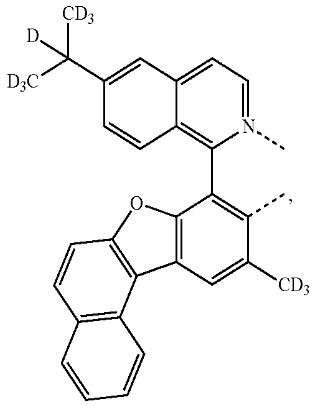

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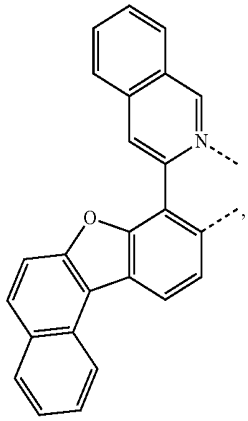

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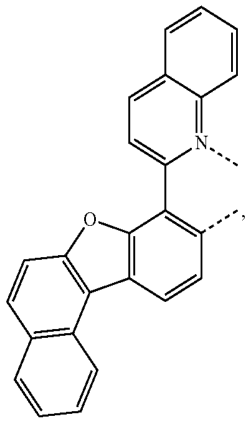

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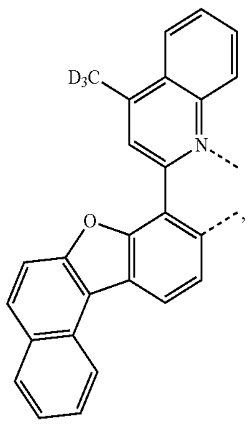

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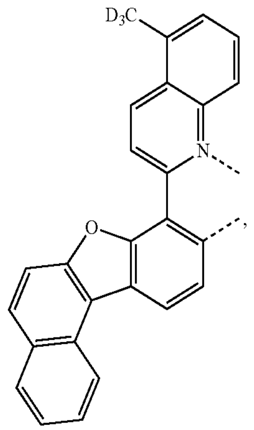

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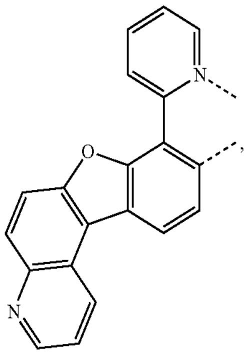

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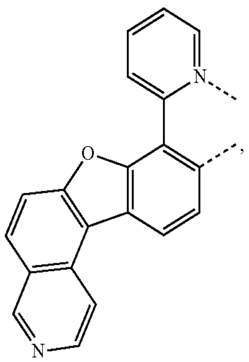

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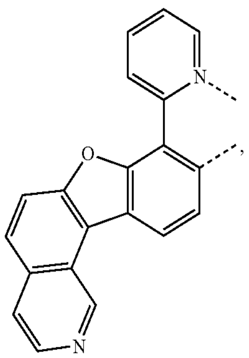

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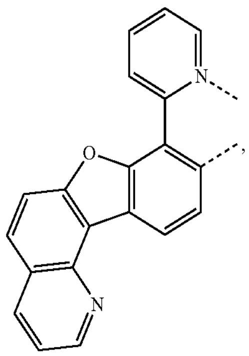

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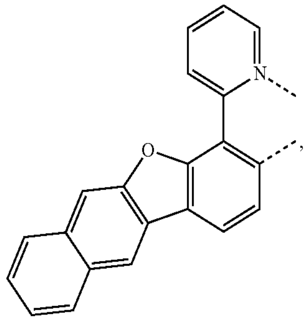

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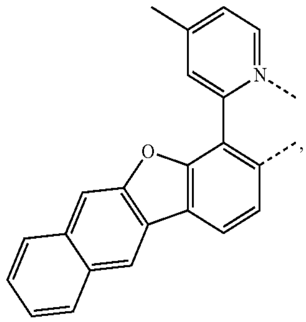

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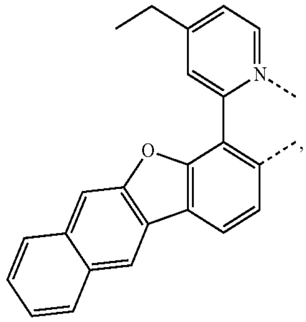

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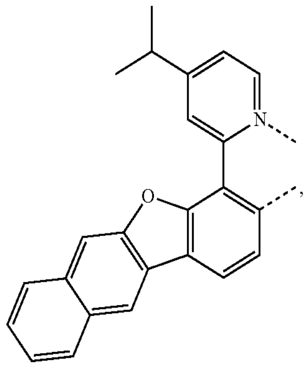

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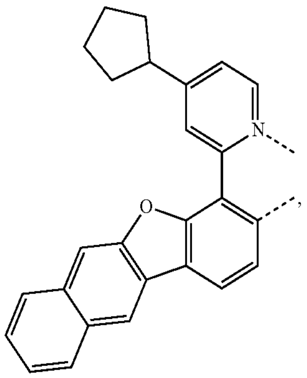

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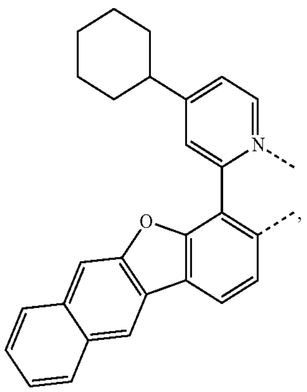

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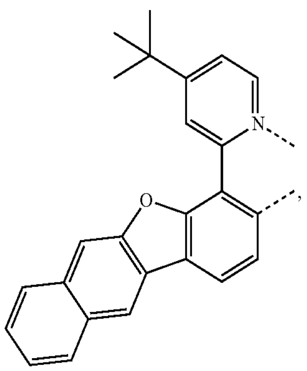

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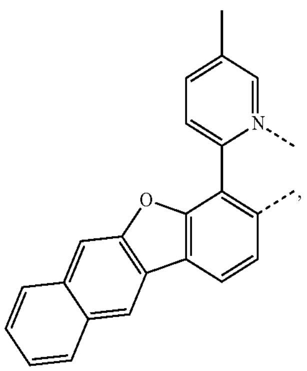

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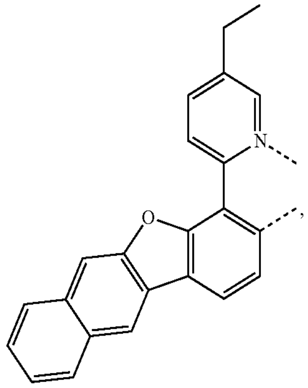

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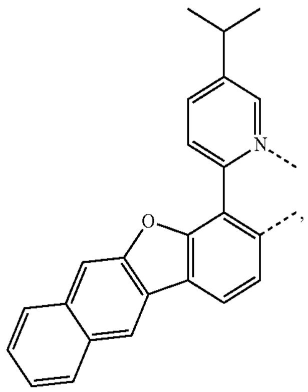

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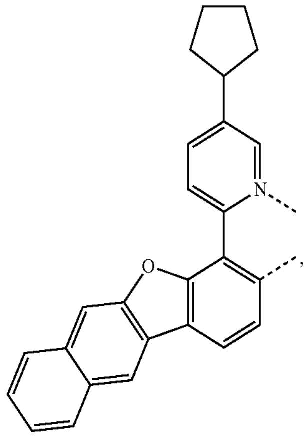

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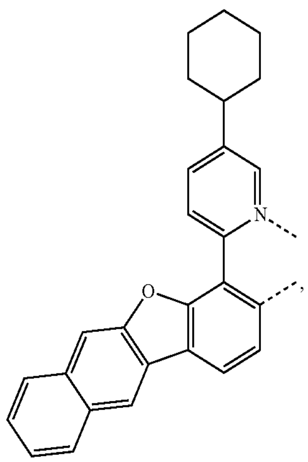

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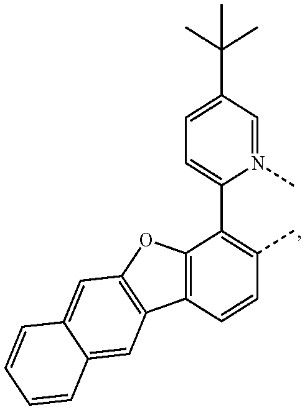

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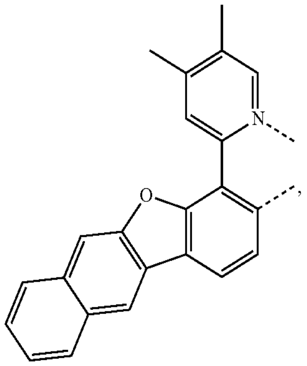

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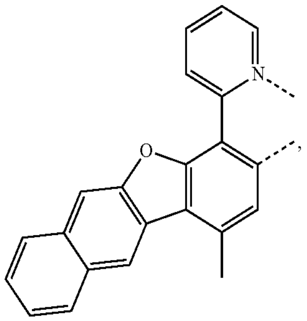

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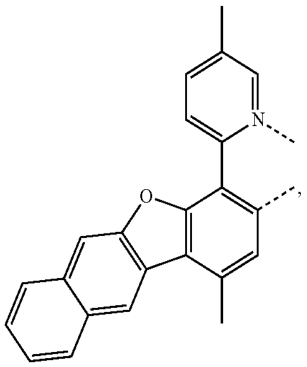

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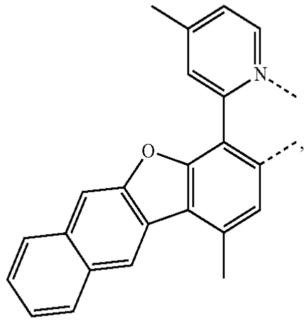

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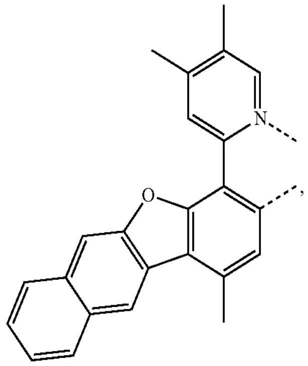

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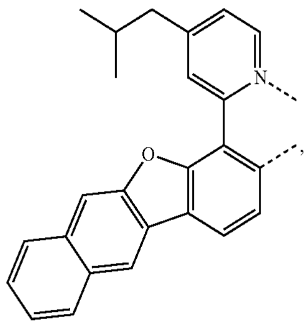

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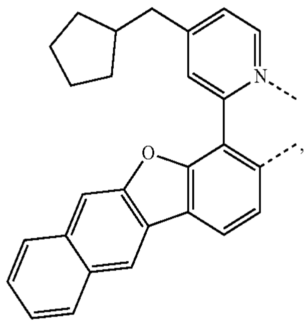

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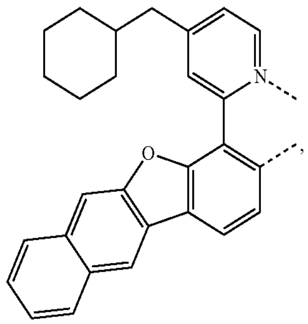

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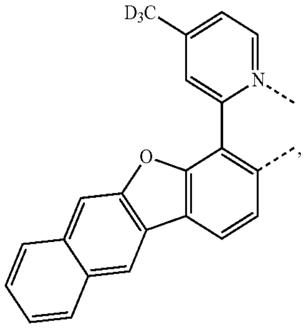

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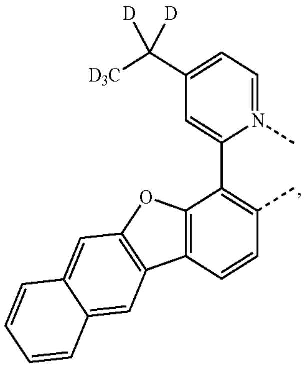

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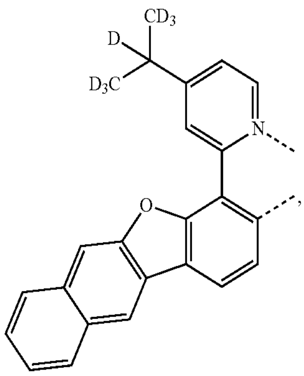

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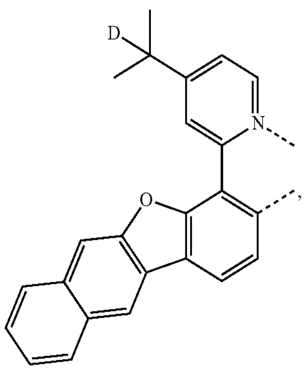

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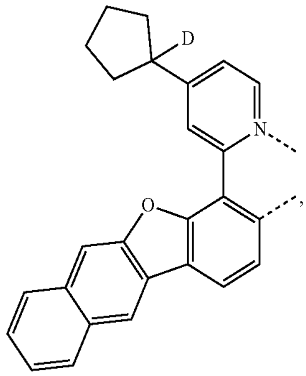

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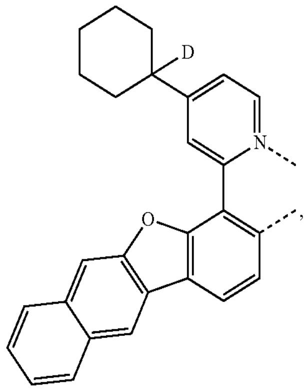

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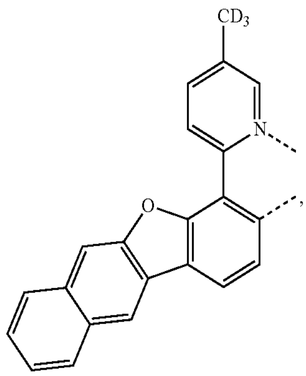

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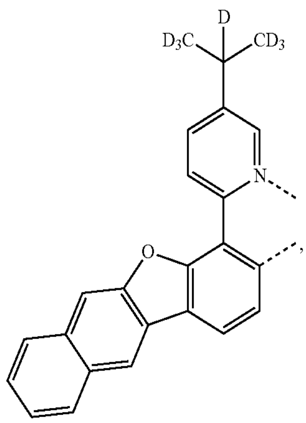

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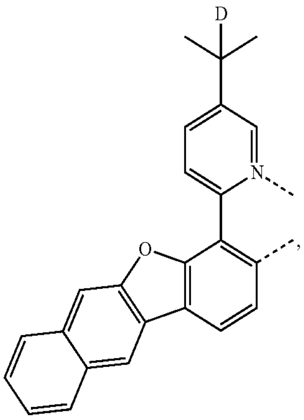

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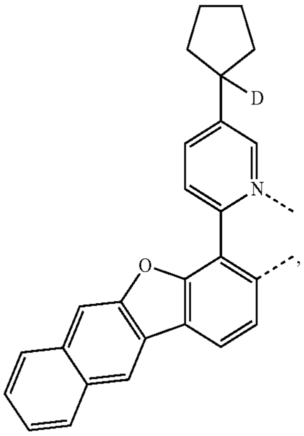

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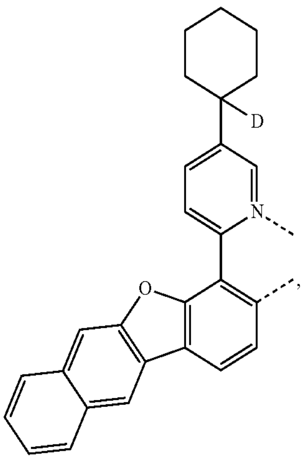

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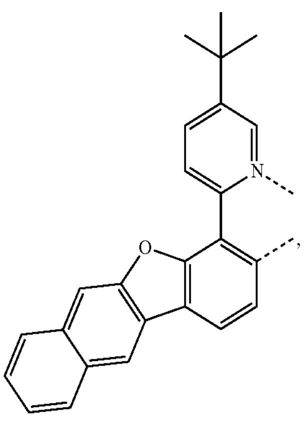

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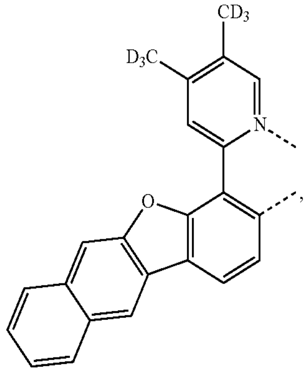

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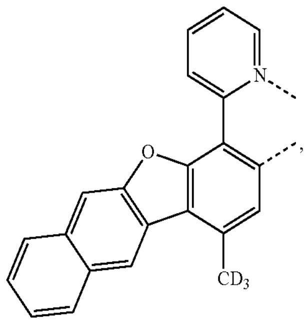

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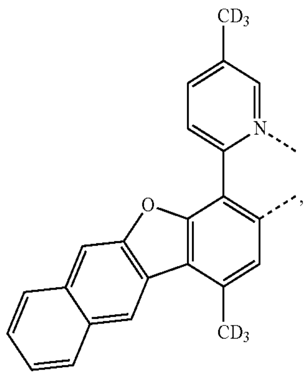

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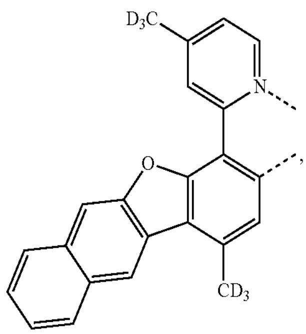

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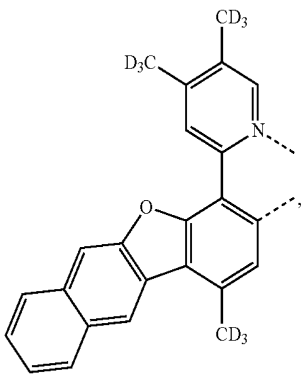

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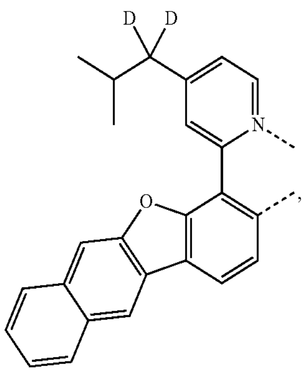

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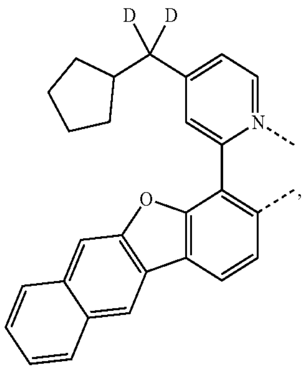

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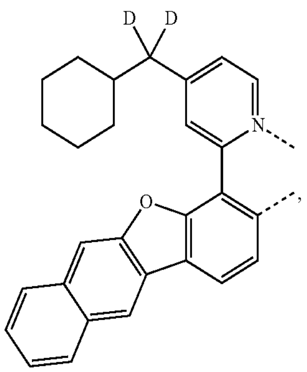

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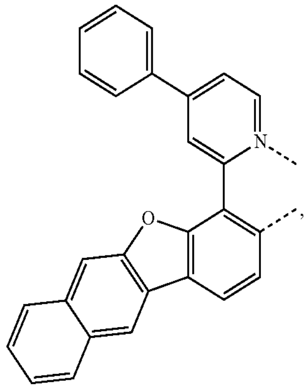

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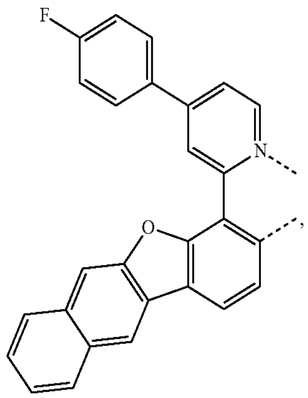

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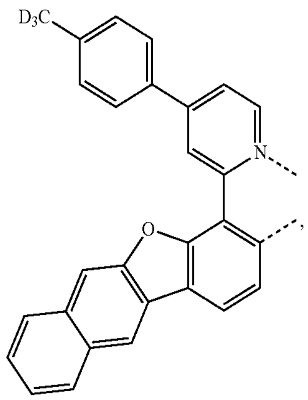

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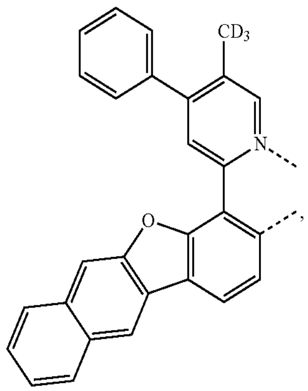

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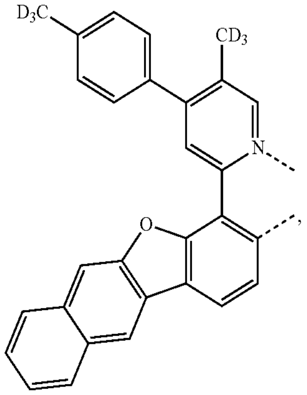

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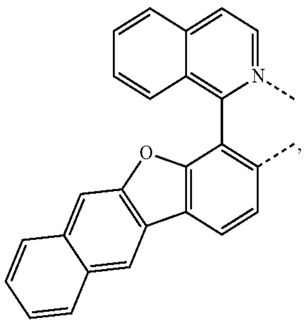

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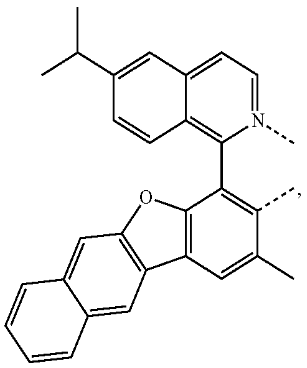

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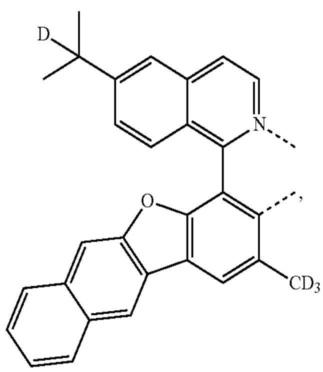

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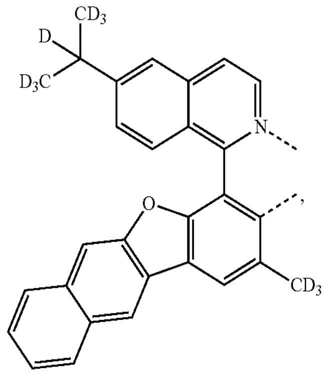

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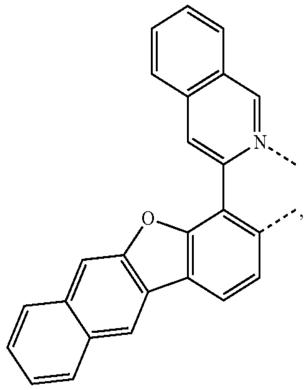

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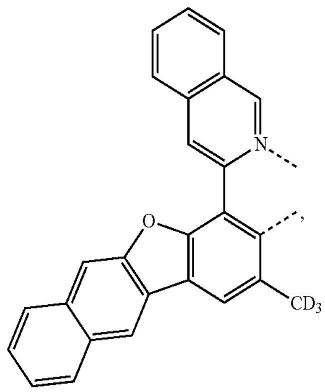

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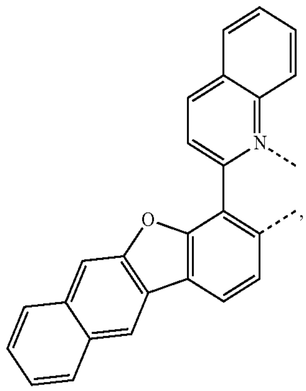

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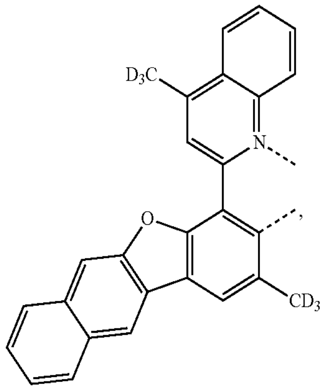

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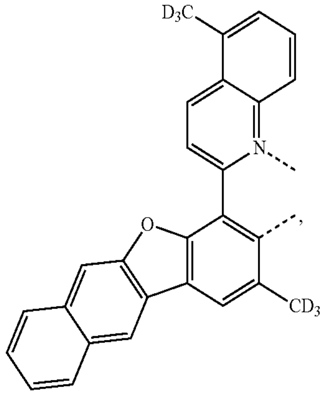

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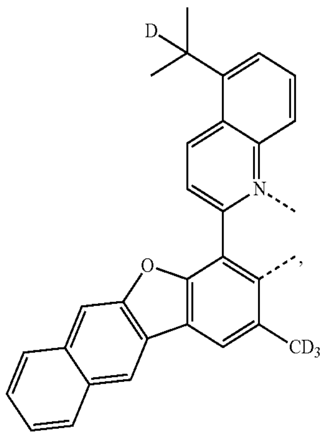

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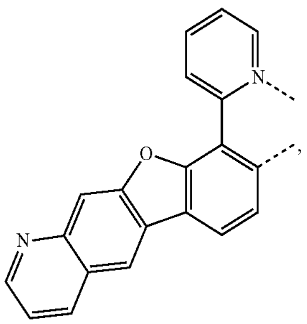

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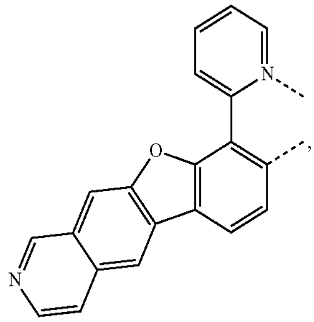

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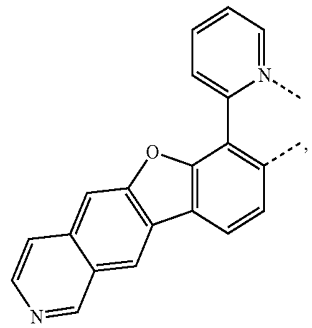

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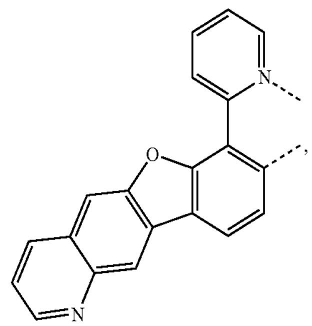

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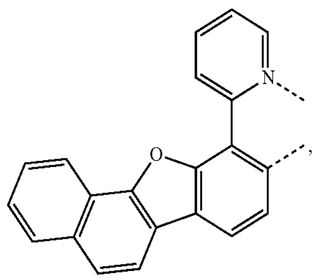

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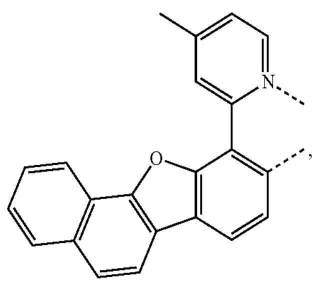

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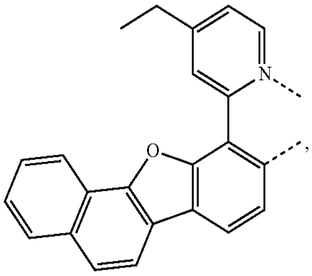

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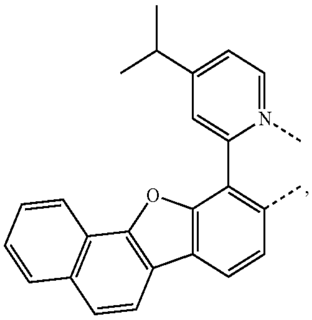

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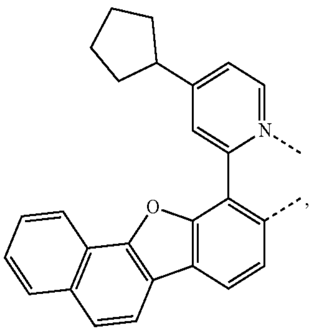

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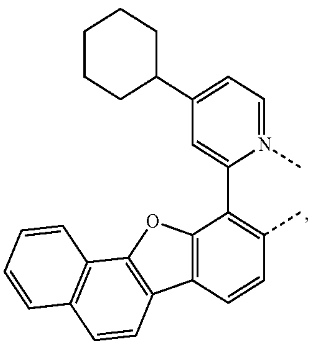

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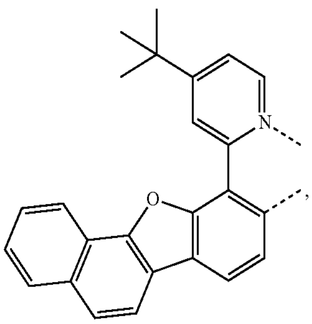

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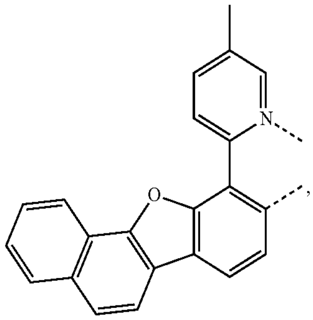

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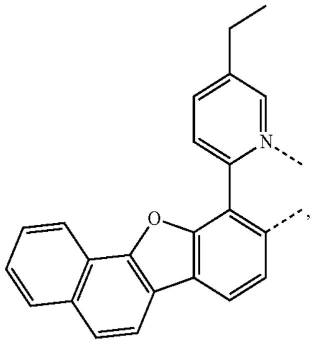

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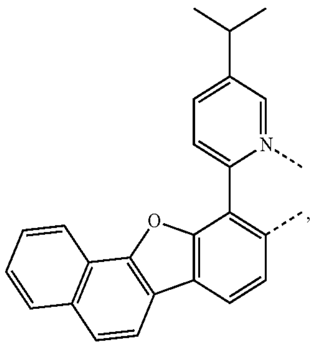

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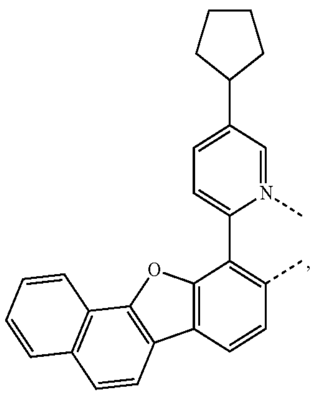

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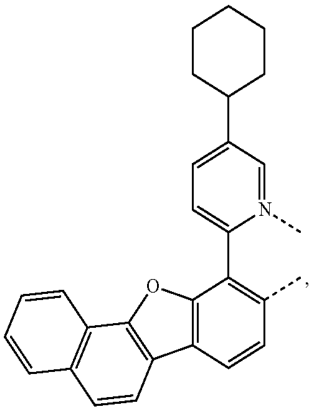

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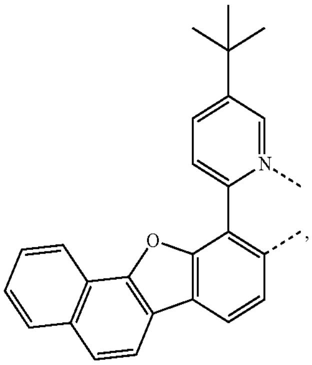

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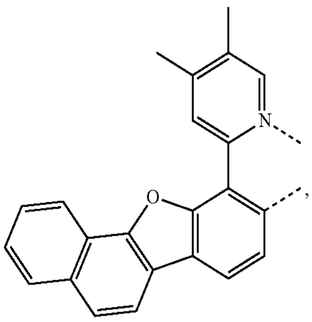

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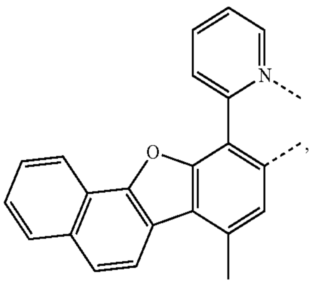

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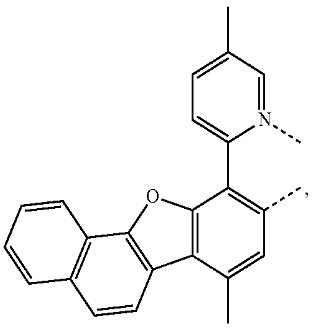

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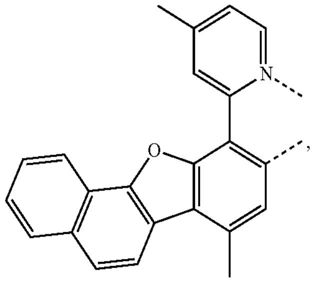

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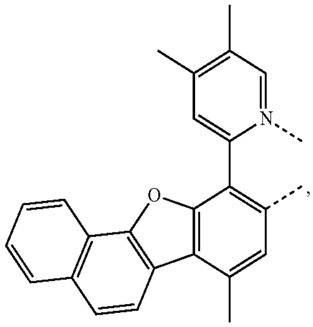

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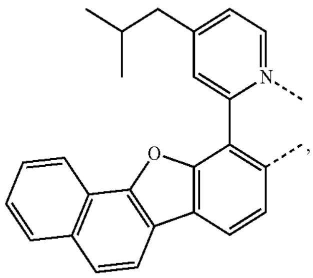

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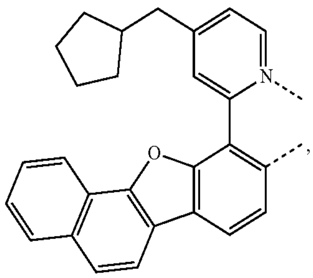

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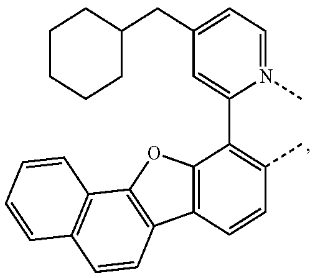

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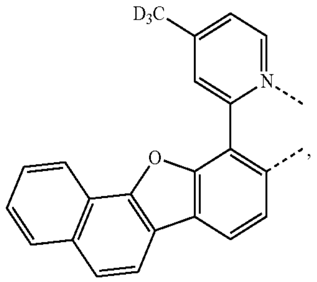

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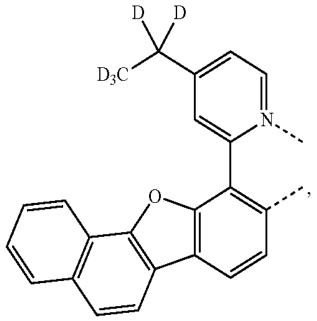

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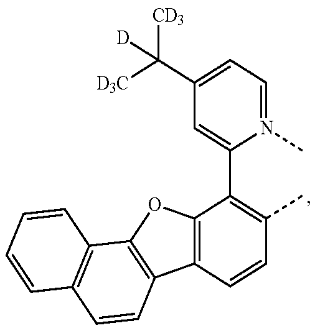

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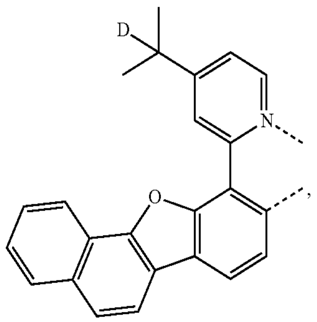

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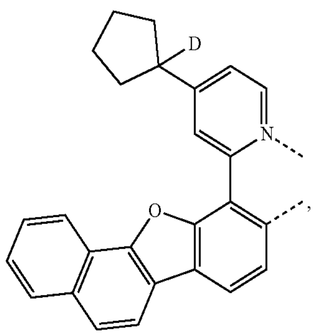

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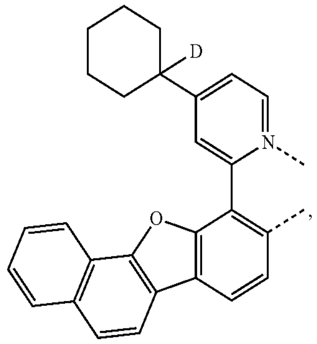

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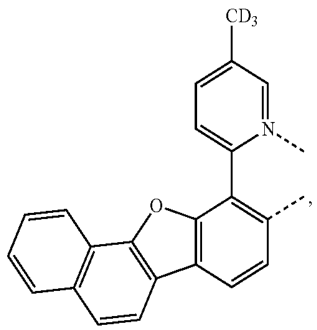

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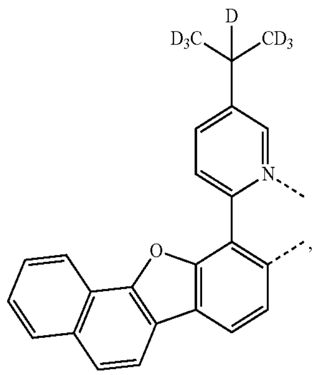

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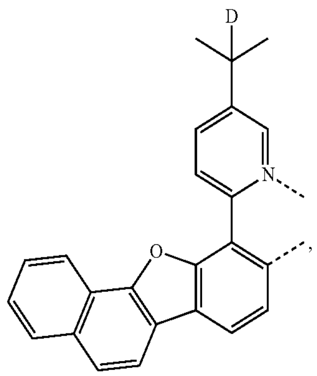

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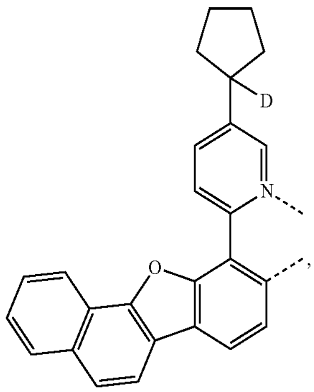

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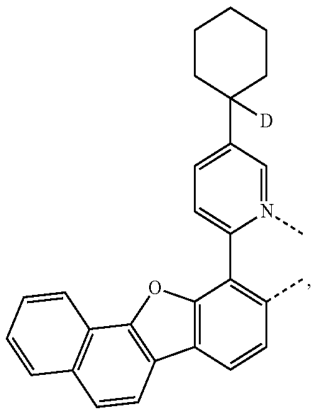

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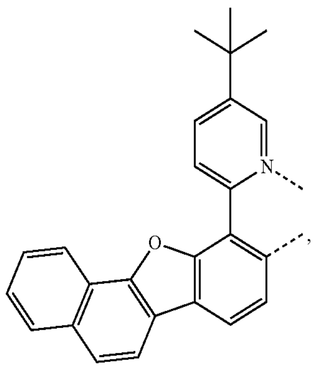

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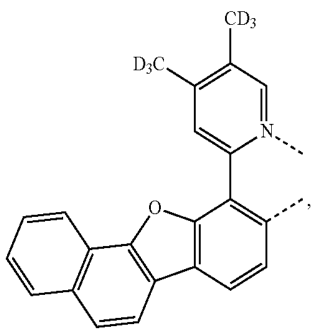

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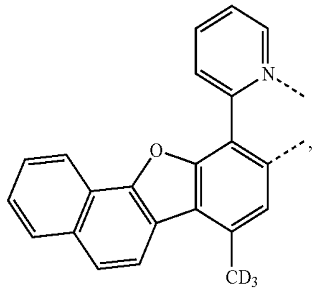

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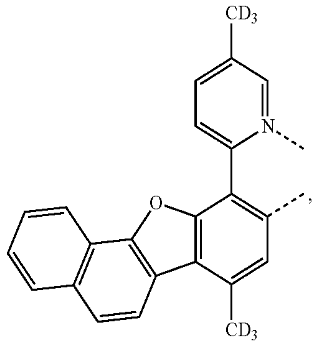

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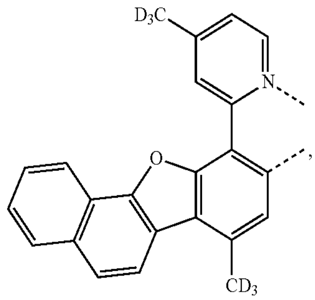

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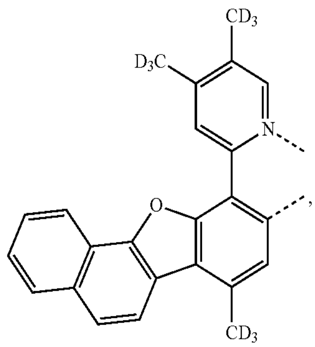

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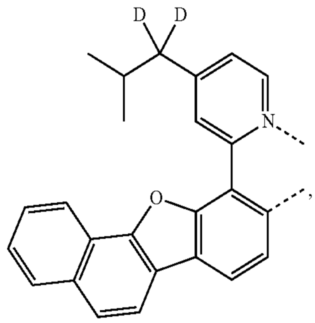

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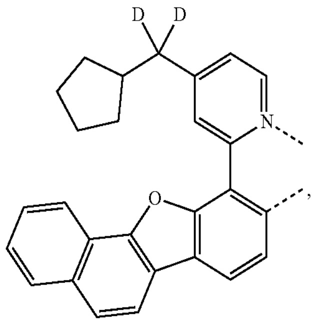

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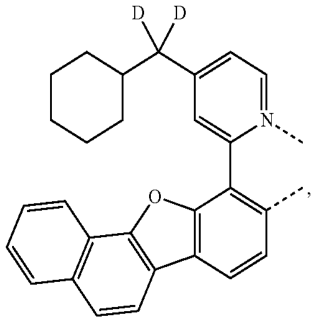

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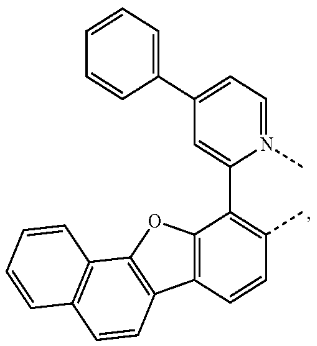

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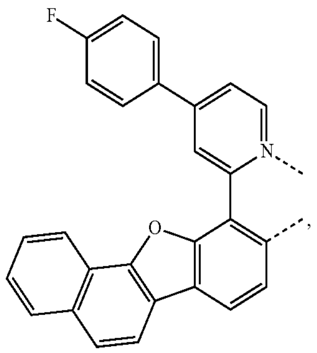

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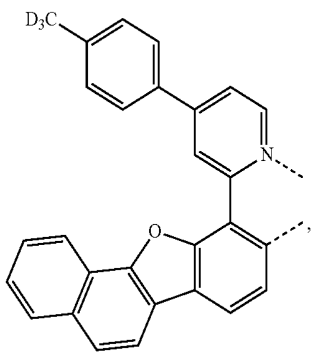

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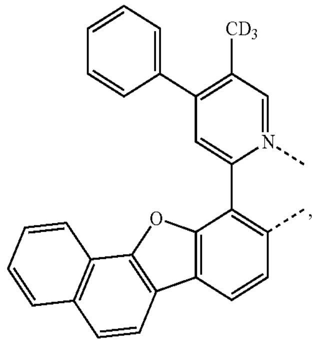

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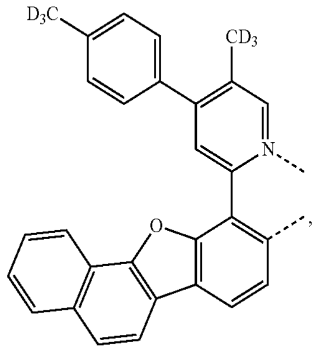

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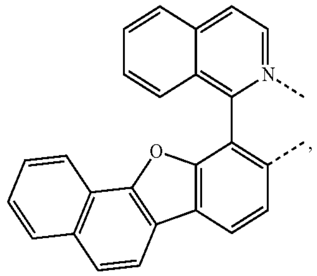

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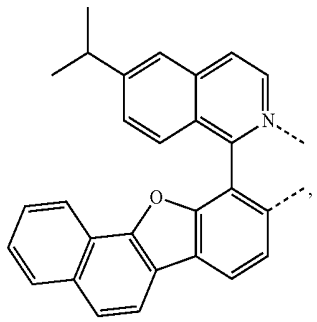

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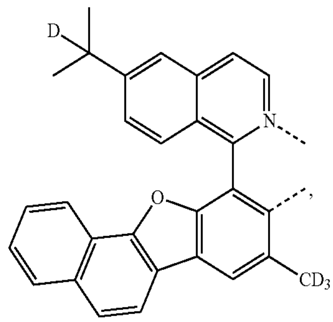

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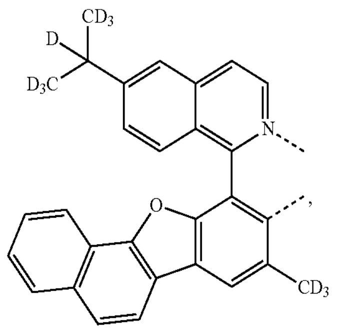

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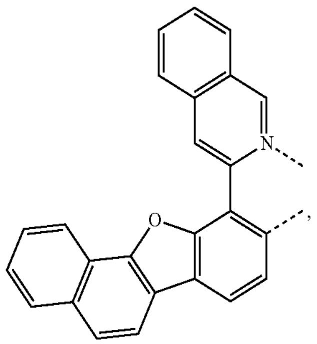

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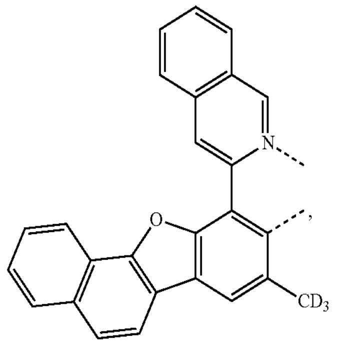

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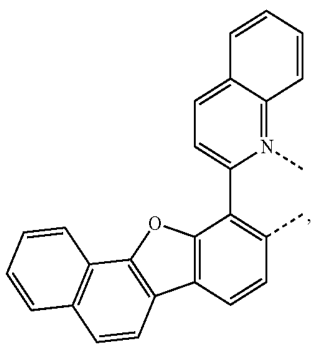

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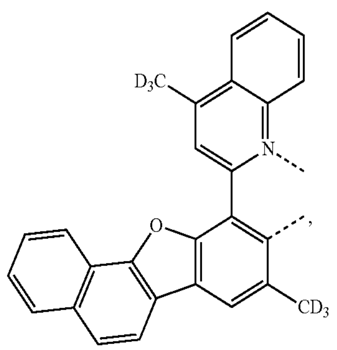

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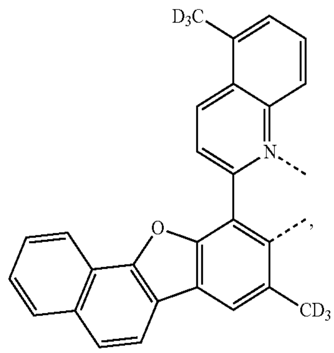

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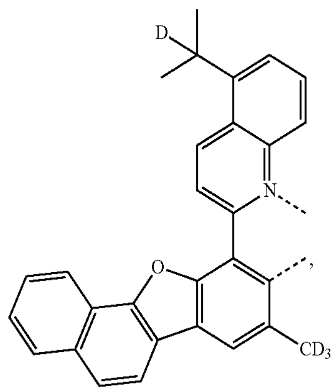

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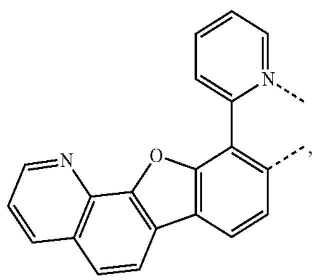

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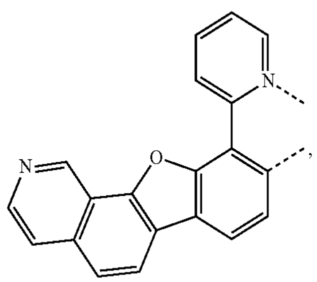

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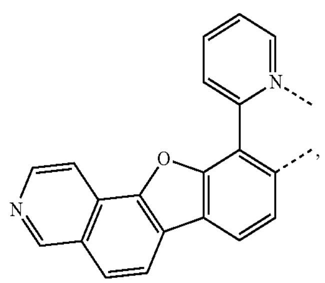

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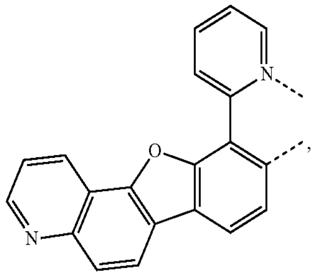

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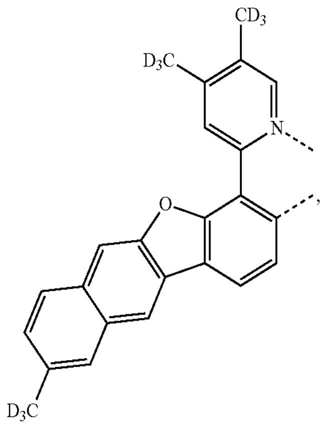

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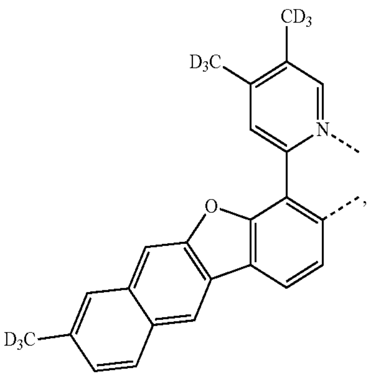

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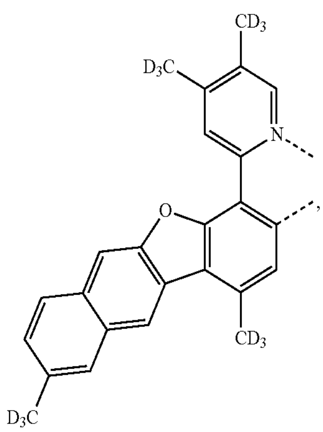

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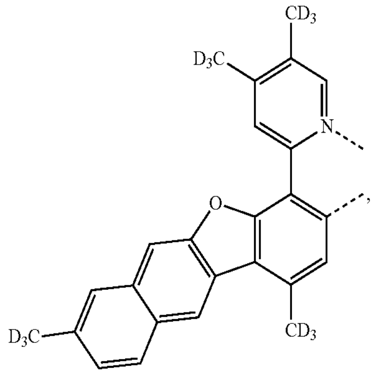

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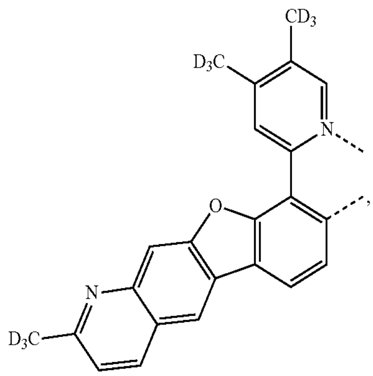

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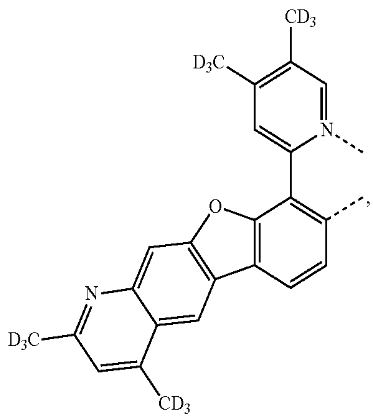

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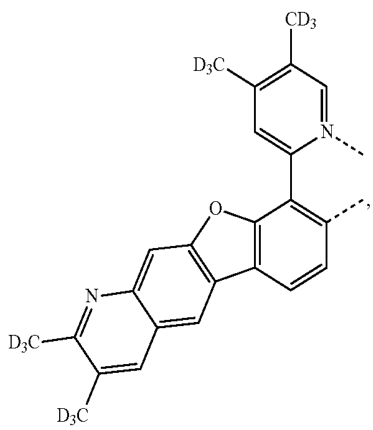

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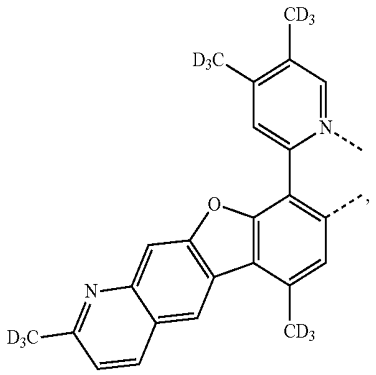

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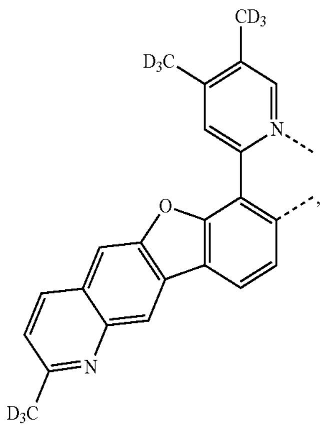

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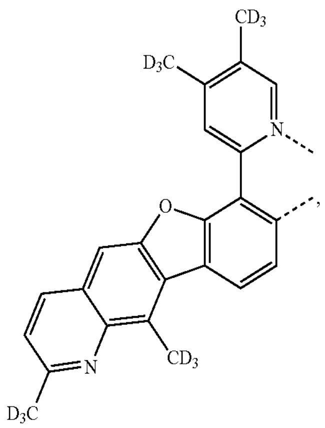

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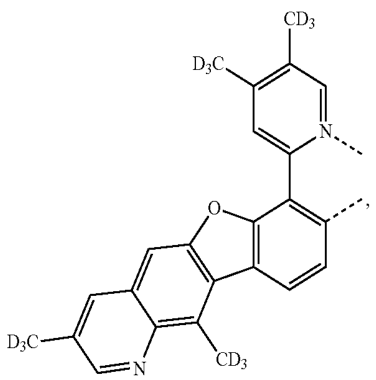

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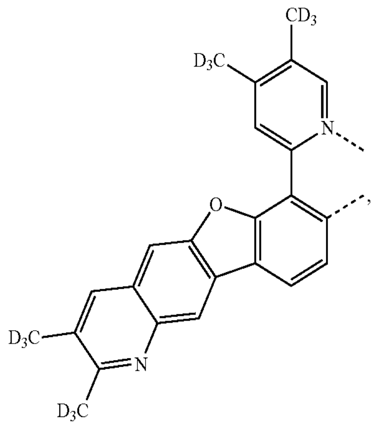

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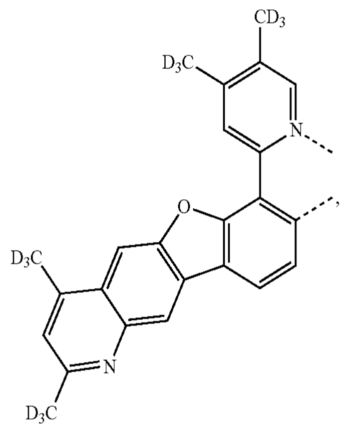

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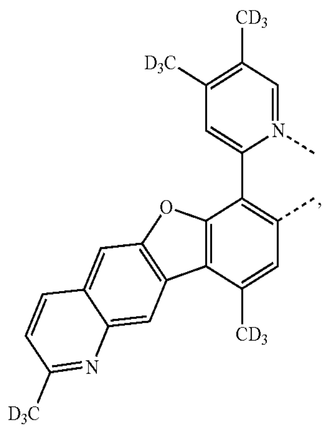

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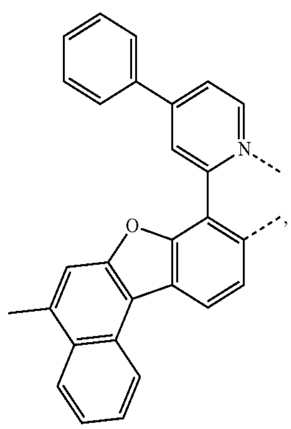
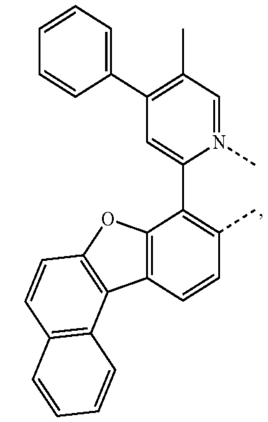


L_{A895}

L_{A896}



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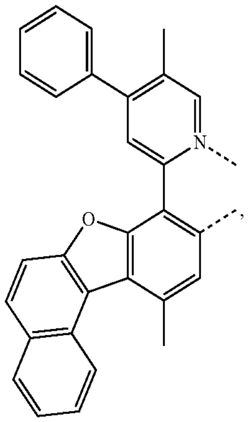

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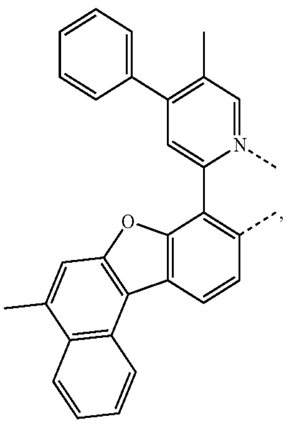

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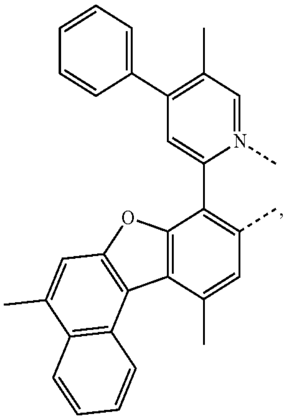

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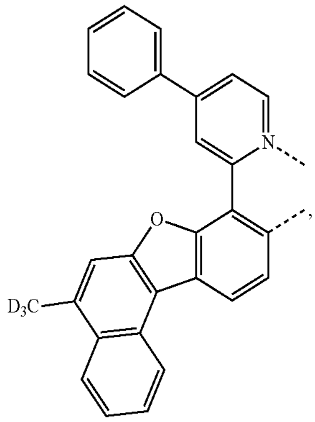

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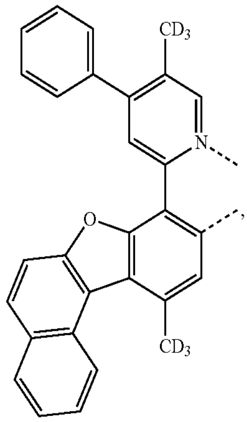

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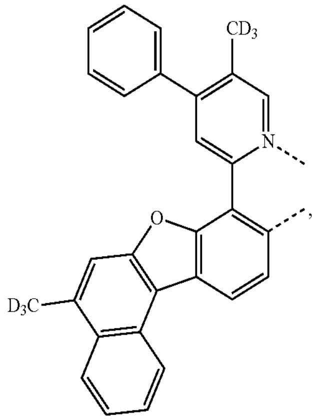

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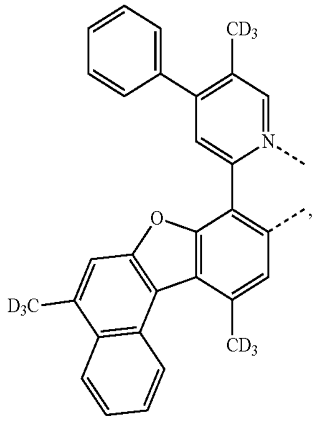

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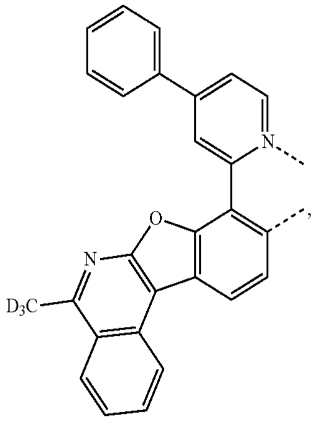

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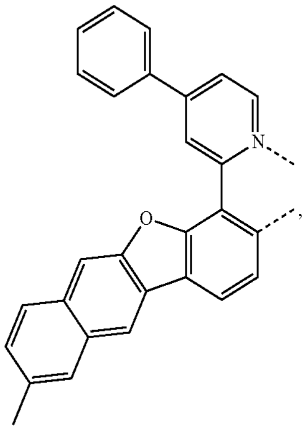

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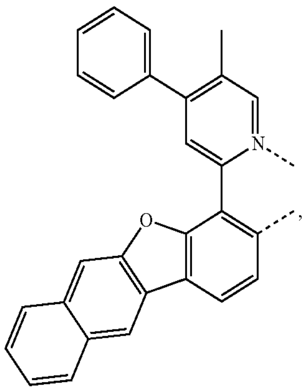

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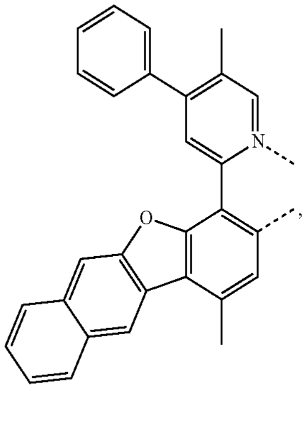

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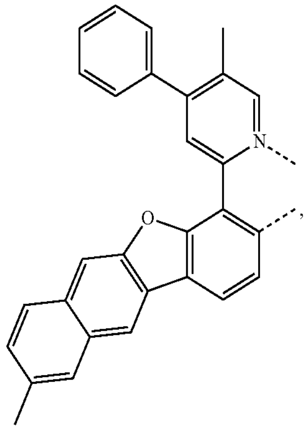

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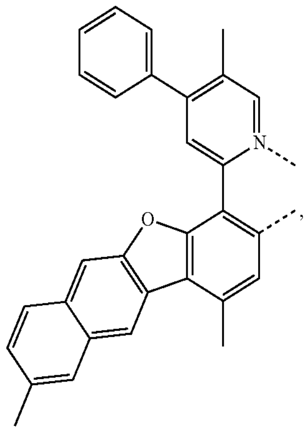

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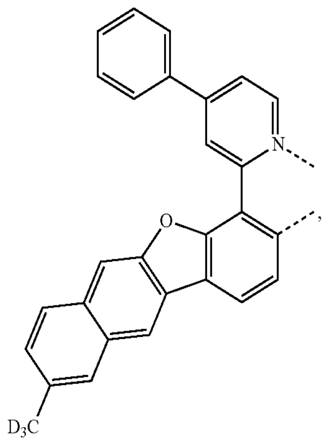

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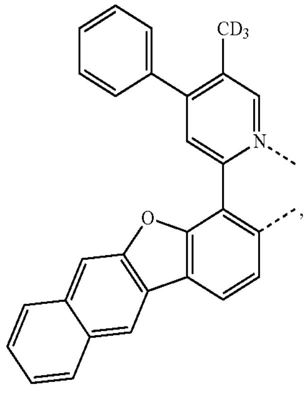

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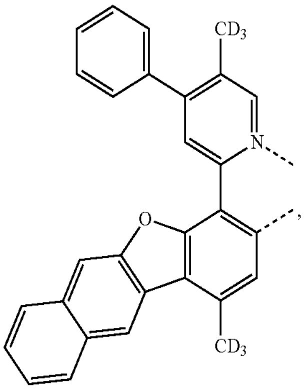

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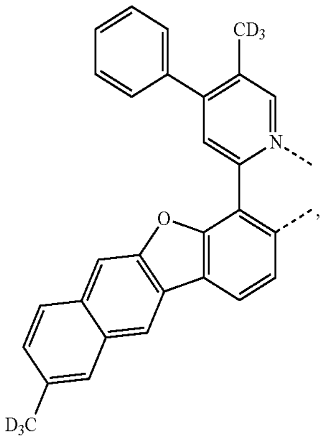

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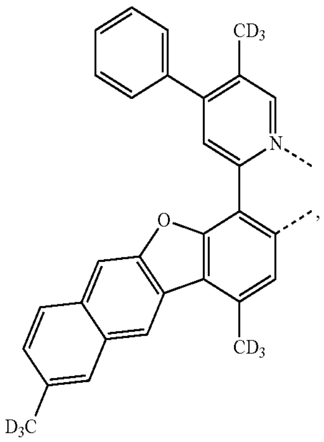

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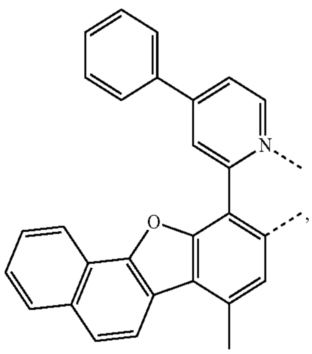

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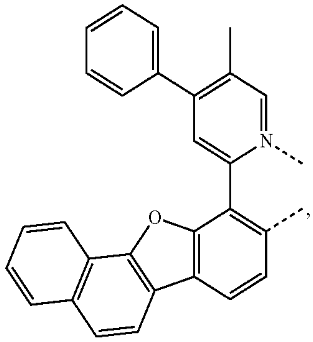

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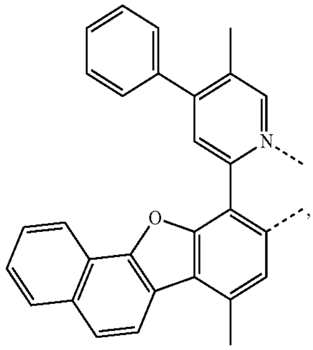

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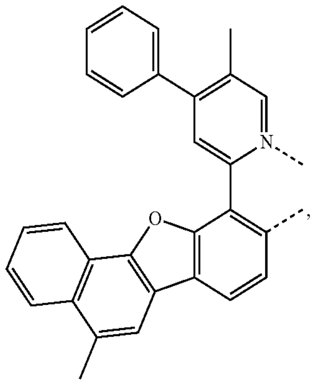

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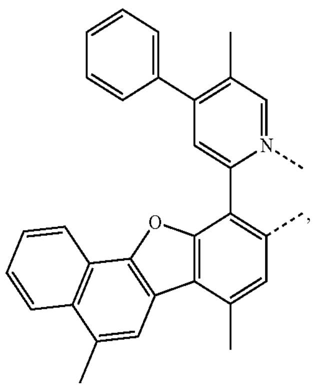

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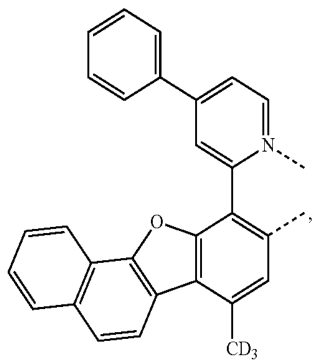

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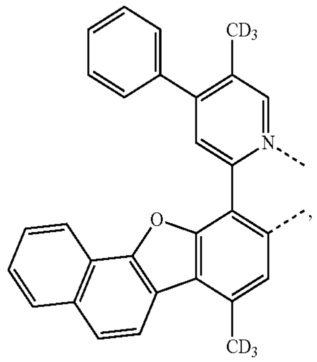

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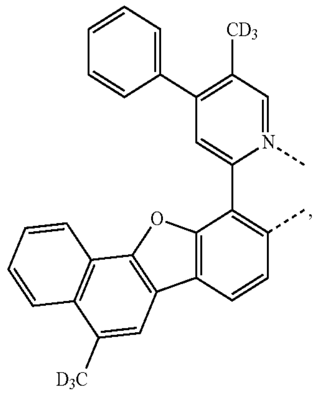
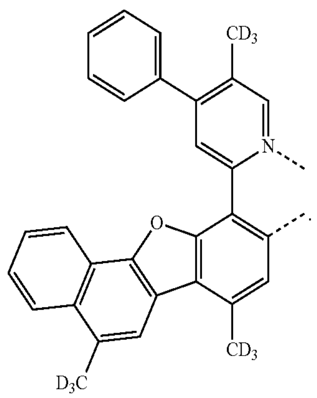


and

L_{A1052}



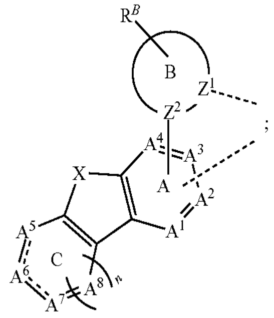
11. An organic light-emitting device (OLED) comprising:

an anode;

a cathode; and

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

Formula I



wherein ring B is a 5 or 6-membered carbocyclic or heterocyclic ring;

wherein R^B represents mono to the possible maximum number of substitution, or no substitution;

wherein Z^2 is selected from the group consisting of carbon or nitrogen;

wherein, when ring B is a 5-membered ring, Z^1 is nitrogen or carbon, and when ring B is a 6-membered ring, Z^1 is nitrogen;

wherein A^1, A^2, A^3, and A^4 are each independently CR or N;

wherein ring C is a 6 membered aromatic ring;

n is 1;

wherein A^1, A^2, A^3, A^4, A^5, A^6, A^7, and A^8 are each independently CR, and the Rs of two adjacent A^5, A^6, A^7, and A^8 are joined together to form a six-membered ring fused to ring C;

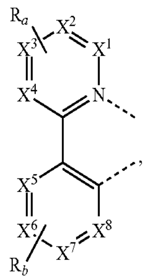
wherein X is O, S, or Se;

wherein the ligand L_A is coordinated to an Ir atom;

wherein the Ir atom is bonded to ring A through an Ir—C bond;

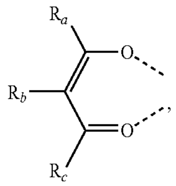
wherein the Ir atom is also coordinated to at least one of:

(1) a ligand L_B and the compound has a structure $Ir(L_A)(L_B)_2$, wherein L_B has a structure



wherein X^1, X^2, X^3, X^4, X^5, X^6, X^7, and X^8 are C, wherein R_a and R_b are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof, or

(2) a ligand L_C and the compound has a formula of $Ir(L_A)_2(L_C)$, wherein L_C has a structure



wherein Ra, Rb, and Rc are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, and combinations thereof;

wherein, when the Ir atom is coordinated to L_B, Ring B is pyridine, Z^1 is nitrogen, Z^2 is carbon;

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

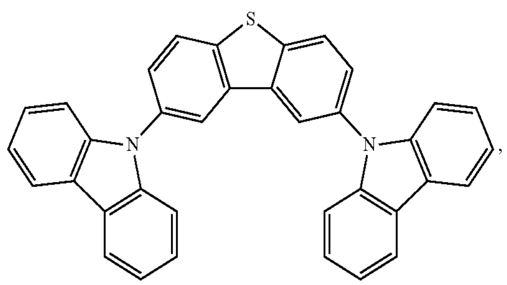
wherein any adjacent substituents are optionally joined or fused into a ring;

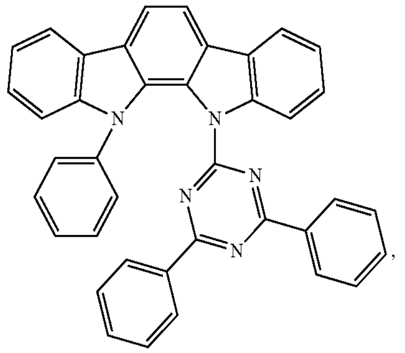
wherein the ligand L_A is optionally linked with ligand L_B or ligand L_C to comprise a tetradentate or hexadentate ligand.

12. The OLED of claim **11**, wherein the organic layer is an emissive layer and the compound is an emissive dopant or a non-emissive dopant.

13. The OLED of claim **11**, wherein the organic layer further comprises a host, wherein host comprises at least one chemical group selected from the group consisting of triphenylene, carbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, azatriphenylene, azacarbazole, aza-dibenzothiophene, aza-dibenzofuran, and aza-dibenzoselenophene.

14. The OLED of claim **11**, wherein the organic layer further comprises a host, wherein the host is selected from the group consisting of:





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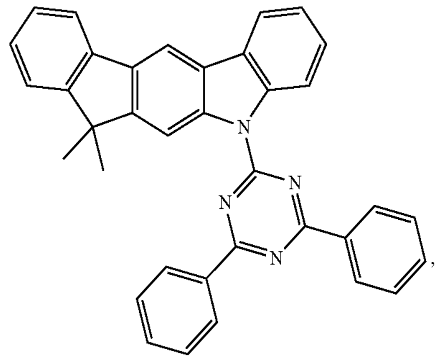

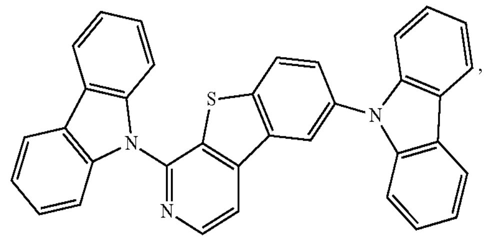

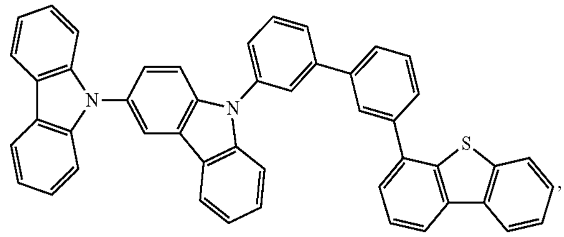

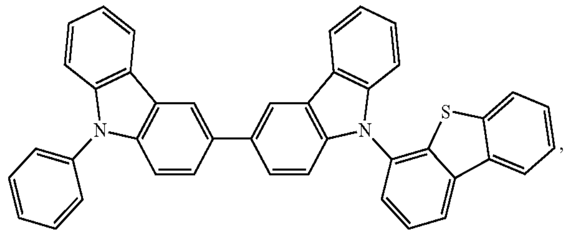

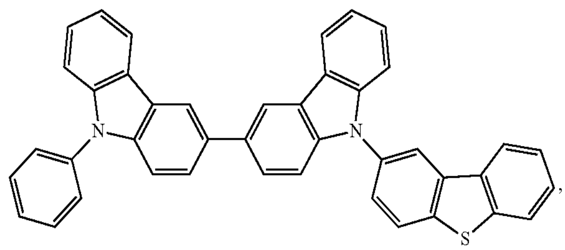

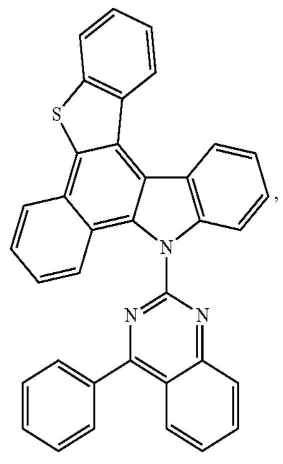

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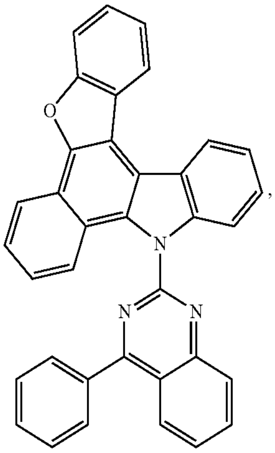

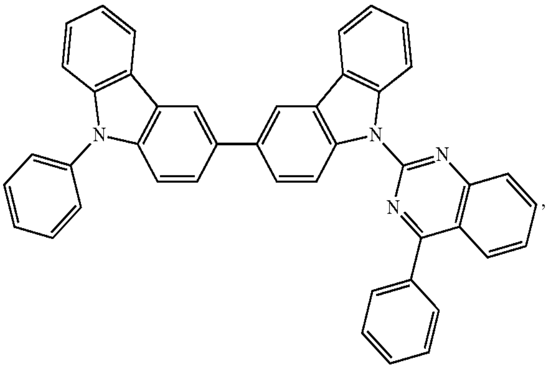

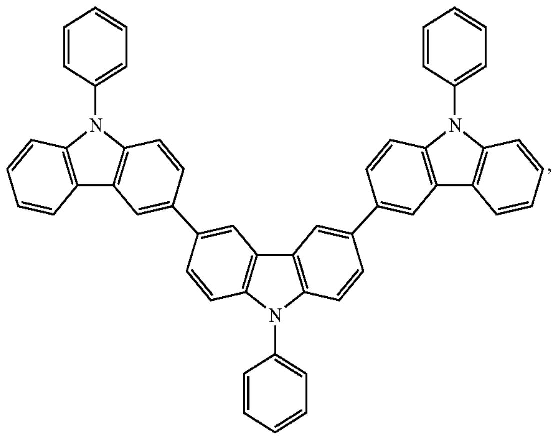

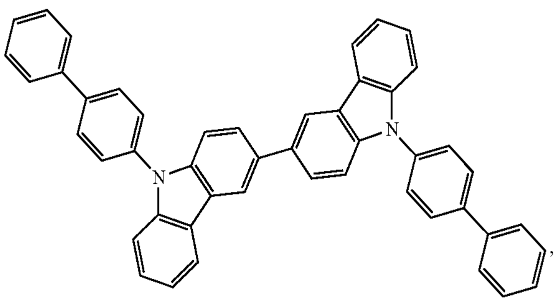

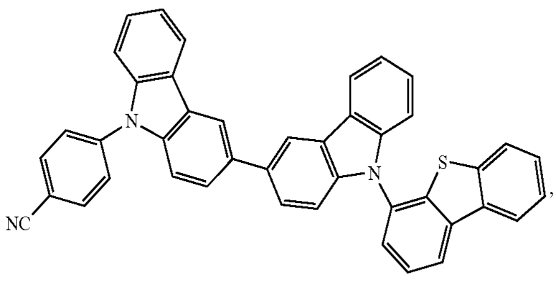

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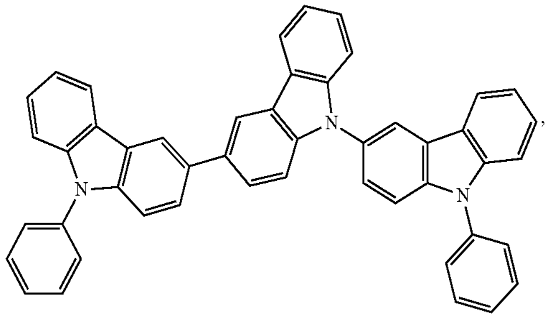

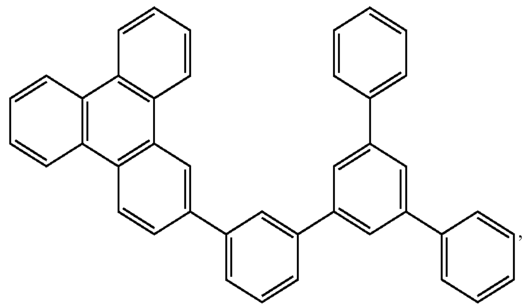

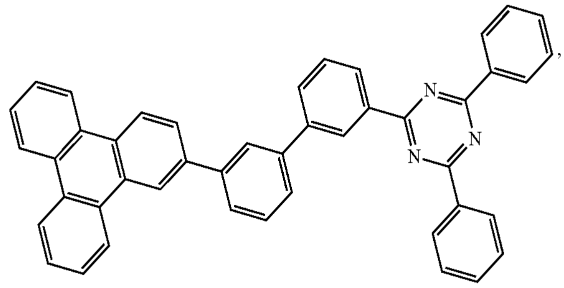

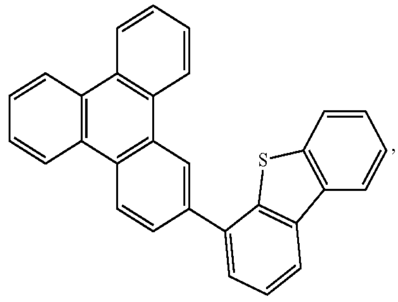

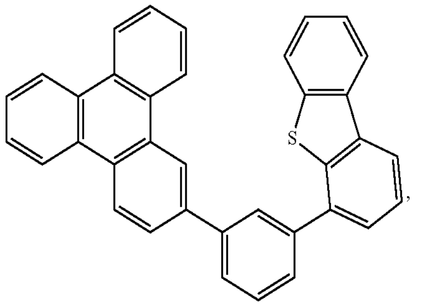

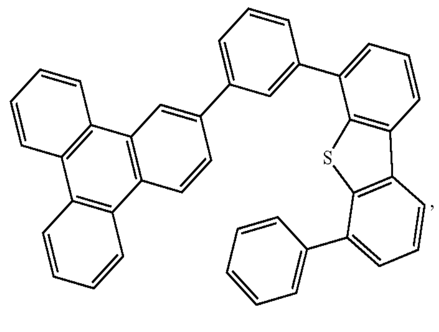

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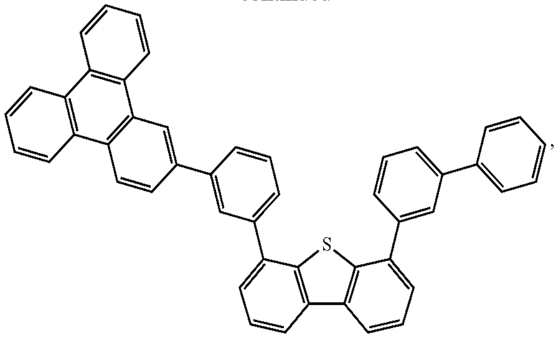
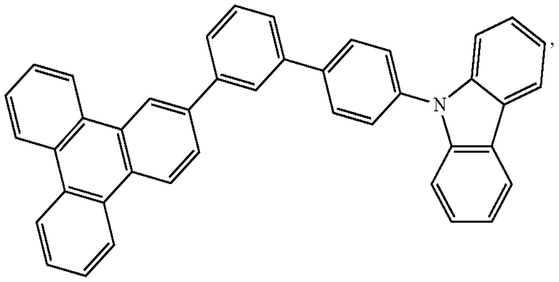
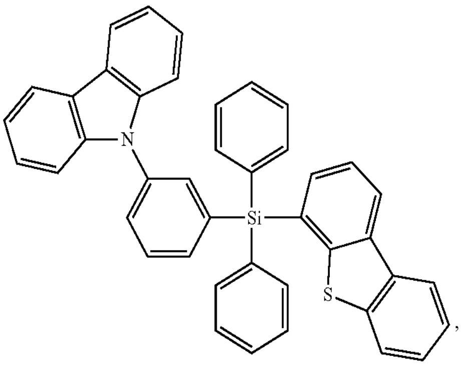
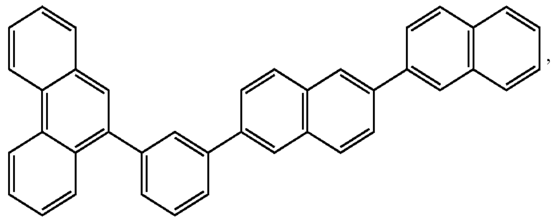


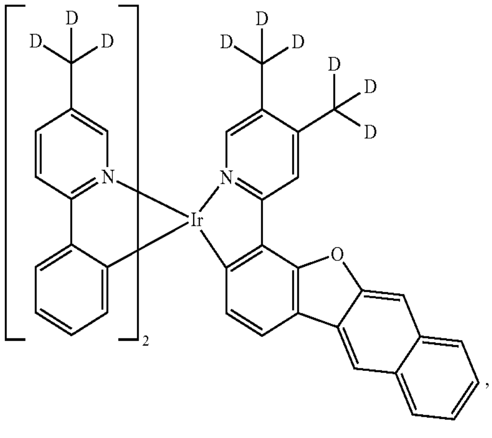




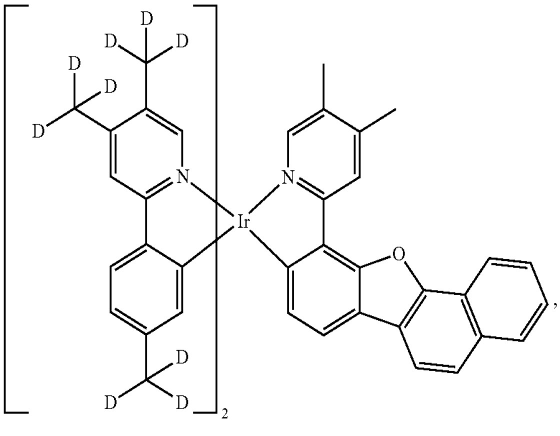


and combinations thereof.

15. A compound selected from the group consisting of:



$Ir[L_{A239}(L_{B9})_2]$



$Ir[L_{A416}(L_{B97})_2]$

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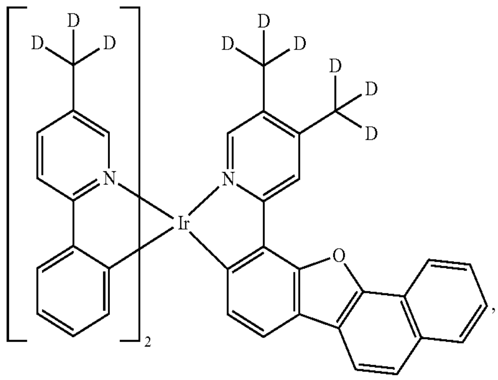
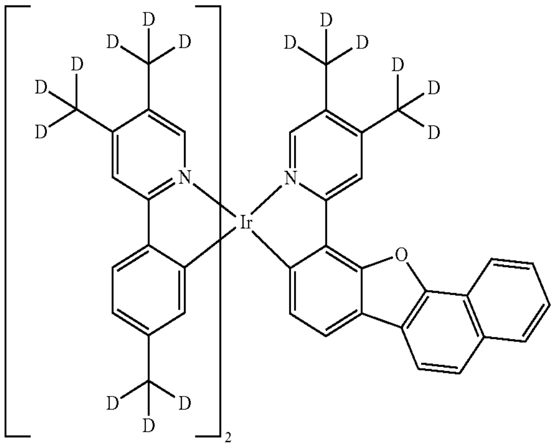


$Ir[L_{A436}(L_{B9})_2]$



$Ir[L_{A436}(L_{B97})_2]$

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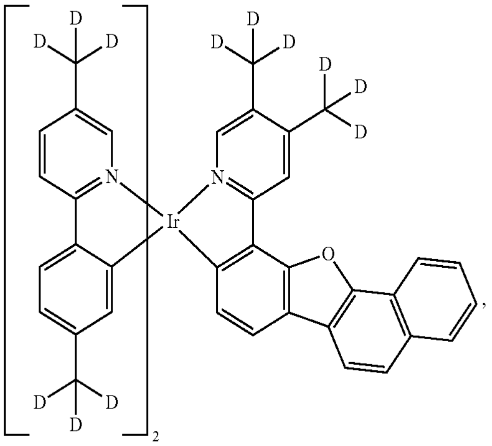
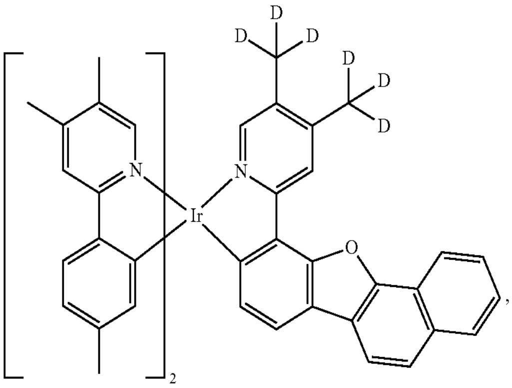
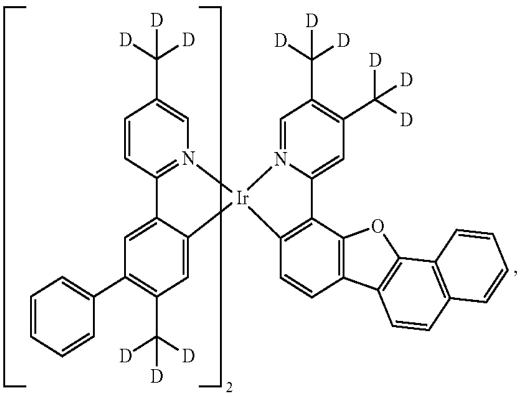


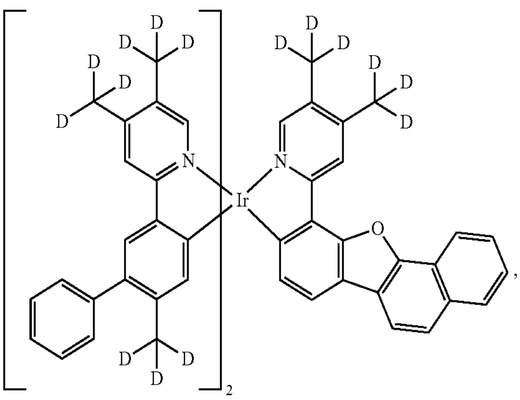
$Ir[L_{A436}(L_{B91})_2]$



$Ir[L_{A436}(L_{B89})_2]$



$Ir[L_{A436}(L_{B189})_2]$



$Ir[L_{A436}(L_{B199})_2]$

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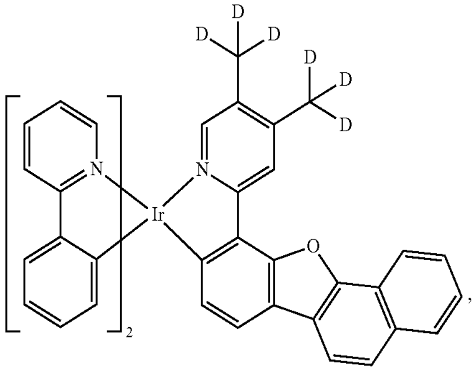
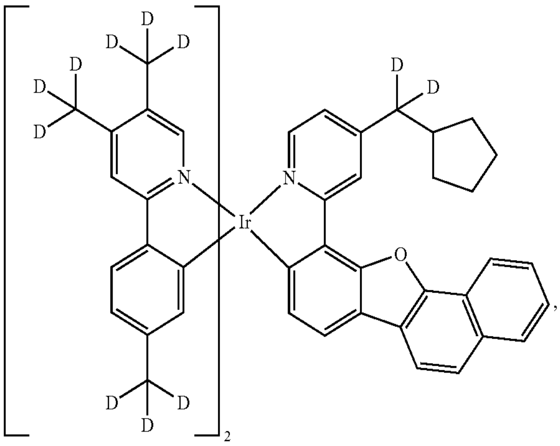
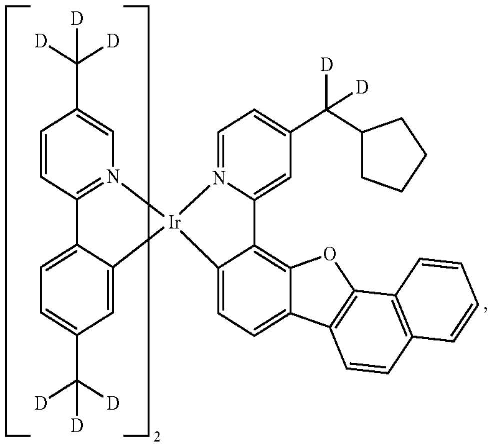


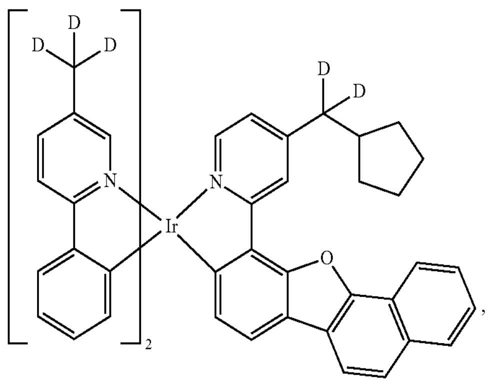
$Ir[L_{A436}(L_{B1})_2]$



$Ir[L_{A442}(L_{B97})_2]$



$Ir[L_{A442}(L_{B91})_2]$



$Ir[L_{A442}(L_{B9})_2]$

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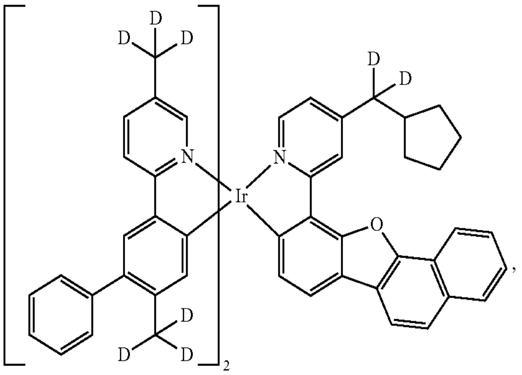

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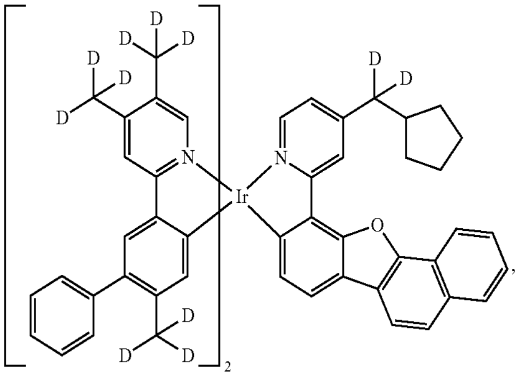
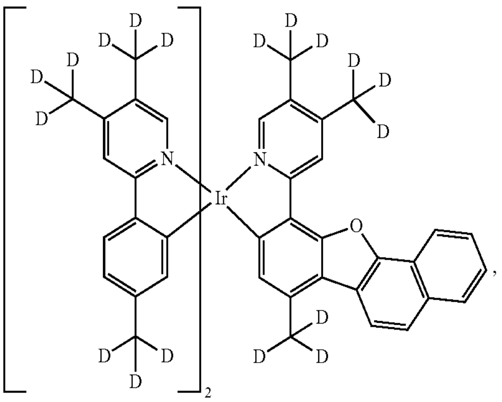
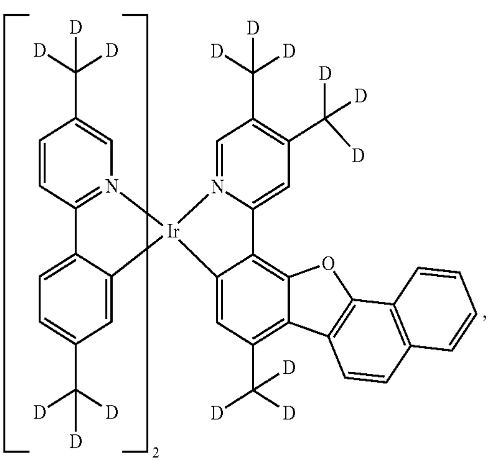


$Ir[L_{A442}(L_{B199})_2]$



$Ir[L_{A440}(L_{B97})_2]$



$Ir[L_{A440}(L_{B91})_2]$

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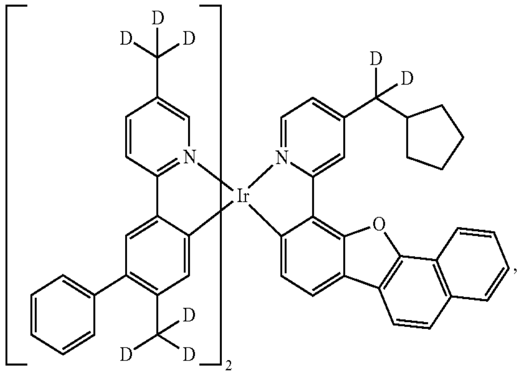
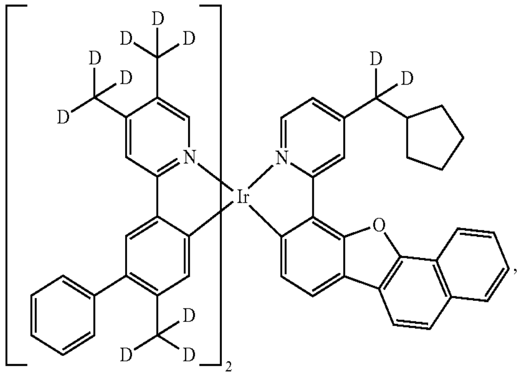
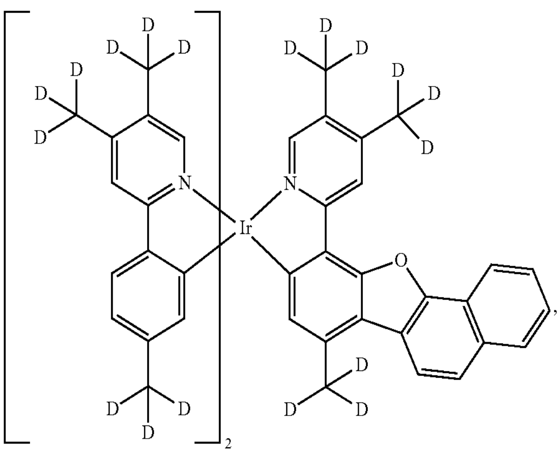


$Ir[L_{A442}(L_{B198})_2]$



$Ir[L_{A442}(L_{B199})_2]$



$Ir[L_{A440}(L_{B97})_2]$

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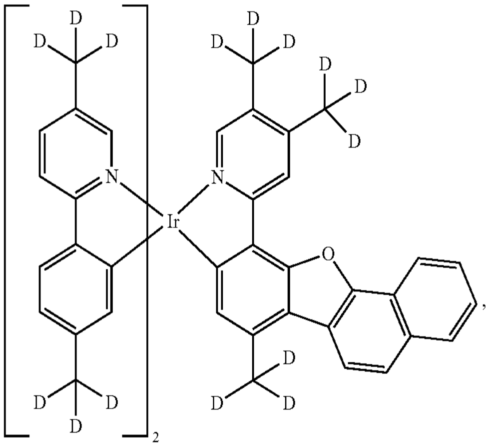
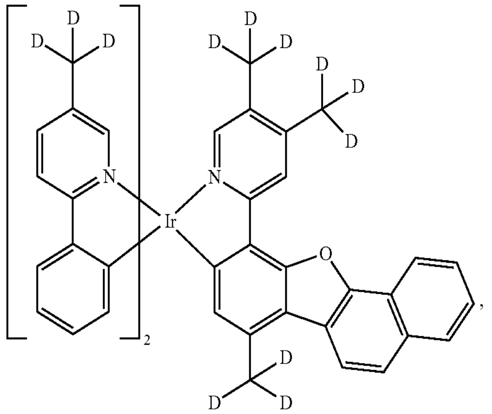
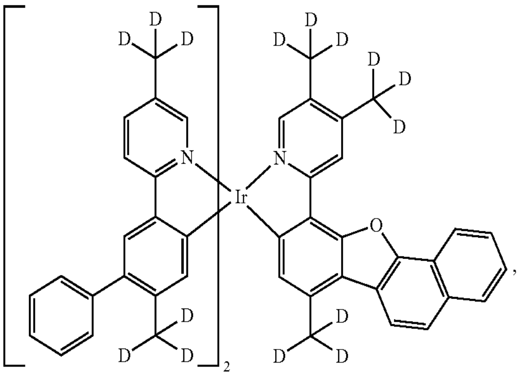


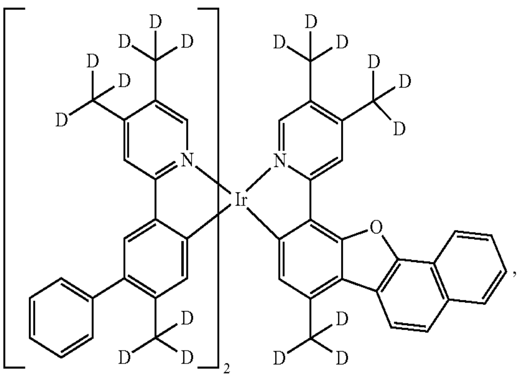
Ir[$L_{A440}(L_{B91})_2$]



Ir[$L_{A440}(L_{B9})_2$]



Ir[$L_{A440}(L_{B198})_2$]



Ir[$L_{A440}(L_{B199})_2$]

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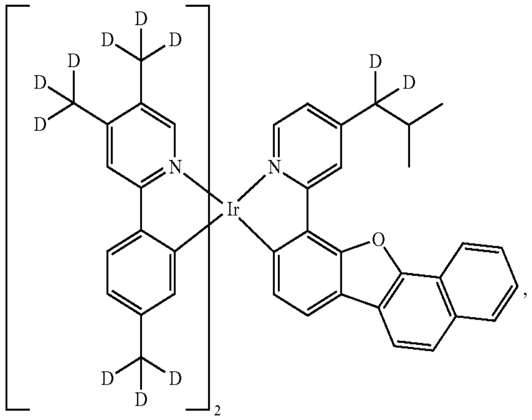
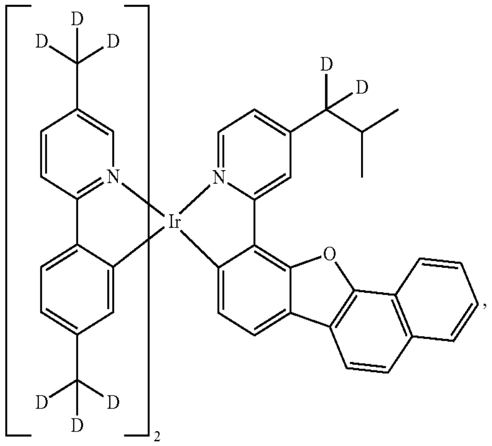
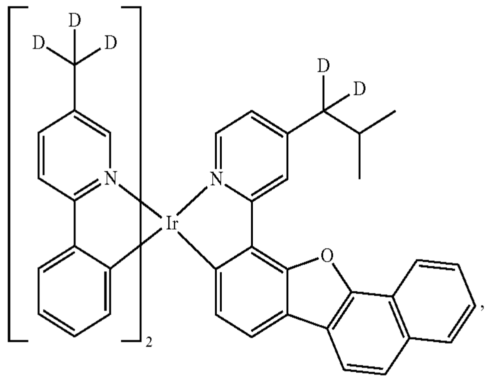


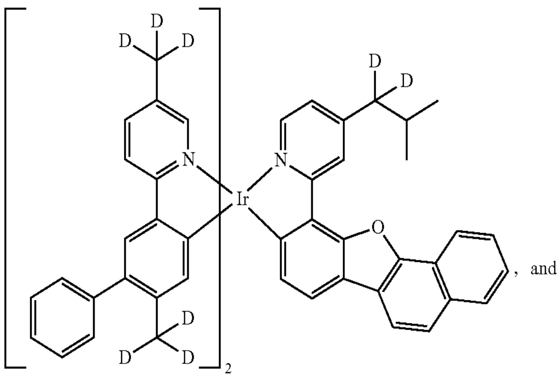
Ir[$L_{A441}(L_{B97})_2$]



Ir[$L_{A441}(L_{B91})_2$]



Ir[$L_{A441}(L_{B9})_2$]



Ir[$L_{A441}(L_{B198})_2$]

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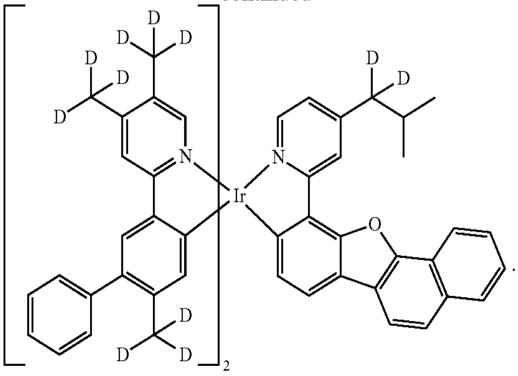


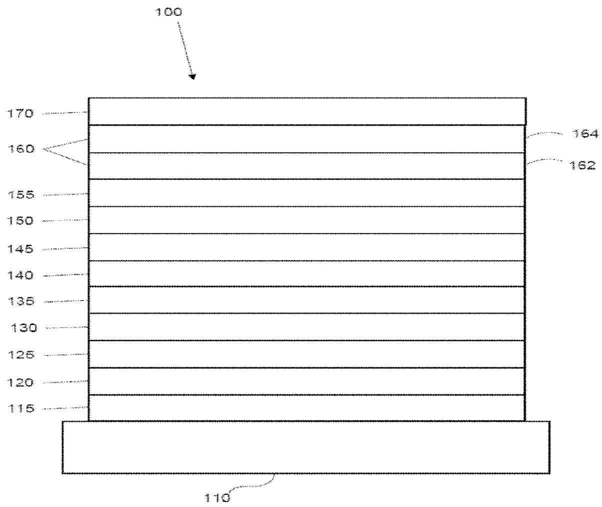
$Ir[L_{A441}(L_{B199})_2]$

* * * * *

专利名称(译)	有机电致发光材料和器件		
公开(公告)号	US10686140	公开(公告)日	2020-06-16
申请号	US15/728737	申请日	2017-10-10
[标]申请(专利权)人(译)	环球展览公司		
申请(专利权)人(译)	通用显示器公司		
当前申请(专利权)人(译)	通用显示器公司		
[标]发明人	SU MINGJUAN YEAGER WALTER DEANGELIS ALAN MA BIN TSAI JUI YI ZENG LICHANG XIA CHUANJUN		
发明人	SU, MINGJUAN YEAGER, WALTER DEANGELIS, ALAN MA, BIN TSAI, JUI-YI ZENG, LICHANG XIA, CHUANJUN		
IPC分类号	H01L51/00 C09K11/06 C07F15/00 C07D239/70 C07D209/82 C07D333/76 H01L51/50		
CPC分类号	H01L51/0067 C07F15/0033 C09K11/06 H01L51/0085 H01L51/0094 H01L51/0068 H01L51/0073 C07D239/70 H01L51/5016 C07D333/76 H01L51/0071 C09K2211/1088 C09K2211/185 C09K2211/1007 C09K2211/1029 C07D209/82		
代理机构(译)	DUANE MORRIS LLP		
审查员(译)	LOEWE，ROBERT小号		
优先权	62/352119 2016-06-20 US		
其他公开文献	US20180097185A1		
外部链接	Espacenet		

摘要(译)

本发明包括用于金属配合物的一系列新的苯并稠合的杂环配体。 当掺入OLED时，这些络合物显示出有希望的光物理性能。



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