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(54) Title: PLATINUM (II) ISOQUINOLINE-PYRIDINE-BENZENE BASED COMPLEXES, PREPARING METHOD THEREOF, AND ORGANIC LIGHT-EMITTING DIODES MADE THEREFROM

(57) Abstract: Organometallic complexes comprising a tridentate isoquinoline-pyridine-benzene based ligand, a monodentate ligand and a platinum (II) center show high emission quantum efficiency and good thermal stability. Organic light-emitting diode made from organometallic complexes is also described.

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PLATINUM (II) ISOQUINOLINE-PYRIDINE-BENZENE BASED COMPLEXES, PREPARING METHOD THEREOF, AND ORGANIC LIGHT-EMITTING DIODES MADE THEREFROM

FIELD OF THE INVENTION

This invention relates novel platinum (II) complexes and their usage in organic light-emitting diodes (OLED). The platinum (II) complexes in the invention possess high emission quantum efficiency and good thermal stability. High efficiency single color and white OLEDs (WOLEDs) can be fabricated.

BACKGROUND OF THE INVENTION

Organic electroluminescence was first observed and studied in the 1960's (U. S. Patent No. 3,172,862). In the 1980's, a double-layer structure OLEDs (organic light emitting device) was disclosed by Tang (U.S. Patent No. 4,356,429; Appl. Phys. Lett. 1987, 51, 12, 913). This discovery was based on employing a multilayer structure including an emissive electron-transporting layer and a hole-transport layer of suitable organic materials. Alq_3 (q = deprotonated 8-hydroxyquinolinyl) was chosen as the emissive electron-transporting material. Since then, research on materials used in OLEDs has continued. OLEDs provide several advantages including: (1) low operating voltage; (2) thin, monolithic structure; (3) emitting light, rather than modulating light; (4) good luminous efficiency; (5) full color potential; and (6) high contrast and resolution. These advantages suggest possible use of OLEDs in flat panel displays.

Investigations on organic small molecules have been made in order to improve the performance of OLEDs. In general, fluorescent and phosphorescent materials are employed as light emitters in the emissive layer of OLEDs. Light emission from a fluorescent compound occurs as a result of formation of singlet excitons in the emissive layer of the electroluminescent device. U.S. Published Patent App. No. 2003/178619 B2 disclosed that theoretically 25 % singlet excitons and 75 % triplet excitons are produced after recombination of holes and electrons in the emissive layer of an electroluminescent device. The singlet excitons transfer their energy to the singlet excited state while the triplet excitons transfer their energy to triplet excited state. Most of the organic small molecules exhibit fluorescence; hence, only 25 % of the generated excitons are utilized resulting in the device with low external efficiency.

Electroluminescence from conjugated polymers was first discovered by Friend et al. at Cambridge University during an investigation on the electrical properties of poly(p-phenylene vinylene) (PPV) in 1990 (Nature 1990, 347, 539). Yellow-green light with emission maximum at 551 nm was observed from this bright yellow polymer when excited by a flow of electric current between two electrodes. To deal with the solubility problem, Heeger et al. subsequently fabricated a PLED using soluble PPV derivative. (Appl. Phys. Lett. 1991, 1982).

As PLEDs can be used for large area flat panel displays and are relatively inexpensive, it has been receiving a growing attention in recent years. In the early stage, PLEDs were usually fabricated by spin coating. However, there are many disadvantages associated with this spin coating such as solution wastage and lack of lateral patterning capability, thus limiting the commercial applications of PLEDs. To overcome these drawbacks, inkjet printing has been introduced by Yang et al. (Appl.

Phys. Lett. 1998, 2561) and now PLEDs can be fabricated using a commercial available inkjet printer.

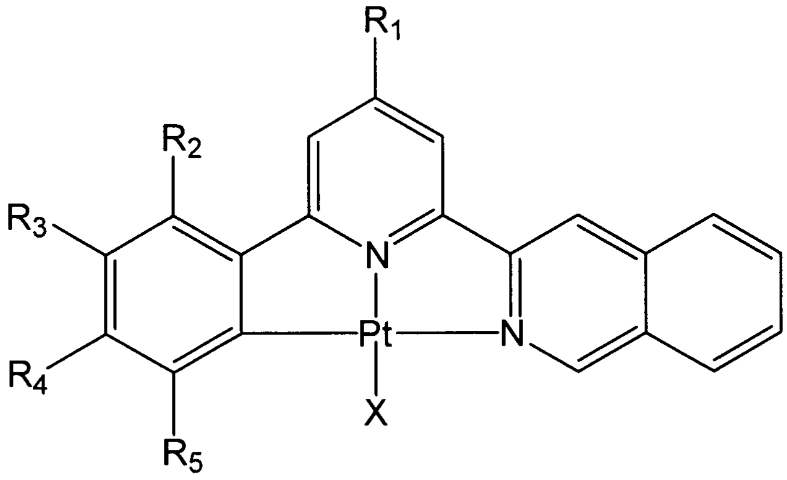
In recent years, red-, green- and blue-light emitting polymers have been actively employed for the fabrication of full color panels. However, the commercial applications of the presently known polymers such as poly(p-phenylene) (PPP), PPV, polythiophene (PT), and polyfluorene (PF) are hampered by their oxidative stabilities and/or structural and electronic properties. Although PPV-based materials demonstrate high PL and EL efficiencies and their emission energies are tunable, they usually undergo photo-oxidative degradation upon incorporation into EL devices (Angew. Chem. Int. Ed. 1998, 37, 403). The applications of PPP are limited by its low solubility. PF is a blue-emitting material, which shows good thermal stability and high EL quantum efficiency, but chain aggregation and keto-defect sites in the polymer can cause degradation of EL devices (J. Mater. Chem. 2000, 10, 1471). Also, light-emitting polymers present technical problems in the fabrication of LEDs, including color impurity, imbalanced charge injection, and low EL efficiencies.

In contrast to fluorescent compounds, a series of effective phosphorescent iridium complexes with different color emissions has been reported jointly by Thompson et al. at the University of Southern California and Forrest et al. at Princeton University (U.S. Patent No. 6,515,298; J. Am. Chem. Soc. 2001, 123, 4304; Adv. Mat. 2001, 13, 1245). Che et al. also demonstrated the use of organic metal complexes employing various metal centers such as platinum (II), copper (I), gold (I), and zinc (II) as OLED emitters (U.S. Published Patent Application No. 2005/244672 A1; Chem. Eur. J. 2003, 9, 1263; Chem. Commun., 2002, 206; New J. Chem. 1999, 263; Appl. Phys. Lett., 1999, 74, 1361; Chem. Commun. 1998, 2101; Chem. Commun. 1998, 2491).

Recently, phosphorescent metal-organic materials, which have demonstrated a tremendous success in the development of high performance OLEDs through vacuum deposition process, have been attached to polymer backbones to make new class of light emitting polymers some of the recent examples are: Sky-blue emitting devices by Holdcroft et al. (Macromolecules 2006, 9157) and red-emitting devices by Cao et al. (Organometallics 2007, 26, 3699) In 2006, Thompson and co-workers reported high efficiency green light-emitting PLED with a maximum of external quantum efficiency (EQE) of 10.5 %. (Chem. Mater. 2006, 18, 386) Using this method, a near white light-emitting (CIE: 0.30, 0.43) PLED have been fabricated by using a polymer which has attached both blue and red emitting units on it (J. Am. Chem. Soc. 2004, 15388). As the polymeric materials used in the PLEDs have high molecular weight and soluble in common solvents, they are potential candidate for inkjet printing.

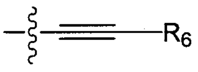
SUMMARY OF THE INVENTION

This invention relates to the preparation and application in organic light-emitting devices (OLEDs) of organometallic complexes having chemical structure of structure I:



Structure I

wherein R_1 – R_5 are independently hydrogen, halogen, hydroxyl, an unsubstituted alkyl, a substituted alkyl, cycloalkyl, an unsubstituted aryl, a substituted aryl, acyl, alkoxy, acyloxy, amino, nitro, acylamino, aralkyl, cyano, carboxyl, thio, styryl, aminocarbonyl, carbamoyl, aryloxycarbonyl, phenoxycarbonyl, or an alkoxycarbonyl group; X is halogen,



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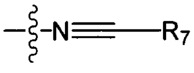

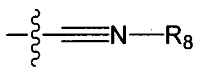

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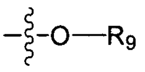

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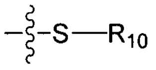

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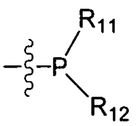

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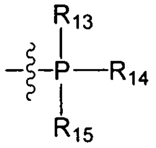

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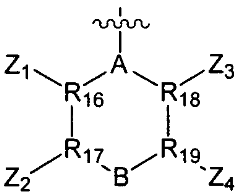
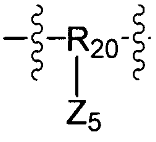


wherein A is carbon, nitrogen, oxygen, silicon, phosphorus, sulphur, arsenic and selenium; B is a chemical bonding connecting R_{17} and R_{19},



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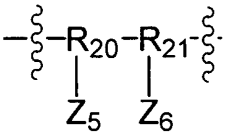

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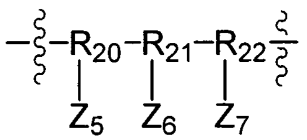

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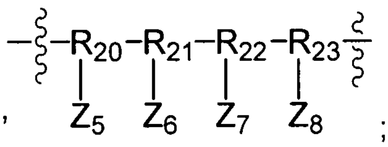


;

R_6–R_{15} are independently hydrogen, alkyl, substituted alkyl, cycloalkyl, aryl, and substituted aryl group; R_{16} – R_{23} are independently carbon, nitrogen, oxygen, silicon, phosphorus, sulphur, arsenic and selenium; Z_1 – Z_8 are independently hydrogen, alkyl, substituted alkyl, cycloalkyl, aryl, substituted aryl group and Z_1 – Z_8 can form 5 – 7 member ring(s) with neighboring groups. The invention also provides ligands useful for making such complexes.

The invention further provides a method for making such organic metallic complexes, OLEDs incorporating same and methods for making such OLEDs.

The invention also provides compositions useful in making organic metallic complexes, methods for making such complexes, OLEDS including such complexes, and methods for making such OLEDS.

For the purposes of the present application, the terms halogen, alkyl, cycloalkyl, aryl, acyl and alkoxy may have the following meanings:

The halogen or halo used herein includes fluorine, chlorine, bromine and iodine, preferably F, Cl, Br, particularly preferably F or Cl.

The aryl group or aryl moiety as used herein includes aryl having from 6 to 30 carbon atoms, preferably from 6 to 18 carbon atoms, and is made up of an aromatic ring or a plurality of fused aromatic rings. Suitable aryls are, for example, phenyl, naphthyl, acenaphthenyl, acenaphthylenyl, anthracenyl, fluorenyl, phenalenyl, phenanthrenyl. This aryl can be unsubstituted (i.e. all carbon atoms which are capable of substitution bear hydrogen atoms) or be substituted on one, more than one or all substitutable positions of the aryl. Suitable substituents are, for example, halogen, preferably F, Br or Cl, alkyl radicals, preferably alkyl radicals having from 1 to 8 carbon atoms, particularly preferably methyl, ethyl, i-propyl or t-butyl, aryl radicals, preferably C_6-aryl radicals or fluorenyl, which may once again be substituted or unsubstituted, heteroaryl radicals, preferably heteroaryl radicals containing at least one nitrogen atom, particularly preferably pyridyl radicals, alkenyl radicals, preferably alkenyl radicals which have one double bond, particularly preferably alkenyl radicals having a double bond and from 1 to 8 carbon atoms, or groups having a donor or acceptor action. For the purposes of the present invention, groups having a donor action are groups which display a +1 and/or +M effect, and groups having an acceptor action are groups which display a -I and/or -M effect. Suitable groups having a donor or acceptor action are halogen radicals, preferably F, Cl, Br, particularly preferably F, alkoxy radicals, carbonyl radicals, ester radicals, amine radicals, amide radicals, CH_2F groups, CHF_2 groups, CF_3 groups, CN groups, thio groups or SCN groups. The aryl radicals very particularly preferably bear substituents selected from the group consisting of methyl, F, Cl and alkoxy, or the aryl radicals are unsubstituted. Preference is given to the aryl radical or the aryl group being a C_6-aryl radical which may optionally be substituted by at least one of the abovementioned substituents. The C_6-aryl radical particularly preferably bears none, one or two of the abovementioned substituents, with the one substituent preferably being located in the para position relative to the further linkage point of the aryl radical and, in the case of two substituents, these are each located in the meta position relative to the further linkage point of the aryl radical. The C_6-aryl radical is very particularly preferably an unsubstituted phenyl radical. The aryl or aryl moiety as used herein is preferably fluorenyl or phenyl, which may be unsubstituted or substituted by the abovementioned substituents, preferably halogen, alkyl or unsubstituted or substituted fluorenyl as used herein.

The alkyl or alkyl moiety used herein includes alkyl having from 1 to 20 carbon atoms, preferably from 1 to 10 carbon atoms, particularly preferably from 1 to 6 carbon atoms. This alkyl can be branched or unbranched and may be interrupted by one or more heteroatoms, preferably N, O or S. Furthermore, this alkyl may be substituted by one or more of the substituents mentioned in respect of the aryl groups. For example, possible substituted alkyl includes trifluoromethyl group. It is likewise possible for the alkyl radical to bear one or more aryl groups. All the mentioned aryl groups are suitable for this purpose. The alkyl radicals are particularly preferably selected from the group consisting of methyl, ethyl, i-propyl, n-propyl, i-butyl, n-butyl, t-butyl, sec-butyl, i-pentyl, n-pentyl, sec-pentyl, neopentyl, n-hexyl, i-hexyl and sec-hexyl. Very particular preference is given to methyl, i-propyl and n-hexyl.

The cycloalkyl as used herein contemplates cyclic alkyl radicals. Preferred cycloalkyl groups are those containing 3 to 7 carbon atoms and includes cyclopropyl, cyclopentyl, cyclohexyl, and the like. Additionally, the cycloalkyl group may be optionally substituted with one or more substituents selected from halo, CN, CO_2R, C(O)R, NR_2, cyclic-amino, NO_2, and OR.

The acyl as used herein is an alkyl group as used herein that is attached to the CO group with a single bond.

The alkoxy is an alkyl group as used herein linked to oxygen.

BRIEF DESCRIPTION OF DRAWINGS AND FIGURES

Further features and advantages of the invention will become apparent by reviewing the following detailed description of the preferred embodiments, taken in conjunction with the attached drawings in which:

Figure 1 is a schematic drawing of a configuration of organic light-emitting diode;

Figure 2 is a current density, voltage and brightness (J-V-B) relationship graph for device A;

Figure 3 is an external quantum efficiency, current density relation graph for device A.

Figure 4 is an electroluminescence spectrum for device A;

Figure 5 is a current density, voltage and brightness (J-V-B) relationship graph for device B;

Figure 6 is an external quantum efficiency, current density relation graph for device B;

Figure 7 is an electroluminescence spectrum for device B;

Figure 8 is a current density, voltage and brightness (J-V-B) relationship graph for device C;

Figure 9 is an external quantum efficiency, current density relation graph for device C;

Figure 10 is an electroluminescence spectrum for device C;

Figure 11 is a current density, voltage and brightness (J-V-B) relationship graph for device D;

Figure 12 is an external quantum efficiency, current density relation graph for device D;

Figure 13 is an electroluminescence spectrum for device D;

Figure 14 is a current density, voltage and brightness (J-V-B) relationship graph for device E;

Figure 15 is an external quantum efficiency, current density relation graph for device E;

Figure 16 is an electroluminescence spectrum for device E;

Figure 17 is a current density, voltage and brightness (J-V-B) relationship graph for device F;

Figure 18 is an external quantum efficiency, current density relation graph for device F.

Figure 19 is an electroluminescence spectrum for device F;

Figure 20 is a current density, voltage and brightness (J-V-B) relationship graph for device G;

Figure 21 is an external quantum efficiency, current density relation graph for device G;

Figure 22 is an electroluminescence spectrum for device G;

Figure 23 is a current density, voltage and brightness (J-V-B) relationship graph for device H~~p~~;

Figure 24 is external quantum efficiency, current density relation graph for device H;

Figure 25 is an electroluminescence spectrum for device H;

Figure 26 is a current density, voltage and brightness (J-V-B) relationship graph for device I;

Figure 27 is external quantum efficiency, current density relation graph for device I; and

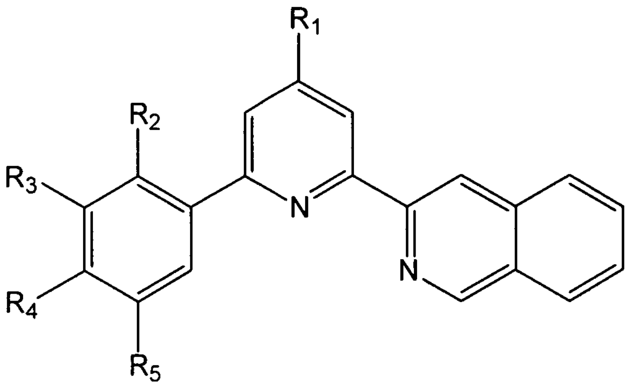
Figure 28 is an electroluminescence spectrum for device I.

DETAILED DESCRIPTION OF INVENTION

The organometallic complexes with the chemical structure of Structure I are referred to as cyclometallated complexes. The platinum center in Structure I (see above) is in +2 oxidation state and has a square planar geometry.

The coordination sites of the platinum center are occupied by one tridentate ligand and one mono-dentate ligand. The tridentate ligand coordinates to the platinum center through two nitrogen donor bonds and a metal-carbon bond where the nitrogen donors are from pyridine and isoquinoline groups and the metal-carbon bond is formed by benzene or substituted benzene and platinum. The tridentate ligand bears a formal negative charge localized at the site of a metal-carbon bond.

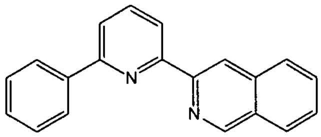
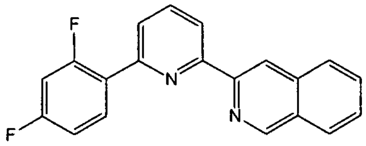
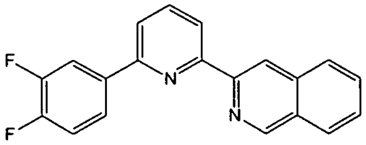
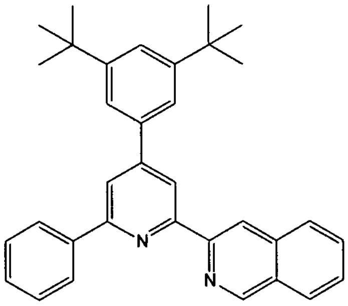
The tridentate ligand is represented by Structure II:

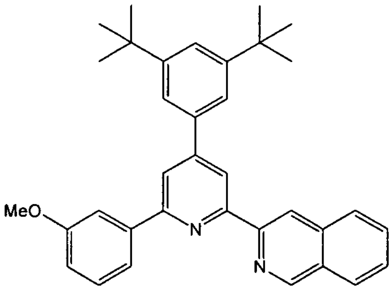
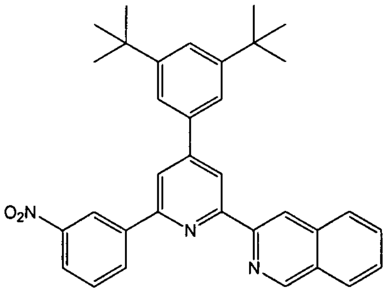
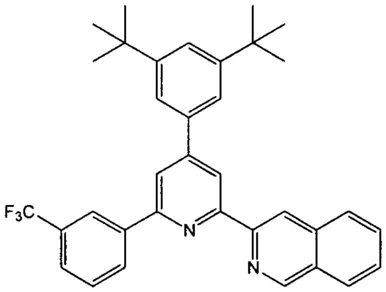
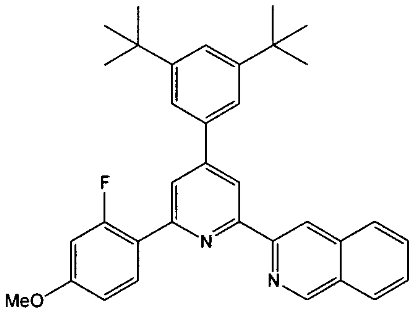
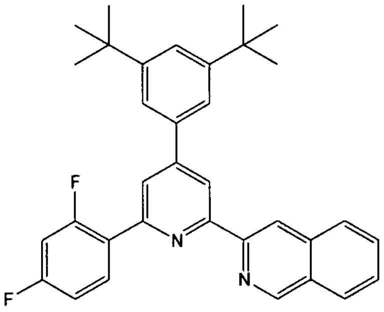
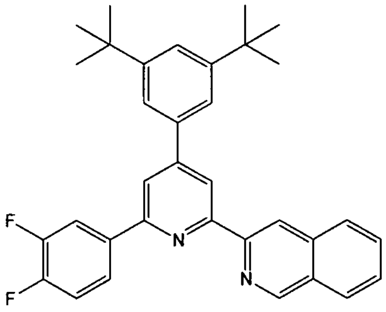
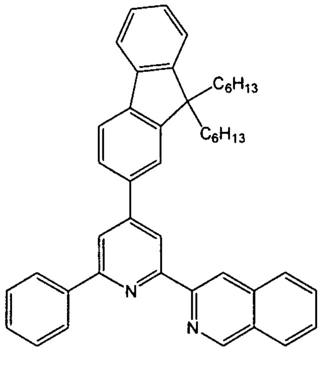
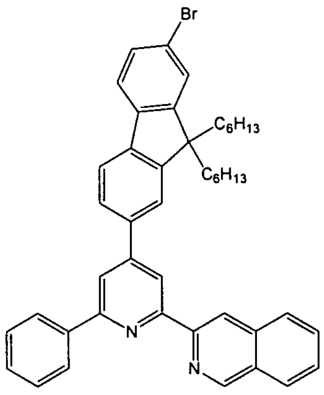


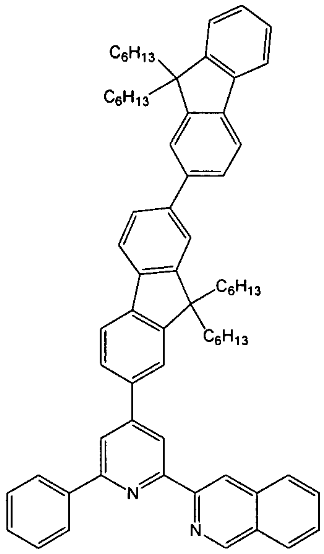
Structure II

wherein $R_1 - R_5$ are independently hydrogen, halogen, hydroxyl, an unsubstituted alkyl, a substituted alkyl, cycloalkyl, an unsubstituted aryl, a substituted aryl, acyl, alkoxy, acyloxy, amino, nitro, acylamino, aralkyl, cyano, carboxyl, thio, styryl, aminocarbonyl, carbamoyl, aryloxycarbonyl, phenoxycarbonyl, or an alkoxycarbonyl group.

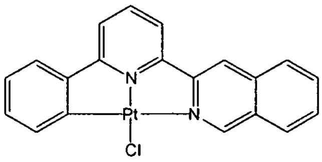
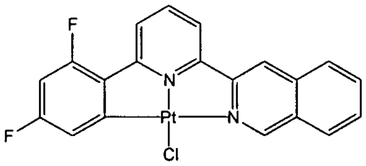
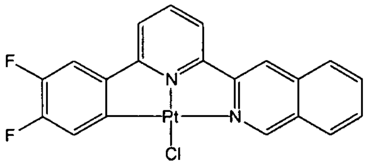
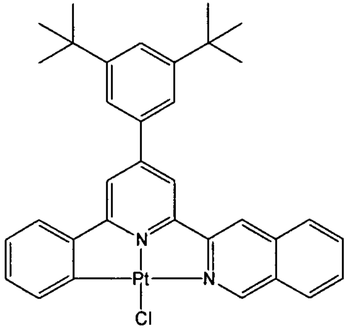
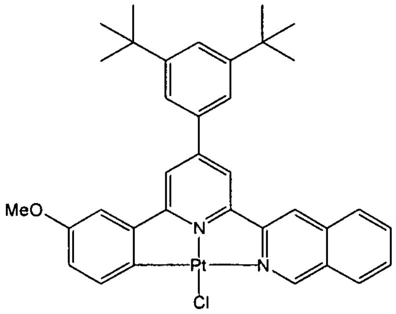
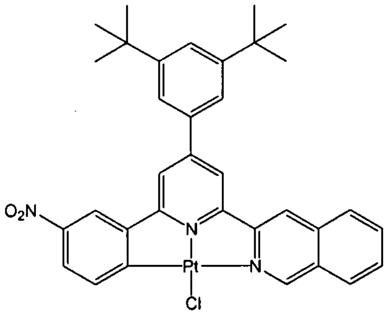
Representative examples of the tridentate ligand are shown below:

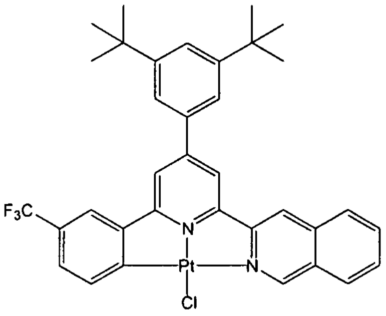
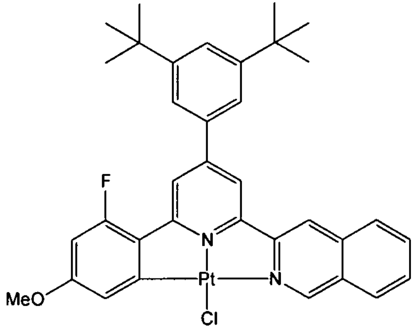
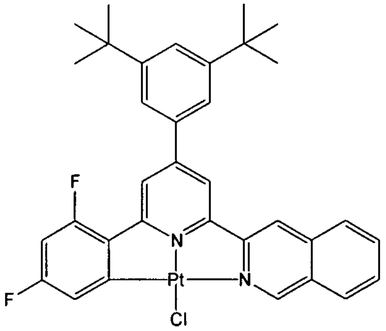
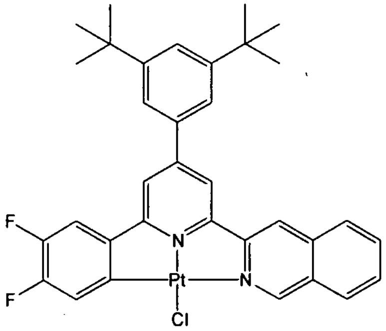
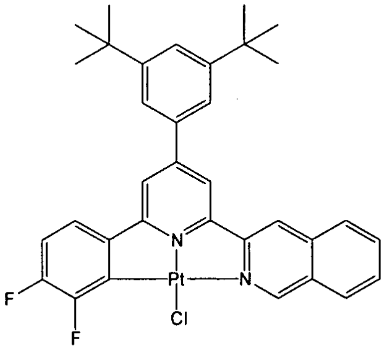
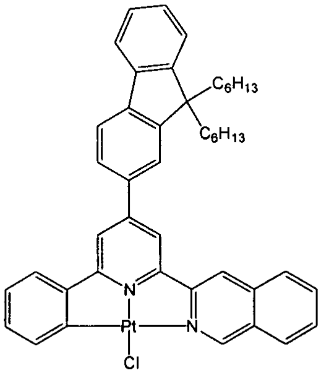
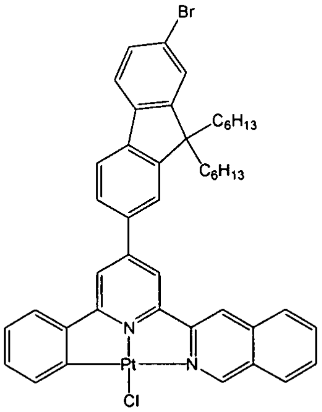
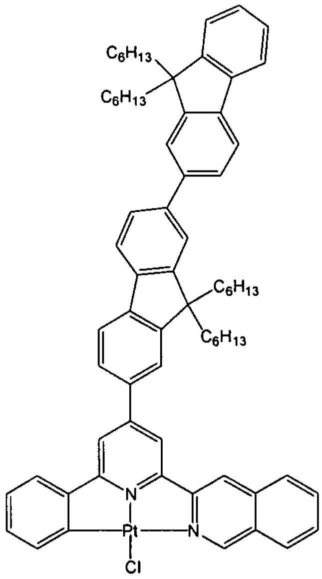
 Ligand 1	 Ligand 2
 Ligand 3	 Ligand 4

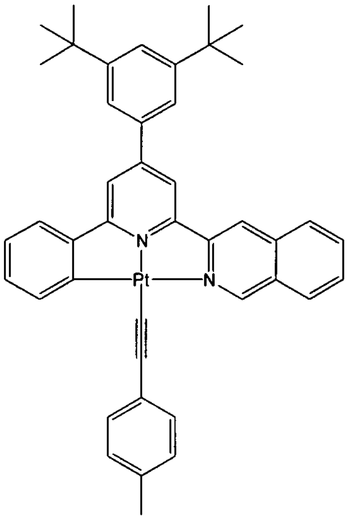
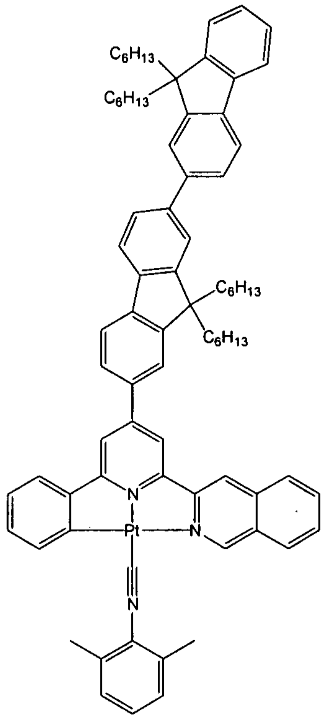
 Ligand 5	 Ligand 6
 Ligand 7	 Ligand 8
 Ligand 9	 Ligand 10
 Ligand 11	 Ligand 12

 Ligand 13	

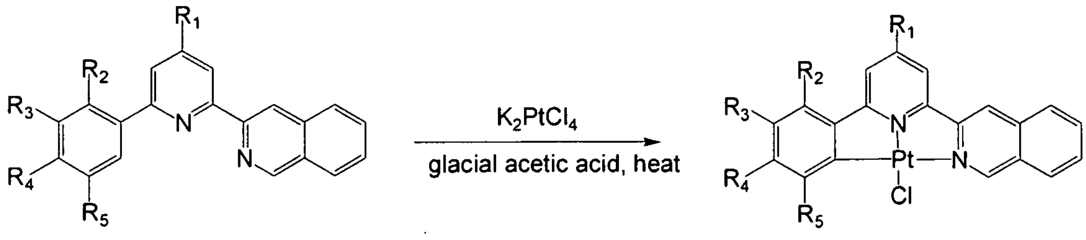
Representative examples of the platinum (II) complexes (Complexes 1 – 16) based on Structure I are shown below:

 Complex 1	 Complex 2
 Complex 3	 Complex 4
 Complex 5	 Complex 6

 Complex 7	 Complex 8
 Complex 9	 Complex 10
 Complex 11	 Complex 12
	

Complex 13	Complex 14
	
Complex 15	Complex 16

In preferred embodiments, there is a general method for preparing platinum (II) complexes with corresponding ligands (Ligands 1 – 13) in the representative examples. To prepare of these platinum (II) complexes a mixture of potassium tetrachloroplatinate (K_2PtCl_4) and ligand (Ligands 1 – 13) in glacial acetic acid was refluxed for 24 hours gave a yellow suspension. The yellow solid was washed with water and acetone, and recrystallized in CH_2Cl_2 or DMF. Reaction I below illustrates the preferred use of acetic acid as solvent in forming neutral platinum complexes.



Reaction I

The present invention also relates to OLED comprising at least one emissive layer containing organometallic complex with chemical structure of Structure I. The organic light-emitting device according to the present invention may comprise (preferably in sequence): a transparent substrate; a transparent electrode; a hole transporting layer; an emissive layer comprising a host material doped with least one of the organometallic complex according to the present invention; a hole blocking layer; an electron transporting layer; a charge injection layer; and an electrode. The organic light-emitting device according to the present invention may comprise (preferably in sequence): a transparent substrate; a transparent electrode; a hole transporting layer; an emissive layer comprising a host material doped with at least one of the organometallic complexes according to the present invention; a hole transporting layer; an emissive layer comprising a blue to sky blue emitting material; a hole blocking layer; a charge injection layer; and an electrode. As shown in Figure 1, a typical device 100 has a transparent anode layer 120; a cathode layer 170; emissive layer 140; optional hole transporting layer 130; optional hole blocking layer 150 and optional electron transporting layer 160. Layer 110 is transparent substrate. The transparent substrate as used herein can be glass or plastic; rigid or flexible substrate.

The organometallic complexes of the invention are used in emissive layer 140. Layer 140 can be purely comprised of organometallic complex in the invention (100 weight % of organometallic complex) or mixing with host material in certain weight %. Preferably, the host material transport hole and/or electron and have wider band gap than the organometallic complexes in the invention. The host material can be polymeric material such as but not limited to poly (N-vinyl carbazole), polysilane and polyfluorene. It can also be a small molecule such as but not limited to CBP (4,4'-N,N'-dicarbazole-biphenyl) or tertiary aromatic amines.

The transparent anode layer as used herein such as layer 120 can comprise or can be made of materials containing metal, alloy, metal oxide or mixed-metal oxide such as indium-tin-oxide.

The hole transport layer as used herein such as layer 130 can comprise or is fabricated by organic materials such as but not limited to TPD (N,N'-Bis(3-methylphenyl)-N,N'-diphenylbenzidine), NPB (N,N'-di-1-naphthyl-N,N'-diphenyl-benzidine), TAPC (1,1-bis[(di-4-tolylamino)phenyl]cyclohexane), ETPD (N,N'-bis(4-methylphenyl)-N,N'-bis(4-ethylphenyl)-[1,1'-(3,3'-dimethyl)biphenyl]4,4'-diamine, CuPc (copper phthalocyanine), PVK (polyvinylcarbazole) and PEDOT (poly(3,4-ethylendioxythiophene).

The hole blocking layer as used herein such as layer 150 can comprise or is fabricated from organic materials with high electron mobility and low HOMO (highest occupied molecular orbital) level such as but not limited to BCP (2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline, bathocuproine) and $BAlq_3$ (*bis*(2-methyl-8-quinolinolato)(4-phenylphenolato)aluminum).

The electron transporting layer as used herein such as layer 160 can comprise or is fabricated by organic materials with high electron mobility such as but not limited to Alq_3 (*tris*(8-quinolinolato)aluminum), $BAlq_3$ (*bis*(2-methyl-8-quinolinolato)(4-phenylphenolato)aluminum), PBD (2-(4-biphenylyl)-5-(4-*tert*-butylphenyl)-1,3,4-oxadiazole) and TAZ (3-(4-biphenylyl)-4-phenyl-5-(4-*tert*-butylphenyl)-1,2,4-triazole).

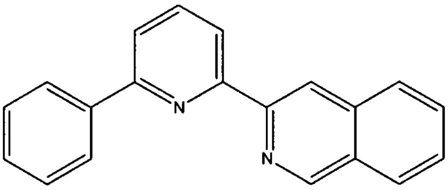
The cathode as used herein such as layer 170 can comprise or is fabricated by low work function metal such as but not limited to Ca, Al and Ba. The electrode as used herein can comprise the cathode as used herein and/or anode as used herein.

Examples

A number of examples are listed below to further illustrate the invention. They should not be construed to limit the invention in any way.

Example 1

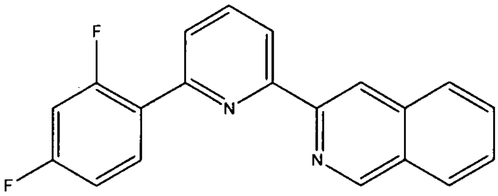
Synthetic procedure for Ligand 1:



Refluxing a methanol (100 mL) solution of 1.00 g (2.64 mmol) 1-(2-oxo-2-(3'-isoquinolinyl) ethyl) pyridinium iodide, 0.60 g (2.81 mmol) 3-Dimethylamino-1-(2'-pyridinyl)-propanone hydrochloride salt and 5.00 g (64.9 mmol) ammonium acetate for 24 hours give a suspension solution. The crude product was filtered from the solution mixture, washed with water and cold methanol, and purified by column chromatography. Yield: 0.64 g (86.0 %). ^{1}H NMR (500 MHz, $CDCl_3$) δ = 7.45 (t, J = 7.2 Hz, 1H), 7.55(t, J = 7.2 Hz, 2H), 7.63 (t, J = 7.3 Hz, 1H), 7.65 (t, J = 7.8 Hz 1H), 7.78 (d, J = 7.5 Hz, 1H), 7.93 (t, J = 7.8 Hz, 1H), 8.02 (d, J = 8.6 Hz, 2H), 8.21 (d, J = 6.3 Hz, 2H), 8.49 (d, J = 7.8 Hz, 1H), 9.01 (s, 1H), 9.34 (s, 1H). EI-MS (+ve, m/z): 282 [M^+].

Example 2

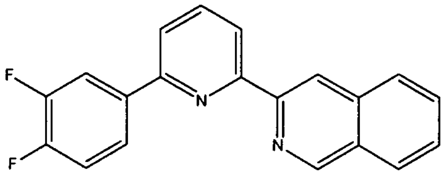
Synthetic procedure for Ligand 2:



A solution of 3-acetylisoquinoline (0.84 g, 4.94 mmol) and potassium tert-butoxide (0.83 g, 7.40 mmol) in THF (30 ml) was stirred for 2 hr at room temperature to give a yellow suspension. A solution of 1-*N*,*N*-dimethylamino-3-(2',4'-difluorophenyl) -3-oxo-1-propene (1.04g, 4.94 mmol) in THF (20 ml) was then added and the mixture was stirred for 12 hr at room temperature to give a dark red solution. A solution of ammonium acetate (26.0 g, 0.34 mol) in acetate acid (100 ml) was added to the mixture. THF was removed by distillation over 2 hr and the residue was dried under vacuum. Dichloromethane (50 ml) was added to yield a red solution, which was neutralized with saturated sodium bicarbonate solution then extracted with CH_2Cl_2. The organic extract was dried over sodium sulphate. Purification was performed by silica gel chromatography using n-hexane: ethyl acetate (9:1) as eluent to give pale yellow solid. Yield: 0.94 (60%) ^{1}H NMR (500 MHz, $CDCl_3$) δ = 7.09 (m, 1H), 7.11 (m, 1H), 7.62 (t, *J* = 5.51 Hz, 1H), 7.71 (t, *J* = 8.05 Hz, 1H), 7.78 (d, *J* = 7.78 Hz, 1H), 7.92 (t, *J* = 7.83 Hz, 1H), 8.00 (d, *J* = 8.30 Hz, 1H), 8.01 (d, 8.2 Hz, 1H), 8.26 (m, 1H), 8.50 (d, *J* = 7.6 Hz, 1H), 8.90 (s, 1H), 9.34 (s, 1H). EI-MS (+ve, m/z): 319.2[M^+].

Example 3

Synthetic procedure for Ligand 3:



A solution of 3-acetylisoquinoline (1.00 g, 5.84 mmol) and potassium tert-butoxide (0.98 g, 8.76 mmol) in THF (30 ml) was stirred for 2 hr at room temperature to give a yellow suspension. A solution of 1-*N*,*N*-dimethylamino-3-(3',4'-difluorophenyl)-3-oxo-1-propene (1.23g, 5.84 mmol) in THF (20 ml) was then added and the mixture was stirred for 12 hr at room temperature to give a dark red solution. A solution of ammonium acetate (26.0 g, 0.34 mol) in acetate acid (100 ml) was added to the mixture. THF was removed by distillation over 2 hr and the residue was dried under vacuum. Dichloromethane (50 ml) was added to yield a red solution, which was neutralized with saturated sodium bicarbonate solution then extracted with CH_2Cl_2. The organic extract was dried over sodium sulphate. Purification was performed by silica gel chromatography using n-hexane: ethyl acetate (9:1) as eluent to give pale yellow solid. Yield: 0.93 g (50 %). ^{1}H NMR (500 MHz, $CDCl_3$, 25°C). δ = 7.32 (q, 1H), 7.65 (t, 1H), 7.72 (d, 1H), 7.75 (t, 1H), 7.90 (m, 1H), 8.00 (t, 2H), 8.11 (t, 1H), 8.51 (d, 1H), 8.96 (s, 1H), 9.34 (s, 1H). ^{13}C NMR (150 MHz, $CDCl_3$, 25 °C): δ = 156.3, 154.4, 152.1, 149.7, 140.0, 136.6, 130.6, 128.9, 127.8, 127.7, 127.6, 122.9(3), 122.8, 120.0, 119.6, 117.8, 117.4 (d, J = 17.25 Hz), 116.1 (d, J = 18.15 Hz) EI-MS (+ve, m/z): 319.1[M^+].

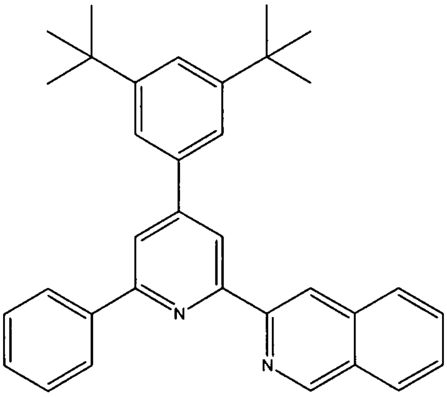
Example 4

General synthetic procedures for Ligands 4 – 10.

Refluxing a methanol mixture of 1-(2-oxo-2-(3'-isoquinolinyl) ethyl) pyridinium iodide, excess ammonium acetate and the corresponding α,β-unsaturated ketone for 24 hours gave a suspension mixture. The crude product was filtered from the solution mixture, washed with water and cold methanol, and purified by column chromatography (silica gel, *n*-hexane/Et_2O = 8:1 as eluent).

Example 5

Synthetic procedure for Ligand 4:

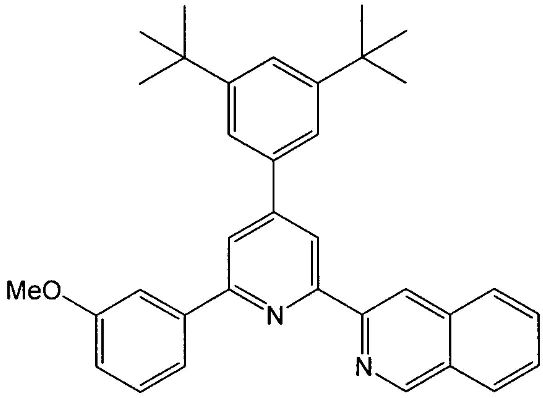


Ligand 4 was synthesized by general procedures in Example 4 with 1.00 g (2.64 mmol) 1-(2-oxo-2-(3'-isoquinolinyl)ethyl)pyridinium iodide, 0.85 g (2.65 mmol) 3',5'-di-tert-butylbenzylidene-2-acetophenone, 5.00g (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 4 was obtained as yellow solid. Yield 1.11 g (89.0 %). ^{1}H NMR (500 MHz, $CDCl_3$, 25 °C) δ = 1.47 (s, 18H), 7.51 (m, 1H), 7.58 (m, 3H), 7.65 (t, *J* = 7.8 Hz, 3H), 7.75 (t, *J* = 7.8 Hz, 1H,), 7.90 (s, 1H), 8.01 (m, 2H), 8.23 (d, *J* = 7.5 Hz, 2H), 8.80 (s, 1H), 9.10 (s, 1H), 9.32 (s, 1H). ^{13}C NMR (500 MHz, $CDCl_3$, 25 °C): δ = 31.6, 35.1, 118.1, 118.3, 118.9, 121.7, 123.1, 127.3, 127.5, 127.6, 127.8, 128.3, 128.6, 128.8, 129.0, 130.5, 133.1, 136.7, 138.7, 139.9, 150.3, 151.9. 152.0, 156.5.

EI-MS (+ve, m/z): 471 [M$^+$].

Example 6

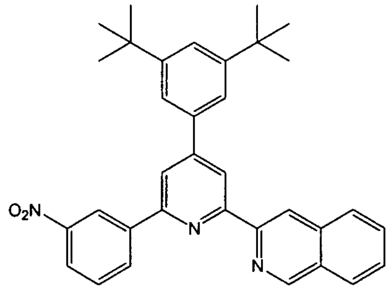
Synthetic procedure for Ligand 5:



Ligand 5 was synthesized by general procedures in Example 4 with 0.75 g (1.97 mmol) 1-(2-oxo-2-(3'-isoquinolinyl) ethyl) pyridinium iodide, 0.69 g (1.97 mmol) 3',5'-di-tert-butylbenzylidene-2-(1-aceto-3-methoxyphenone), 5.00g, (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 5 was obtained as yellow solid. Yield 0.81 g (82.0 %). ^{1}H NMR (500MHz, $CDCl_3$, 25°C) δ = 1.47 (s, 18H), 3.97 (s, 3H), 7.10 (d, J = 9.4 Hz, 1H), 7.52 (t, J = 7.8 Hz,1H), 7.61 (s, 1H), 7.65 (s, 2H), 7.68 (t, J = 7.8 Hz, 1H), 7.79 (t, J = 7.8 Hz, 1H), 7.82 (d, J = 7.5 Hz, 1H), 7.87 (s, 1H), 7.97 (s, 1H) , 8.04 (d, J = 8.6 Hz, 2H), 8.72 (s, 1H), 9.00 (s, 1H), 9.35 (s, 1H). ^{13}C NMR (500 MHz, $CDCl_3$, 25 °C): δ = 31.6, 35.1, 55.5, 113.2, 114.3, 118.1, 118.5, 119.1, 119.8, 121.7, 123.1, 127.5, 127.6, 127.8, 128.8, 129.8, 130.5, 136.7, 138.7, 141.5, 150.3, 151.6, 151.9, 152.0. EI-MS (+ve, m/z): 501 [M$^+$].

Example 7

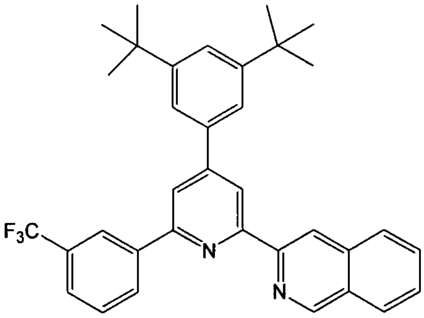
Synthetic procedure for Ligand 6:



Ligand 6 was synthesized by general procedures in Example 4 with 1.32 g (3.51 mmol) 1-(2-oxo-2-(3'-isoquinolinyl) ethyl) pyridinium iodide, 1.28 g (3.5 mmol) (*E*)-3-(3,5-di-*tert*-butylphenyl)-1-(3-nitrophenyl)prop-2-en-1-one, 5.00g (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 6 was obtained as yellow solid. Yield: 1.12 g (62 %). ^{1}H NMR (600 MHz, $CDCl_3$, 25 °C) δ = 1.44 (s, 18H), 7.59 (d, *J* = 1.5 Hz, 1H), 7.61 (d, *J* = 1.62 Hz, 2H), 7.66 (t, *J* = 7.80 Hz), 7.75 (m, 2H), 7.98 (d, J = 1.2 Hz, 1H), 8.06 (d, *J* = 8.10 Hz, 1H), 8.09 (d, *J* = 8.16 Hz, 1H), 8.34 (d, *J* = 6.12 Hz, 1H), 8.60 (d, *J* = 7.68 Hz, 1H), 8.81 (s, 1H), 9.04 (s, 1H). 9.12 (t, *J* = 1.62 Hz, 1H), 9.38 (s, 1H). FAB-MS (+ve, m/z): 516.4[M^+].

Example 8

Synthetic procedure for Ligand 7:

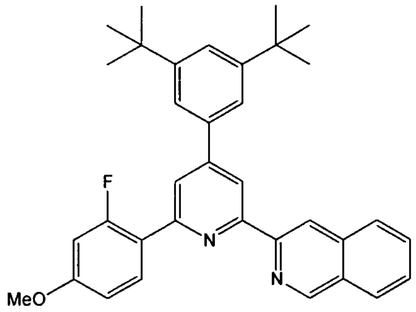


Ligand 7 was synthesized by general procedures in Example 4 with 0.87 g (2.3 mmol) 1-(2-oxo-2-(3'-isoquinolinyl) ethyl)pyridinium iodide, 0.89 g (2.3 mmol)

3',5'-di-tert-butylbenzylidene-2-(1-aceto-3-trifluromethylphenone), 5.00 g (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 7 was obtained as yellow solid. Yield 1.05 g (85.0 %). ^{1}H NMR (500 MHz, CDCl$_3$, 25 °C). δ= 1.47 (s, 18H), 7.60 (s, 1H), 7.63 (s, 2H), 7.68 (t, *J* = 7.8 Hz, 1H), 7.72 (t, *J* = 7.8 Hz, 1H), 7.80 (m, 2H), 8.00 (s, 1H), 8.10 (t, *J* = 8.4 Hz 2H), 8.47 (d, *J* = 7.5 Hz, 1H), 8.55 (s, 1H), 8.80 (s, 1H), 9.00 (s, 1H), 9.35 (s, 1H). ^{13}C NMR (500 MHz, CDCl$_3$, 25 °C): δ = 31.6, 35.1, 118.2, 119.0, 121.7, 123.3, 124.1, 124.2, 125.4, 125.5, 127.6, 127.7, 127.9, 128.9, 129.2, 130.5, 130.6, 130.9, 131.1, 131.4, 131.6, 136.7, 138.5, 140.7, 150.0, 152.1, 151.6. EI-MS (+ve, m/z): 539 [M$^+$].

Example 9

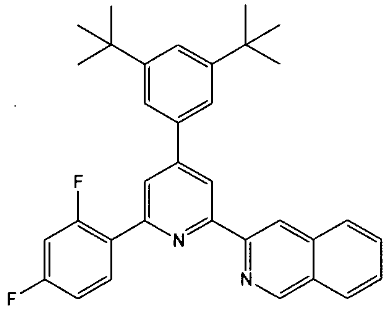
Synthetic procedure for Ligand 8:



Ligand 8 was synthesized by general procedures in Example 4 with 0.62 g (1.62 mmol) 1-(2-oxo-2-(3'-isoquinolinyl)ethyl)pyridinium iodide, 0.52 g (1.62 mmol)(*E*)-3-(3,5-di-tert-butylphenyl)-(2-fluoro-4methoxyphenyl)prop-2-en-1- one, 5.00g, (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 8 was obtained as yellow solid. Yield: 0.50 g (60.0 %). ^{1}H NMR (500 MHz, CDCl$_3$). δ = 1.42 (s, 18H), 3.90 (s, 3H), 6.76 (d, *J* = 13 Hz, 1H), 6.93 (d, *J* = 6.68 Hz), 7.54 (s, 1H), 7.62 (m, 3H), 7.72 (t, *J* = 7.25 Hz, 1H), 8.00 (m, 3H), 8.27 (t, *J* = 8.9 Hz, 1H), 8.70 (d, *J* = 1.2 Hz, 1H), 8.98 (s, 1H), 9.37 (s, 1H). ^{13}C NMR (500 MHz, CDCl$_3$): δ = 31.7, 35.1, 55.7, 101.9, 102.1, 110.7, 117.9, 120.4, 121.8, 122.2, 123.0, 127.5, 127.8, 128.8, 130.5, 131.9, 132.0, 136.7, 138.6, 150.3, 151.4, 152.0, 153.1, 156.4, 160.6, 161.4, 161.5, 162.6. EI-MS (+ve, m/z): 519.4 [M^+].

Example 10

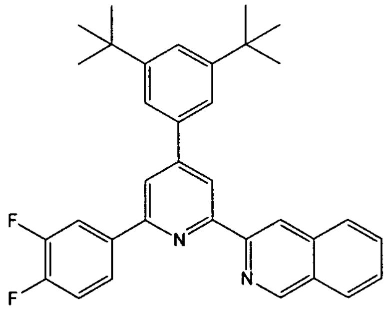
Synthetic procedure for Ligand 9:



Ligand 9 was synthesized by general procedures in Example 4 with 1.00 g (2.66 mmol) 1-(2-oxo-2-(3'-isoquinolinyl) ethyl) pyridinium iodide, 0.95 g (2.66 mmol) 3-(2,4-di-tert-butylphenyl)-(3,4-difluorophenyl)prop-2-en-1-one, 5.00 g, (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 9 was obtained as yellow solid. Yield: 1.35 g (70 %).

Example 11

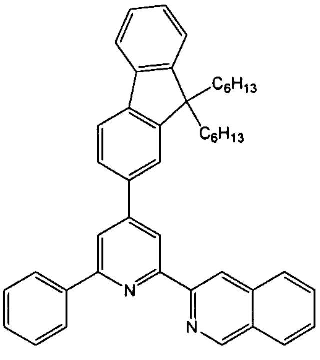
Synthetic procedure for Ligand 10:



Ligand 10 was synthesized by general procedures in Example 4 with 1.48 g (3.93 mmol) 1-(2-oxo-2-(3'-isoquinolinyl) ethyl) pyridinium iodide, 1.40 g (3.93 mmol) 3-(3,5-di-tert-butylphenyl)-(3,4-difluorophenyl)prop-2-en-1-one, 5.00g, (64.9 mmol) ammonium acetate and 100 mL methanol. Ligand 10 was obtained as yellow solid. Yield: 1.60 g (80.0 %). ^{1}H NMR (500 MHz, $CDCl_3$). δ= 1.43 (s, 18 H), 7.30-7.36 (m, 1H), 7.56 (s, 1H), 7.59 (s, 2H), 7.63 (t, J = 7.2 Hz, H), 7.77 (t, J = 8.0 Hz, H), 7.86 (s, 1H, H), 7.94-7.97 (m, 1H), 8.03 (d, J = 7.7 Hz, 1H), 8.06 (d, J = 7.8 Hz, 1H), 8.14-8.18 (m, 1H), 8.74 (s, 1H), 9.00 (s, 1H, H), 9.37 (s, 1H, H). 13C NMR (126 MHz, $CDCl_3$,25°C):δ= 31.7, 35.1, 116.3, 116.4, 117.4, 117.5, 118.1, 118.4, 118.8, 121.7, 123.0, 123.2, 127.6, 128.9, 130.6, 136.6, 137.0, 138.4, 149.8, 151.7, 151.8, 152.0, 152.2, 154.9, 156.7. ^{19}F NMR (376 MHz, $CDCl_3$, 25 °C): δ = -137.4, -137.7. FAB-MS (+ve, m/z): 507 [M^+].

Example 12

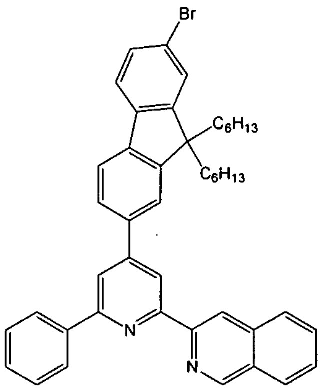
Synthetic procedure for Ligand 11:



Ligand 11 was synthesized by general procedures in Example 4 with 3.83 g (8.97 mmol) 1-(2-oxo-2-(3'-isoquinolinyl)ethyl)pyridinium iodide, 4.20 g (8.89 mmol) (E)-3-(9,9-dihexyl-9H-fluoren-2-yl)-1-phenylprop-2-en-1-one, 7.1 g (91 mmol) ammonium acetate and 550 mL methanol / dichloromethane (10:1 by volume) mixture . Ligand 11 was obtained as yellow oil. Yield: 4.35 g (82 %). ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.39 (s, 1H), 9.07 (s, 1H), 8.82 (s, 1H), 8.28 (d, *J* = 7.3 Hz, 2H), 8.03-8.06 (m, 3H), 7.84 (s, 2H), 7.73–7.79 (m, 3H), 7.64 (t, J = 7.0 Hz, 1H), 7.58 (t, J = 7.5 Hz, 2H), 7.49 (t, J = 7.5 Hz, 2H), 7.35–7.39 (m, 3H), 2.04–2.12 (m, 4H), 1.11–1.23 (m, 12H), 0.73–0.89 (m, 10H). FAB-MS (m/z): 614 [M$^+$].

Example 13

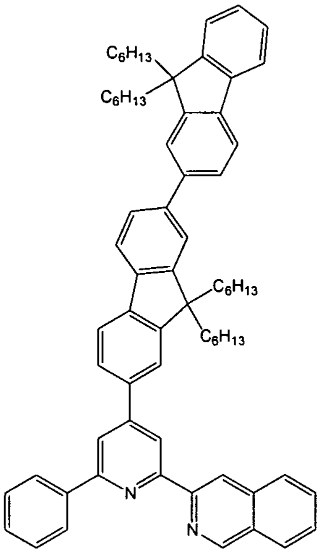
Synthetic procedure for Ligand 12:



Ligand 12 was synthesized by general procedures in Example 4 with 3.83 g (8.97 mmol) 1-(2-oxo-2-(3'-isoquinolinyl)ethyl)pyridinium iodide, 4.88 g (8.97 mmol) (*E*)-3-(7-bromo-9,9-dihexyl-9H-fluoren-2-yl)-1-phenylprop-2-en-1-one, 15.4 g, (0.20 mmol) ammonium acetate and 100 mL methanol / chloroform (10:1 by volume) mixture. Ligand 12 was obtained as yellow oil. Yield: 4.52 g (73 %). ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.39 (s, 1H), 9.08 (s, 1H), 8.81 (s, 1H), 8.28 (d, J = 8.5 Hz, 2H), 8.05 (d, J = 8.9 Hz, 2H), 8.01 (s, 1H), 7.74–7.86 (m, 4H), 7.61–7.67 (m, 2H), 7.59 (t, J = 7.6 Hz, 2H), 7.49–7.51 (m, 3H), 2.01–2.10 (m, 4H), 1.06–1.18 (m, 12H), 0.65–0.86 (m, 10H). FAB-MS (m/z): 694 [M$^+$].

Example 14

Synthetic procedure for Ligand 13:



2 M aqueous Na_2CO_3 solution (15 mL) were injected to a degassed toluene solution (150mL) of 1.03 g (1.48 mmol) Ligand 12, 0.17 g (0.154 mmol) tetrakis(triphenylphosphine) palladium(0) and 0.68 g, (1.48 mmol) 9,9-Di-*n*-hexylfluoren-2-yl-4,4,5,5-tetramethyl-[1,3,2]dioxaborolane by a syringe. The reaction mixture was stirred with 80°C for 12 h. The product was extracted with dichloromethane (3 × 100 mL), washed with water, and dried over $MgSO_4$. After evaporation of the solvent, the residue was purified by flash chromatography on silica gel using CH_2Cl_2 as eluent to obtain Ligand 13 as pale yellow oil. Yield: 0.89 g, 64 %. ^1H NMR (400 MHz, $CDCl_3$): δ 9.40 (s, 1H), 9.09 (s, 1H), 8.85 (s, 1H), 8.30 (d, *J* = 7.6 Hz, 2H), 8.04–8.06 (m, 3H), 7.63–7.88 (m, 12H), 7.59 (t, *J* = 7.6 Hz, 2H), 7.50 (t, *J* = 7.6 Hz, 1H), 7.30–7.38 (m, 3H), 2.12–2.17 (m, 4H), 2.02–2.07 (m, 4H), 1.02–1.18 (m, 24H),0.72–0.83 (m, 20H). FAB-MS (m/z): 947 [M^+].

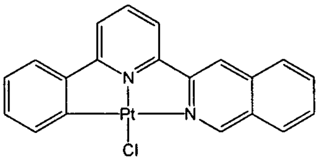
Example 15

General synthetic procedure for complexes 1 – 14.

A mixture of K_2PtCl_4 and ligands 1 – 14 in glacial acetic acid (100 ml) was refluxed for 48 hours to give complexes 1 to 14 as a yellow suspension. The yellow solid was filtered, washed with water and acetone and recrystallized in DMF.

Example 16

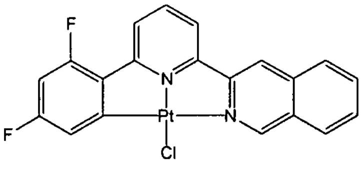
Synthetic procedure for complex 1:



Complex 1 was synthesized by general procedures in Example 15 with 0.42 g (1.01 mmol) K_2PtCl_4, 0.23g (0.82mmol) Ligand 1 and 100 ml glacial acetic acid. Complex 1 was obtained as yellow crystalline solid. Yield: 0.34g (80.0 %). ^1H NMR (400 MHz, DMF, 25 °C):δ = 7.12 (t, *J* = 6.9 Hz, 1H), 7.20 (t, *J* = 6.9 Hz, 1H), 7.68 (d, *J* = 6.6 Hz, 1H), 7.73 (d, *J* = 7.5 Hz, 1H), 7.97 (m, 1H), 8.11 (t, *J* = 7.3 Hz 1H), 8.22 (m, 4H), 8.54 (d, *J* = 7.5 Hz, 1H), 9.15 (s, 1H), 9.75 (s, 1H). ^{13}C NMR (500 MHz, $CDCl_3$, 25 °C): δ = 119.4, 123.1, 124.4, 125.2, 128.8, 130.0, 130.3, 130.7, 130.9, 131.4, 134.5, 135.3, 136.7, 140.1, 143.7, 148.0, 151.0, 152.7, 155.6, 163.2. FAB-MS (+ve, m/z): 512 [M^+].

Example 17

Synthetic procedure for complex 2:

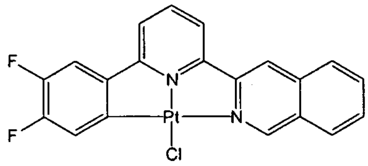


Complex 2 was synthesized by general procedures in Example 15 with 0.49 g (1.17

mmol) K_2PtCl_4, 0.31g (0.98mmol) Ligand 2 and 100 ml glacial acetic acid. Complex 2 was obtained as yellow crystalline solid. Yield: 0.43g (80.0 %). ^{1}H NMR (500 MHz, DMF) δ = 7.37 (t, *J* = 8.44 Hz, 1H), 7.44 (t, *J* = 9.98 Hz, 1H), 8.03 (d, *J* = 7.75 Hz, 1H), 8.11 (m, 1H), 8.32 (t, *J* = 7.6 Hz), 8.44 (d, *J* = 8.15 Hz, 1H), 8.67 (t, *J* = 7.85 Hz, 1H), 8.73 (d, *J* = 7.95 Hz, 1H), 8.92 (d, *J* = 8.13 Hz), 9.44 (s, 1H), 10.39 (s, 1H). ^{13}C NMR (500 MHz, $CDCl_3$): δ = 103.9, 104.0, 111.5, 121.8, 123.4, 128.4, 129.6, 130.2, 131.5, 134.0, 134.6, 135.9, 140.3, 151.2, 153.2, 157.4, 159.9, 162.7, 163.0, 164.1.

Example 18

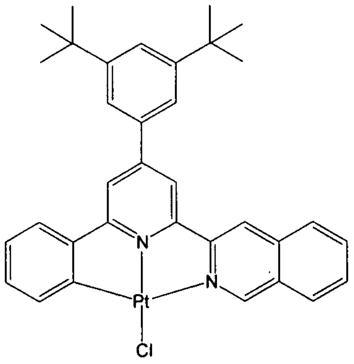
Synthetic procedure for complex 3:



Complex 3 was synthesized by general procedures in Example 15 with 0.78 g (1.88 mmol) K_2PtCl_4, 0.50g (1.57mmol) Ligand 3 and 100 ml glacial acetic acid. Complex 3 was obtained as yellowish green crystalline solid. Yield: 0.69g (80.0 %). FAB-MS (+ve, m/z): 512 [M-Cl$^+$].

Example 19

Synthetic procedure for complex 4:

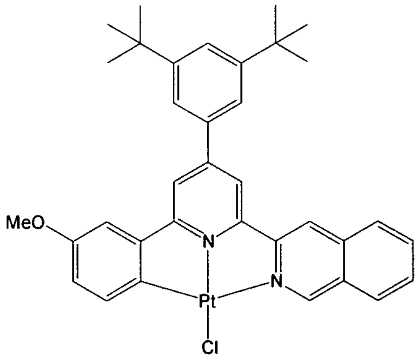


Complex 4 was synthesized by general procedures in Example 15 with 0.31 g (0.75

mmol) K_2PtCl_4, 0.29 g (0.62 mmol) Ligand 4 and 100 ml glacial acetic acid. Complex 4 was obtained as yellow crystalline solid. Yield: 0.39g (90.0 %). ^{1}H NMR (400 MHz, DMF, 25 °C): δ =1.47 (s, 18H), 7.10 (m, 2H), 7.67 (d, J = 6.6 Hz, 1H), 7.77 (s, 1H), 7.79 (d, J = 6.7 Hz, 1H), 7.92 (t, J = 7.3 Hz, 1H), 7.97 (s, 2H), 8.08 (t, J = 7.6 Hz, 1H), 8.12 (d, J = 4.2 Hz, 2H), 8.39 (d, J = 8.1 Hz, 1H), 8.54 (s, 1H), 9.27 (s, 1H), 9.65 (s, 1H). ^{13}C NMR (500 MHz, $CDCl_3$, 25 °C): δ = 31.5, 35.7, 117.4, 117.8, 122.7, 123.3, 123.4, 124.2, 124.7, 125.5, 128.7, 129.9, 130.2, 130.4, 131.2, 134.3, 135.2, 136.7, 137.9, 143.7, 148.2, 151.2, 152.5, 152.9, 155.5, 162.3. FAB-MS (+ve, m/z): 700 [M$^+$].

Example 20

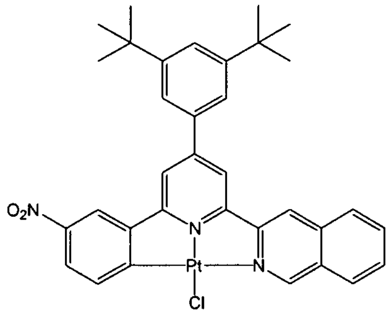
Synthetic procedure for complex 5:



Complex 5 was synthesized by general procedures in Example 15 with 0.37 g (0.90 mmol) K_2PtCl_4, 0.28 g (0.54 mmol) ligand 5 and 100 ml glacial acetic acid. Complex 5 was obtained as yellow crystalline solid. Yield: 0.28 g (70.0 %). ^{1}H NMR (500 MHz, DMF, 25°C): δ = 1.47 (s, 18H), 3.93 (s, 3H), 6.90 (d, J = 7.7 Hz, 1H), 7.54 (s, 1H), 7.60 (d, J = 8.3 Hz, 1H), 7.73 (s, 1H), 7.95 (m, 3H), 8.12 (t, J = 7.5 Hz, 1H), 8.17 (d, J = 8.1 Hz, 1H), 8.33 (s, 1H), 8.52 (d, J = 8.1 Hz, 1H), 8.58 (s, 1H), 9.32 (s, 1H), 9.75 (s, 1H). ^{13}C NMR (500 MHz, DMF, 25°C): δ = 31.6, 35.7, 111.6, 116.7, 117.7, 118.0, 122.8, 123.4, 124.7, 128.7, 129.9, 130.3, 131.3, 133.5, 134.3, 135.8, 136.6, 138.0, 148.7, 151.2, 152.3, 152.4, 153.1, 155.6, 158.1, 162.5 FAB-MS (+ve, m/z): 730 [M$^+$].

Example 21

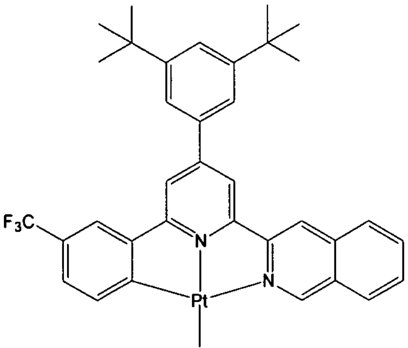
Synthetic procedure for complex 6:



Complex 6 was synthesized by general procedures in Example 15 with 0.17 g (0.45 mmol) K_2PtCl_4, 0.18 g (0.35 mmol) ligand 6 and 100 ml glacial acetic acid. Complex 6 was isolated as a yellow crystalline solid. Yield: 0.23 g (90.0 %). ^{1}H NMR (500 MHz, CD_2Cl_2, 25 °C): δ = 1.50 (s, 18H), 7.12 (s, 1H), 2.93 (m, 2H,), 7.44 (d, J = 7.55 Hz, 1H), 7.55 (t, J = 6.85 Hz, 1H), 7.66 (s, 2H), 7.70 (m, 3H), 7.76 (t, J = 7.15 Hz, 1H), 7.81 (d, J = 8.05 Hz, 1H), 8.13 (s, 1H), 8.91 (s, 1H). FAB-MS (+ve, m/z): 745.2[M^+].

Example 22

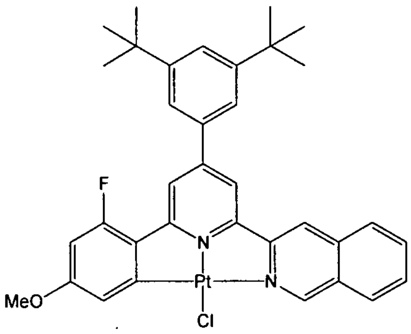
Synthetic procedure for complex 7:



Complex 7 was synthesized by general procedures in Example 15 with 0.19 g (0.46 mmol) K_2PtCl_4, 0.20 g (0.38 mmol) ligand 7 and 100 ml glacial acetic acid. Complex 5 was obtained as yellow crystalline solid. Yield: 0.20g (70.0%). ^{1}H NMR (500 MHz, DMF, 25 °C): δ = 1.47 (s, 18H), 7.37 (d, J = 7.7 Hz, 1H), 7.75 (s, 1H), 7.80 (d, J = 7.8 Hz, 1H), 7.90 (t, J = 7.1 Hz, 1H), 7.98 (s, 2H), 8.10 (m, 2H), 8.30 (d, J = 8.0 Hz, 1H), 8.40 (s, 2H), 8.60 (s, 1H), 9.25 (s, 1H), 9.50 (s, 1H). ^{13}C NMR (500 MHz. DMF, 25 °C): δ = 31.5, 35.7, 117.6, 118.4, 118.7, 121.4, 121.7, 121.9 , 122.1, 122.9, 123.3, 123.7, 124.9, 125.6, 126.4, 127.1, 128.8, 130.0, 131.4, 134.1, 134.5, 135.3, 136.7, 137.7, 142.3,146.2, 146.9, 162.7. FAB-MS (+ve, m/z): 768 [M$^+$].

Example 23

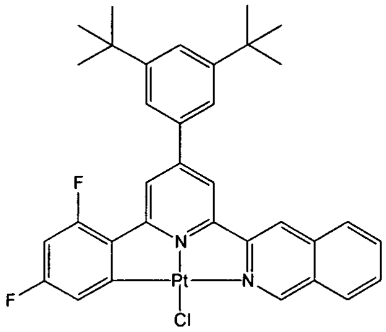
Synthetic procedure for complex 8:



Complex 8 was synthesized by general procedures in Example 15 with 0.17 g (0.45 mmol) K_2PtCl_4, 0.44 g (0.86 mmol) ligand 8 and 100 ml glacial acetic acid. Complex 8 was obtained as orange crystalline solid. Yield: 0.52 g (80.0 %). ^{1}H NMR (500 MHz, DMF, 25 °C): δ= 1.64 (s, 18H), 3.73 (s, 3H), 6.59 (d, J = 14.1 Hz, 1H), 7.00 (d, J = 2.4 Hz, 1H), 7.80 (s, 1H), 7.90 (t, J = 1.6 Hz 1H), 8.00 (t, J = 7.8 Hz, 1H), 8.04 (d, J = 1.7 Hz, 2H), 8.21 (m, 1H), 8.27 (d, J = 4.05 Hz, 1H), 8.29 (d, J = 4.3 Hz, 1H), 8.49 (s, 1H), 9.28 (s, 1H) , 9.59 (s, 1H). ^{13}C NMR (126 MHz, DMF, 25 °C): δ= 30.0, 35.2, 97.4, 115.6, 116.7, 119.2, 119.3, 122.2, 123.0, 124.2, 126.7, 128.3, 129.2, 129.5, 130.7, 133.8, 136.2, 137.9, 145.9, 151.0, 152.0, 152.1, 155, 160.1, 162.1, 162.4, 162.6, 163.2, 163.8. FAB-MS (+ve, m/z): 748.2[M$^+$].

Example 24

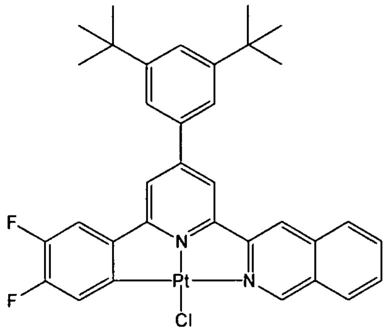
Synthetic procedure for complex 9:



Complex 9 was synthesized by general procedures in Example 15 with 0.49 g (1.18 mmol) K_2PtCl_4, 0.50 g (0.99 mmol) ligand 9 and 100 ml glacial acetic acid. Complex 8 was obtained as orange crystalline solid. Yield: 0.58 g (80.0 %). ^1H NMR (500 MHz, CD_2Cl_2, 25 °C): δ = 1.48 (s, 18H), 6.39-6.44 (m, 1H), 6.97 (d, J = 8.5 Hz, 1H), 7.63-7.67 (m, 5H), 7.73 (d, J = 8.2 Hz), 7.80-7.83 (m, 2H), 7.91 (d, J = 8.2 Hz, H), 8.33 (s, 1H), 9.24 (s, 1H). ^{13}C NMR (126 MHz, CD_2Cl_2, 25 °C): δ= 31.4, 35.2, 99.0, 99.2, 116.7, 116.8, 120.1, 120.3, 121.8, 121.9, 124.3, 127.9, 128.7, 129.2, 130.2, 133.2, 135.7, 137.4, 150.6, 152.1, 152.2, 152.6, 154.4. ^{19}F NMR (400 MHz, CD_2Cl_2, 25 °C): δ= -105.9, -111.3.

Example 25

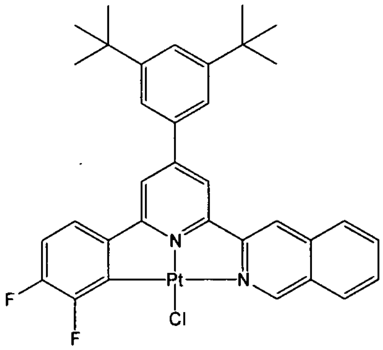
Synthetic procedure for complex 10:



Complex 10 was synthesized by general procedures in Example 15 with 0.93 g (2.37 mmol) K_2PtCl_4, 1.00 g (1.97 mmol) ligand 10 and 100 ml glacial acetic acid. Complex 10 was obtained as yellow solid. Yield: 0.87 g (60.0 %). ^1H NMR (500 MHz, CD_2Cl_2, 25 °C): δ= 1.49 (s, 18H), 6.97-7.01 (m, 1H), 7.06-7.10 (m, 2H), 7.60-7.68 (m, 5H), 7.74 (s, 1H), 7.83 (t, *J* = 8.1 Hz, H), 7.92 (d, *J* = 8.1 Hz, H), 8.25 (s, 1H), 9.17 (s, 1H). ^{13}C NMR (126 Hz, CD_2Cl_2, 25 °C): δ= 31.4, 35.2, 112.3, 112.4, 116.5, 117.1, 121.7, 121.9, 122.0, 124.4, 127.8, 127.9, 128.6, 129.1, 130.2, 133.2, 135.5, 137.2, 139.1, 150.4, 152.0, 152.3, 152.4, 154.6, 163.0. ^{19}F NMR (400 MHz, $CDCl_3$, 25 °C): δ = -134.3, -146.0. FAB-MS (+ve, m/z): 700 $[M-Cl]^+$.

Example 26

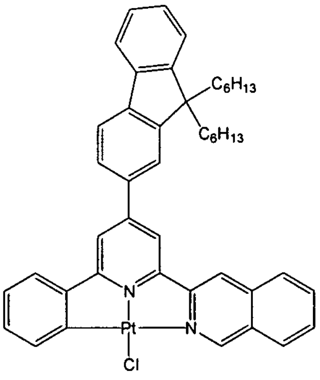
Synthetic procedure for complex 11:



Complex 11 was synthesized by general procedures in Example 15 with 0.93 g (2.37 mmol) K_2PtCl_4, 1.00 g (1.97 mmol) ligand 10 and 100 ml glacial acetic acid. Complex 11 was obtained as yellow solid. Yield: 0.44 g (30.0 %). ^{1}H NMR (500 MHz, CD_2Cl_2, 25 °C): δ= 1.54 (s, 18H), 6.80 (m, 1H), 7.18 (m, 1H), 7.39 (s, 1H), 7.65 (s, 2H), 7.68 (s, 1H), 7.69 (t, *J* = 7.2 Hz, 1H), 7.82 (s, 1H), 7.87 (m, 2H), 7.98 (d, *J* = 8.1 Hz, 1H), 8.36 (s, 1H), 9.59 (s, 1H). ^{13}C NMR (126 MHz, CD_2Cl_2, 25 °C): δ= 31.4, 35.2, 112.1, 112.3, 116.9, 117.3, 120.8, 121.6, 121.7, 124.5, 127.9, 129.0, 129.1, 130.4, 133.6, 135.7, 137.2, 150.7, 151.3, 152.3, 152.7, 154.7, 163.9. ^{19}F NMR (376 MHz, $CDCl_3$, 25 °C): -121.9, -132.5. FAB-MS (+ve, m/z): 700 $[M-Cl]^+$.

Example 27

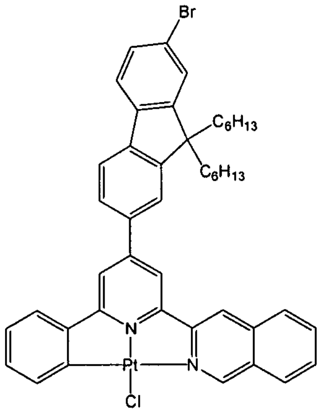
Synthetic procedure for complex 12:



Complex 12 was synthesized by general procedures in Example 15 with 0.71 g (1.71 mmol) K_2PtCl_4, 1.05 g (1.71 mmol) ligand 11 and 50 ml glacial acetic acid. Complex 12 was obtained as yellow solid. Yield: 1.3 g (86 %). ^{1}H NMR (400 MHz, CD_2Cl_2): δ 9.70 (s, 1H), 8.51 (s, 1H), 8.11 (d, *J* = 8.0 Hz, 1H), 8.04 (d, *J* = 8.2 Hz, 1H), 7.98 (s, 1H), 7.92–7.96 (m, 2H), 7.785–7.85 (m, 3H), 7.69 (t, *J* = 6.4 Hz, 1H), 7.50 (d, *J* = 7.5 Hz, 1H), 7.39–7.45 (m, 3H), 7.18 (t, *J* = 6.4 Hz, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 2.08–2.16 (m, 4H), 1.08–1.39 (m, 12H), 0.69–0.89 (m, 10H). FAB-MS (m/z): 844 [M$^+$].

Example 28

Synthetic procedure for complex 13:

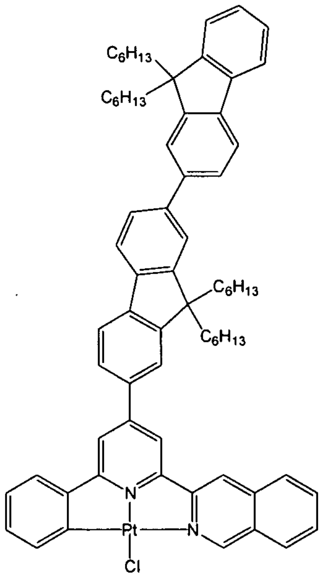


Complex 13 was synthesized by general procedures in Example 15 with 0.71 g (1.71

mmol) K_2PtCl_4, 1.19 g (1.71 mmol) ligand 12 and 50 ml glacial acetic acid. Complex 13 was obtained as yellow solid. Yield: 1.3 g (86 %). ^1H NMR (400 MHz, CD_2Cl_2): δ 9.33 (s, 1H), 8.39 (s, 1H), 7.86–7.93 (m, 5H), 7.82 (t, *J* = 7.5 Hz, 1H), 7.72–7.76 (m, 2H), 7.55–7.63 (m, 3H), 7.47 (d, *J* = 7.4 Hz, 1H), 7.30 (s, 1H), 7.23 (d, *J* = 7.0 Hz, 1H), 6.99 (t, *J* = 7.2 Hz, 1H), 6.94 (t, *J* = 7.2 Hz, 1H), 2.19–2.25 (m, 2H), 2.02–2.13 (m, 2H), 2.02–2.09 (m, 4H), 1.11–1.22 (m, 12H), 0.72–0.81 (m, 10H). FAB-MS (m/z): 923 [M^+].

Example 29

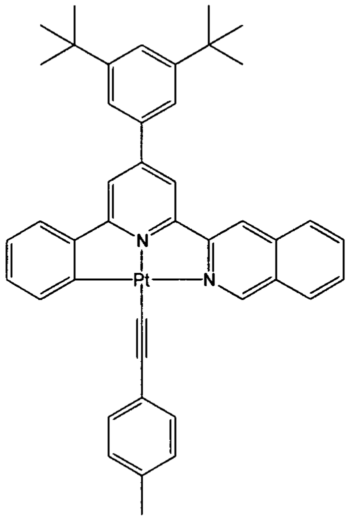
Synthetic procedure for complex 14:



Complex 14 was synthesized by general procedures in Example 15 with 0.71 g (1.71 mmol) K_2PtCl_4, 1.62 g (1.71 mmol) ligand 13 and 50 ml glacial acetic acid. Complex 9 was obtained as orange solid. Yield: 1.3 g, 86 %. ^1H NMR (400 MHz, CD_2Cl_2): δ 9.56 (s, 1H), 8.48 (s, 1H), 7.83–8.02 (m, 8H), 7.64–7.77 (m, 6H), 7.60–7.63 (m, 2H), 7.57 (s, 1H), 7.49 (t, *J* = 7.3 Hz, 1H), 7.42 (m, 1H), 7.37 (t, *J* = 7.5 Hz, 1H), 7.08 (m, 2H), 2.23–2.33 (m, 2H), 2.06–2.15 (m, 2H), 1.01–1.38 (m, 12H), 0.76–0.87 (m, 10H). FAB-MS (m/z): 1177 [M^+].

Example 30

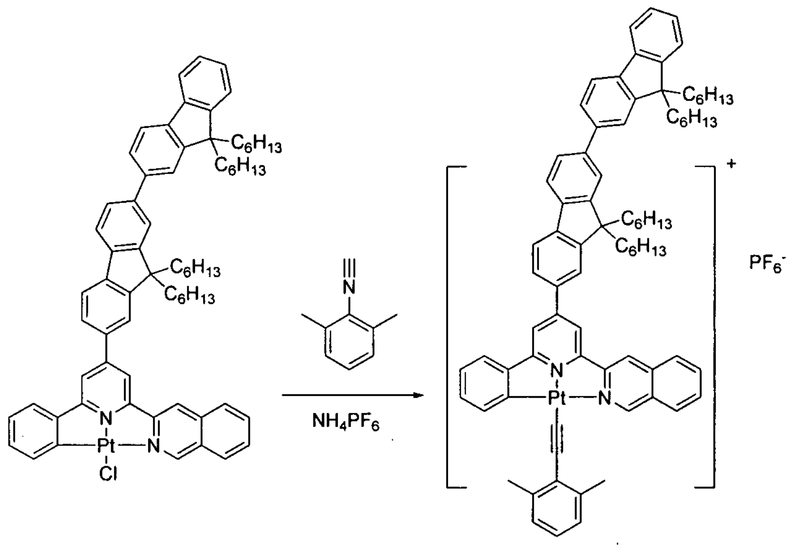
Synthetic procedure for complex 15:



Complex 4 (0.17 g, 0.24 mmol), 1-ethyl-4-methylbenzene (0.18 ml, 1.43 mmol) and triethylamine (1 ml, 6.68 mmol) were dissolved in a solution of acetonitrile: dichloromethane (3:1) (30 ml). CuI (5 mg) was added to the reaction mixture as a catalyst. The yellow mixture was stirred under nitrogen for 48 hr at room temperature. The orange solid was then filtered and washed with cold acetonitrile and diethyl ether. Then the solid was dry to give orange complex 15. Yield: 0.16 g (84%). FAB-MS (+ve, m/z): 779 [M^+].

Example 30a

Synthesis for complex 16:

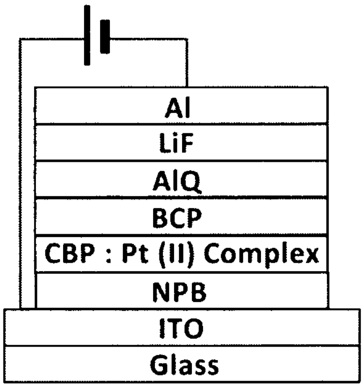


Complex 14 Complex 16

A mixture of complex **14** (100 mg, 0.085 mmol), 2,6-dimethylphenyl isocyanide (12 mg, 0.086 mmol) and excess NH_4PF_6 (500 mg, 3.06 mmol) in CH_2Cl_2/CH_3CN solution (*v*:*v*, 1:1) was stirred for 12 hours to give complex **16** as yellow solution. Solvent was removed under reduced pressure to yield orange solids. The resultant orange solids were collected, washed with copious of H_2O, CH_3CN and Et_2O then dried. Pure product (108 mg, yield 90%) was isolated as orange crysals by layering of n-hexane onto concentrated CH_2Cl_2 solution. FAB-MS (+ve m/z): 1270 $[M-PF_6]^+$. ^1H NMR (CD_2Cl_2): δ 0.70–0.72 (m, 4H, $-CH_2-$), 0.76–0.79 (m, 16H, $-CH_2-$ and $-CH_3$), 1.08–1.26 (m, 24H, $-CH_2-$), 2.06–2.11 (m, 4H, $-CH_2-$), 2.22–2.42 (m, 4H, $-CH_2-$), 2.62 (s,6H), 7.21 (t, J = 8.9 Hz, 1H), 7.27–7.42 (m, 7H), 7.44–7.51 (m, 1H), 7.68–7.71 (m, 3H), 7.45–7.77 (m, 3H), 7.82–7.85 (m, 2H), 7.89–7.93 (m, 3H), 7.95–8.03 (m, 3H), 8.15 (d, J = 8.3 Hz, 1H), 8.20 (d, J = 8.2 Hz, 1H), 8.30 (s, 1H), 9.80 (s, 1H), 9.48 (s, 1H).

Example 31

Example 31 illustrates general procedures for preparing OLEDs in present invention. The OLEDs were prepared on patterned indium-tin-oxide (ITO) glass with a sheet resistance of 20 Ω / □. Thermal vacuum deposition of the materials was carried out sequentially under a vacuum of 1×10^{-6} torr in a thin film deposition system (MBraun three-glove box system integrated with an Edwards Auto 306 deposition system). The devices were encapsulated using anodized aluminum caps and their performance was examined using Photoresearch PR-650. The current-voltage characteristics were studied using a Keithley 2400 sourcemeter. The OLEDs employing Complexes 1 – 6 and 14 have the following configuration: ITO (indium tin oxide) / NPB (4,4'-*bis*[*N*-(1-naphthyl)-*N*-phenylamino]biphenyl, 40 nm) / CBP (4,4'-*N*,*N'*-dicarbazolebiphenyl) : Complexes 1 – 6 and 14, X %, 30 nm) / BCP (bathocuprine, 15 nm) / Alq$_3$ (*tris*(8-quinolinolato)aluminum, 30 nm) / LiF (0.5 nm) / Al (100 nm).



Example 32

Example 32 illustrates the devices performance of OLED devices fabricated by the method stated in Example 31 using complexes 1 – 6 and 14 as emitting materials.

Device	Complex	Conc.$_{optimum}$ (X)/ %	B_{max}/ cdm^{-2}	CIE	η_{max} / cdA^{-1}	η_{max} / luW^{-1}	EQE_{max} / %
A	1	2	39632	0.39,0.57	13.2	6.9	3.7

B	2	5	30048	0.38,0.59	15.7	8.2	5.0
C	3	2	52728	0.37,0.59	16.3	7.0	4.8
D	4	4	50848	0.40,0.58	28.6	12.9	9.3
E	5	4	30024	0.41,0.56	8.0	3.6	2.4
F	6	2	26296	0.37,0.61	21.6	8.5	6.5
G	14	8	29016	0.44, 0.54	13.9	5.5	4.2

Example 33

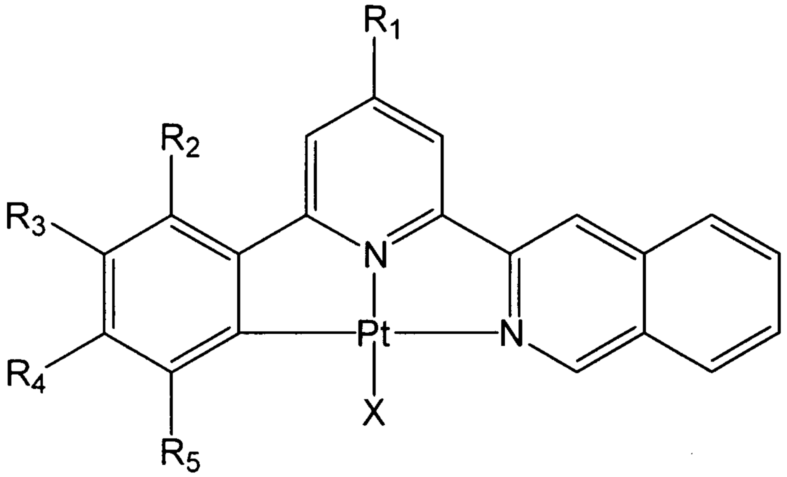
Example 33 illustrates general procedures for preparing OLEDs in present invention. The OLEDs were prepared on patterned indium-tin-oxide (ITO) glass with a sheet resistance of 20 Ω / □. Thermal vacuum deposition of the materials was carried out sequentially under a vacuum of 1 × 10^{-6} torr in a thin film deposition system (MBraun three-glove box system integrated with an Edwards Auto 306 deposition system). The devices were encapsulated using anodized aluminum caps and their performance was examined using Photoresearch PR-650. The current-voltage characteristics were studied using a Keithley 2400 sourcemeter. The OLEDs employing Complexe 13 have the following configuration: ITO (indium tin oxide) / NPB (4,4'-*bis*[*N*-(1-naphthyl)-*N*-phenylamino]biphenyl, 40 nm) / CBP (4,4'-*N*,*N*'-dicarbazolebiphenyl) : Complexe 13, 3.5 %, 20 nm) / BCP (bathocuprine, 40 nm) / LiF (0.5 nm) / Al (100 nm) (device H). Figure 21 shows J-V-B curves of device H. The threshold voltage of is <54 V for 1 cd/m^2. Device H shows maximum luminance of 8270 cd m^{-2} at 14 V.

Example 34

Example 34 illustrates general procedures for preparing a WOLED (device I) in present invention. The WOLED was prepared on patterned indium-tin-oxide (ITO) glass with a sheet resistance of 20 Ω / □. Thermal vacuum deposition of the materials was carried out sequentially under a vacuum of 1×10^{-6} torr in a thin film deposition system (MBraun three-glove box system integrated with an Edwards Auto 306 deposition system). The devices were encapsulated using anodized aluminum caps and their performance was examined using Photoresearch PR-650. The current-voltage characteristics were studied using a Keithley 2400 sourcemeter. The WOLEDs employing Complex have the following configuration: ITO (indium tin oxide) / NPB (4,4'-*bis*[*N*-(1-naphthyl)-*N*-phenylamino]biphenyl, 40 nm) / CBP (4,4'-*N*,*N*'-dicarbazolebiphenyl) : Complexe 12, 4.2 %, 20 nm) / NPB, (2 nm)/ 9,10-bis-(2-naphthyl)-anthrene (DNA, 1nm)/ BCP (bathocuprine, 40 nm) / LiF (0.5 nm) / Al (100 nm) (device I). Figure 24 shows J-V-B curves of device I. The threshold voltage of is <5 V for 1 cd/m^2. Device H shows maximum luminance of 7996 cd m^{-2} at 13 V and CIE of (0.32, 0.31).

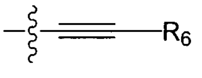
WHAT IS CLAIMED IS:

1. An organometallic complex having a chemical structure of structure I:



Structure I

wherein R_1–R_5 are independently hydrogen, halogen, hydroxyl, an unsubstituted alkyl, a substituted alkyl, cycloalkyl, an unsubstituted aryl, a substituted aryl, acyl, alkoxy, acyloxy, amino, nitro, acylamino, aralkyl, cyano, carboxyl, thio, styryl, aminocarbonyl, carbamoyl, aryloxycarbonyl, phenoxycarbonyl, or an alkoxycarbonyl group; X is halogen,



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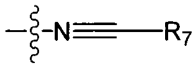

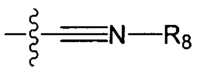

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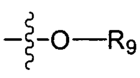

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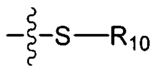

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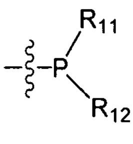

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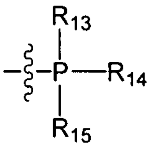
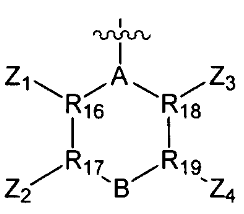
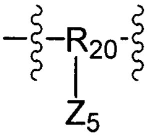


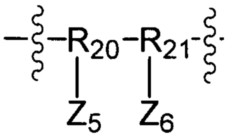
and


wherein A is carbon, nitrogen, oxygen, silicon, phosphorus, sulphur, arsenic and selenium; B is a chemical bonding connecting R_{17} and R_{19},



$$-\underset{Z_5}{R_{20}}-$$

,



$$-\underset{Z_5}{R_{20}}-\underset{Z_6}{R_{21}}-$$

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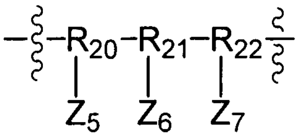

$$-\underset{Z_5}{R_{20}}-\underset{Z_6}{R_{21}}-\underset{Z_7}{R_{22}}-$$

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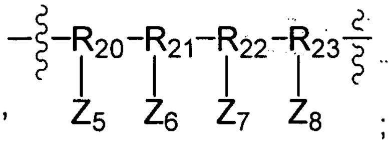
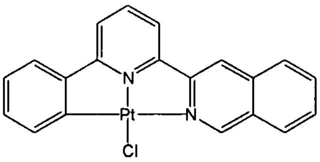
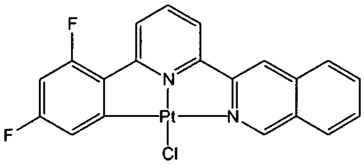
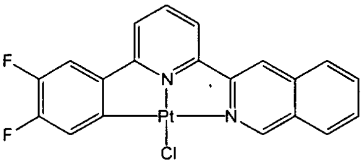
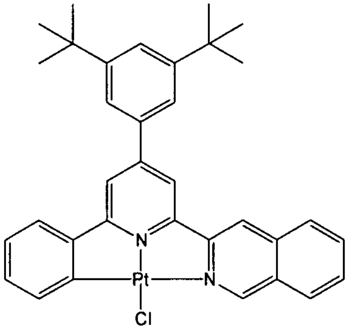
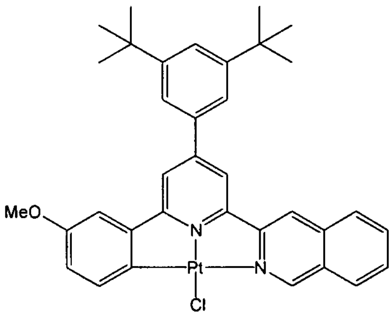
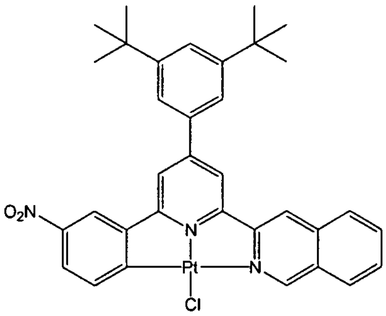


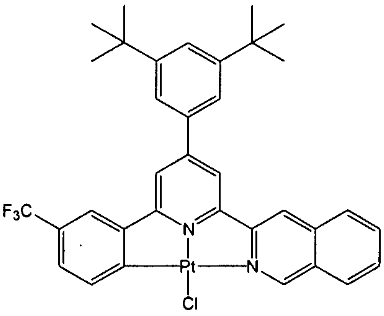
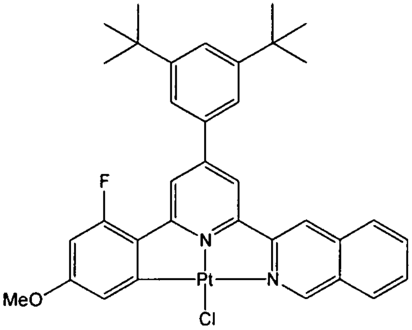
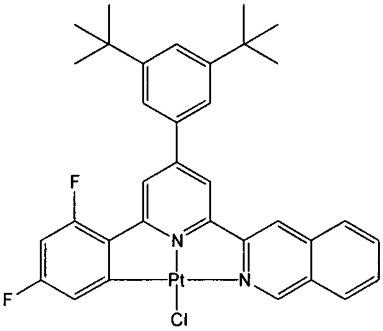
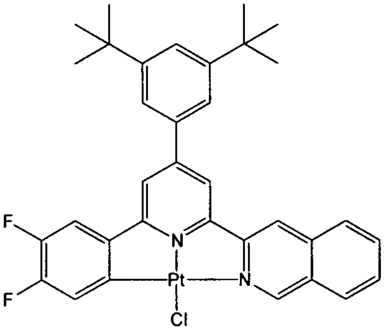
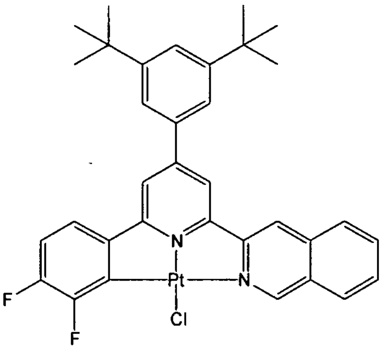
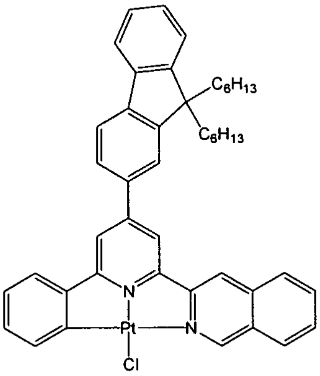
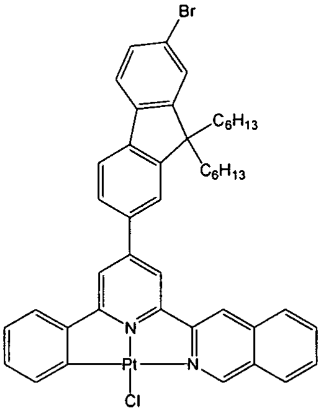
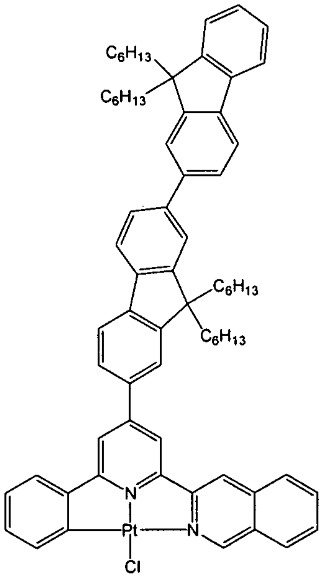
$$-\underset{Z_5}{R_{20}}-\underset{Z_6}{R_{21}}-\underset{Z_7}{R_{22}}-\underset{Z_8}{R_{23}}-$$

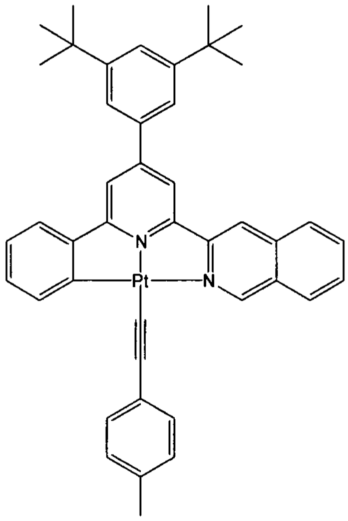
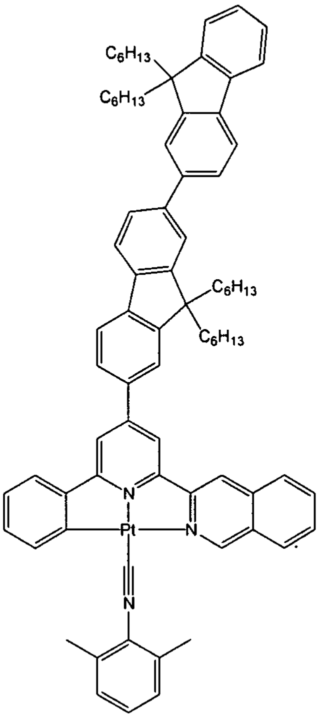
;

R_6–R_{15} are independently hydrogen, alkyl, substituted alkyl, cycloalkyl, aryl, and substituted aryl group; R_{16} – R_{23} are independently carbon, nitrogen, oxygen, silicon, phosphorus, sulphur, arsenic and selenium; Z_1 – Z_8 are independently hydrogen, alkyl, substituted alkyl, cycloalkyl, aryl, substituted aryl group and Z_1 – Z_8 can form 5 – 7 member ring(s) with neighboring groups.

2. The organometallic complex of claim 1 wherein Structure I is one of the following compounds:

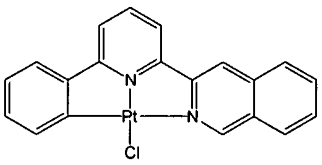
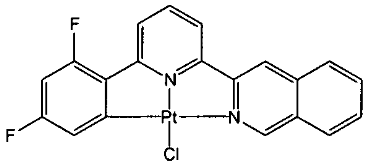
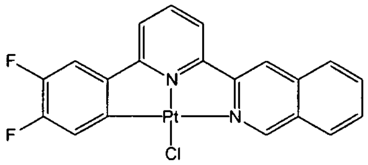
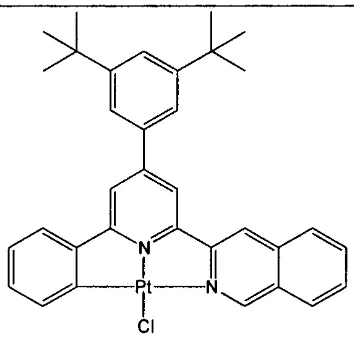
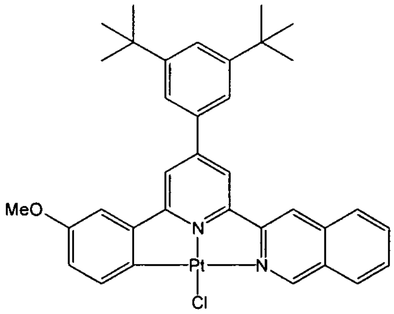
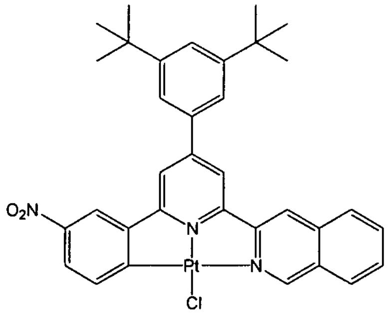
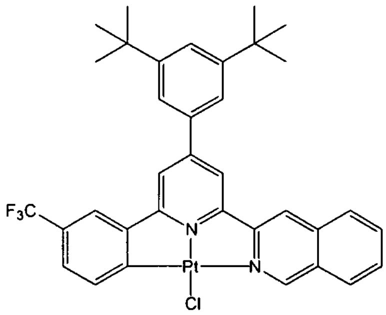
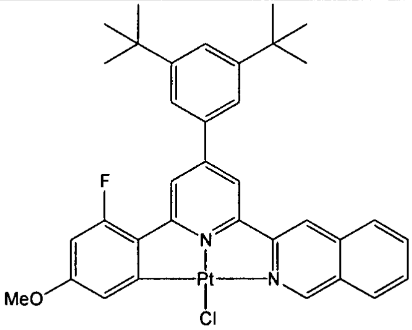
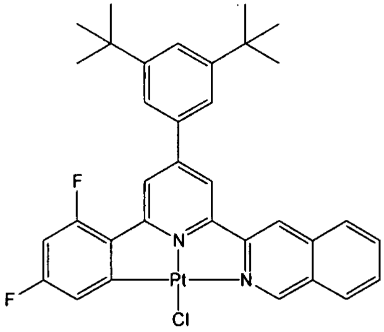
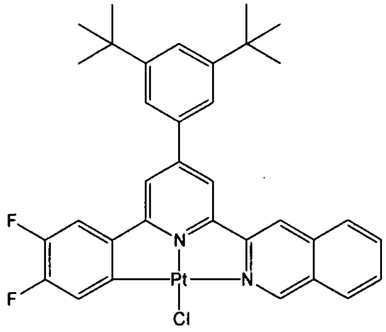
 Complex 1	 Complex 2
 Complex 3	 Complex 4
 Complex 5	 Complex 6

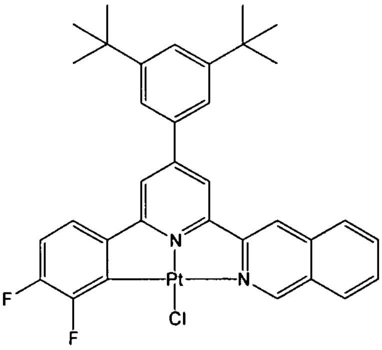
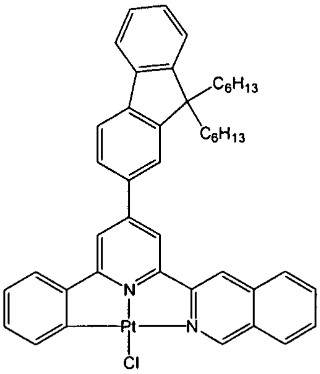
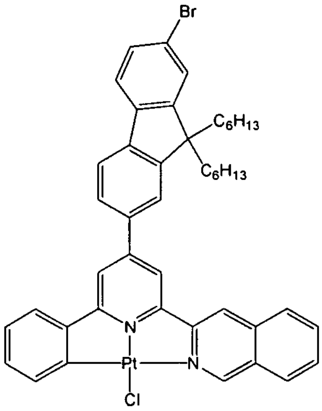
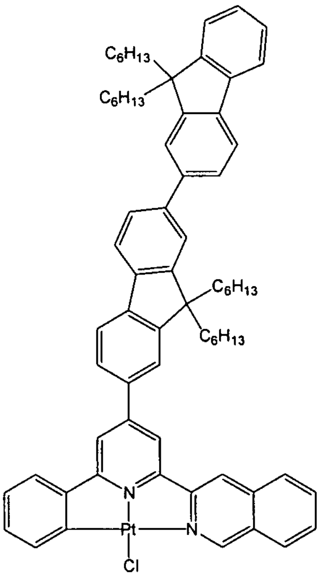
 Complex 7	 Complex 8
 Complex 9	 Complex 10
 Complex 11	 Complex 12
	

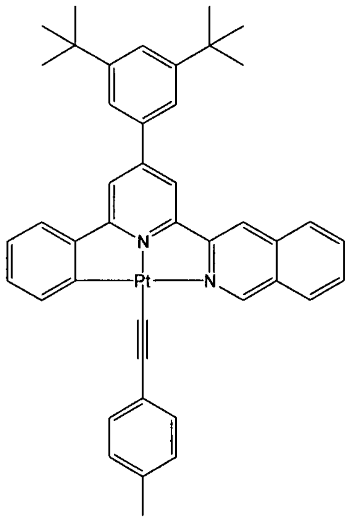
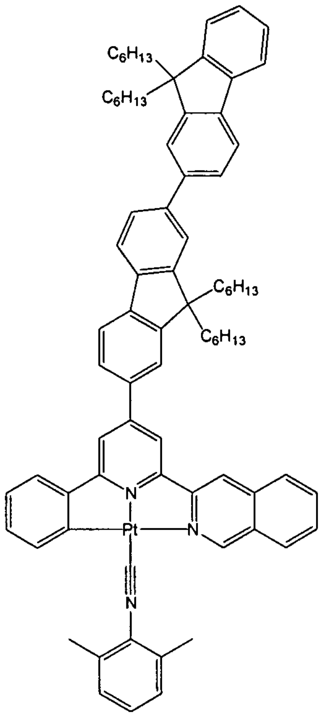
Complex 13	Complex 14
	
Complex 15	Complex 16

3. An organic light-emitting device including a light-emitting material containing one or more of the organometallic complexes set forth in claim 1 .

4. The organic light-emitting device as set forth in claim 3, wherein the complex has one of the following structures:

 Complex 1	 Complex 2
 Complex 3	 Complex 4
 Complex 5	 Complex 6
 Complex 7	 Complex 8
	

Complex 9	Complex 10
 Complex 11	 Complex 12
 Complex 13	 Complex 14

 Complex 15	 Complex 16

5. An organic light-emitting device as set forth in in claim 3 or 4, wherein the organometallic complex is applied as a layer in the device by thermal deposition.

6. An organic light-emitting device as set forth in in any one of claims 3 to 5, wherein the organometallic complex is applied as a layer in the device by spin coating.

7. An organic light-emitting device as set forth in any one of claims 3 to 6, wherein the organometallic complex is applied as a layer in the device by ink-jet printing.

8. An organic light-emitting device as set forth in any one of claims 3 to 7, wherein the device emits a single color when an electric current is applied to a layer.

9. An organic light-emitting device as set forth in any one of claims 3 to 8, wherein the device emits white light when an electric current is applied to a layer containing the one or more organometallic complexes as set forth in claim 1 or 2 and when an electric current is applied to one or more emission components from other emitting

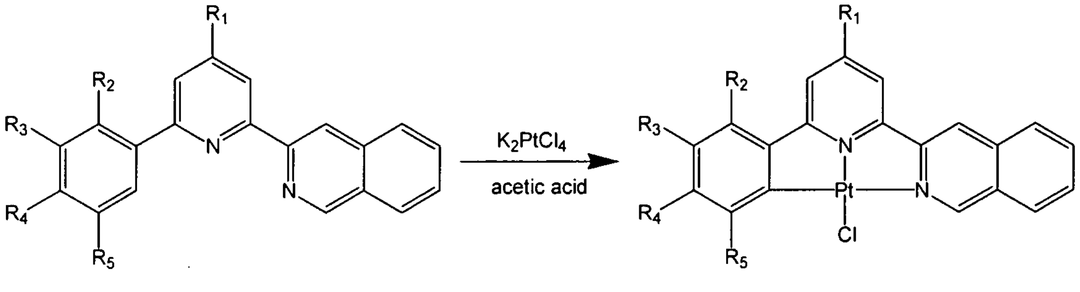
materials.

10. An organic light-emitting device comprising:

a transparent substrate;
a transparent electrode;
a hole transporting layer;
an emissive layer comprising a host material doped with least one of the organometallic complex as set forth in claim 1 or 2;
a hole blocking layer;
an electron transporting layer;
a charge injection layer; and
an electrode.

11. An organic light-emitting device comprising:
a transparent substrate;
a transparent electrode;
a hole transporting layer;
an emissive layer comprising a host material doped with at least one of the organometallic complexes as set forth in claim 1 or 2;
a hole transporting layer;
an emissive layer comprising a blue to sky blue emitting material;
a hole blocking layer;
a charge injection layer; and
an electrode.

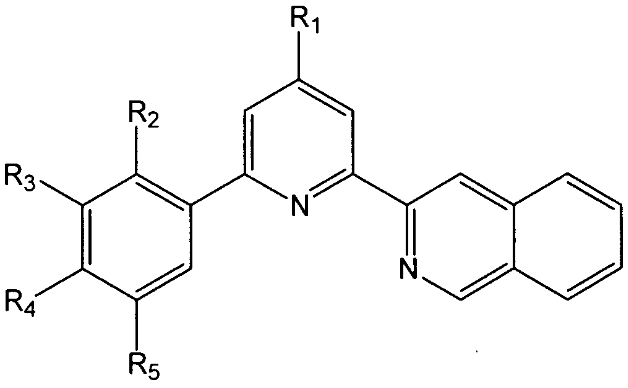
12. A method of making an organometallic complex according to claim 1 comprising: reacting the corresponding ligand identified as Structure II below:



Structure II Structure I

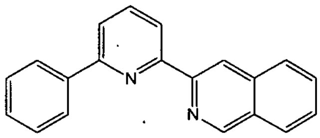
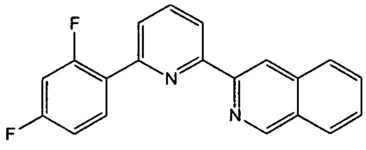
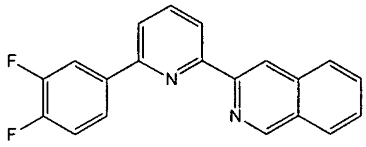
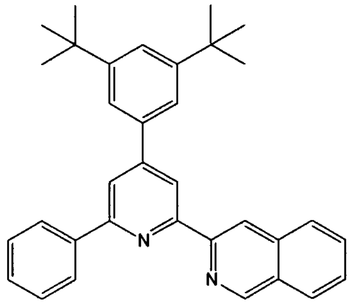
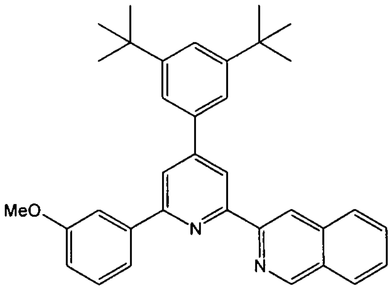
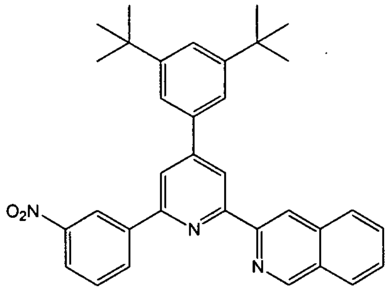
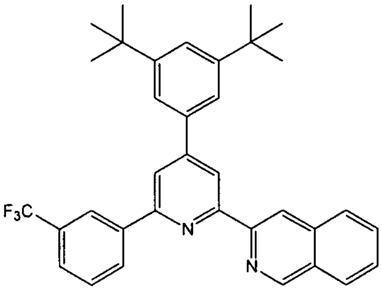
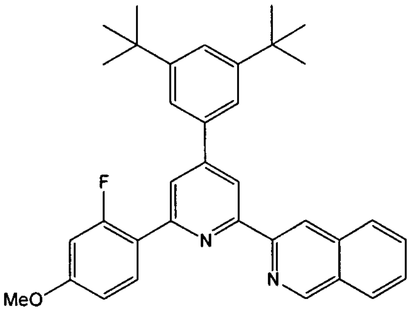
wherein $R_1 - R_5$ are independently hydrogen, halogen, hydroxyl, an unsubstituted alkyl, a substituted alkyl, cycloalkyl, an unsubstituted aryl, a substituted aryl, acyl, alkoxy, acyloxy, amino, nitro, acylamino, aralkyl, cyano, carboxyl, thio, styryl, aminocarbonyl, carbamoyl, aryloxycarbonyl, phenoxycarbonyl, or an alkoxycarbonyl group, with potassium tetrachloroplatinate (K_2PtCl_4), using acetic acid as solvent to form a organometallic complex having a chemical structure of structure I.

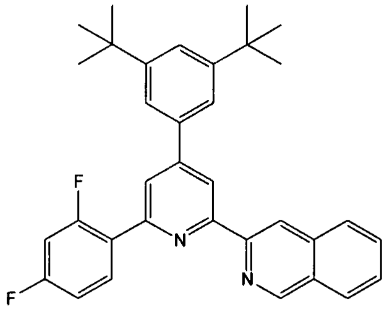
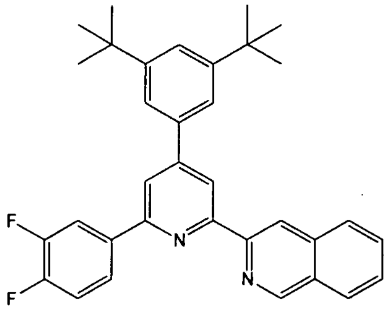
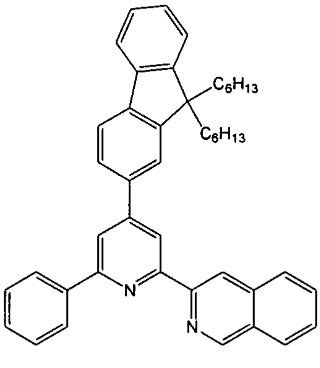
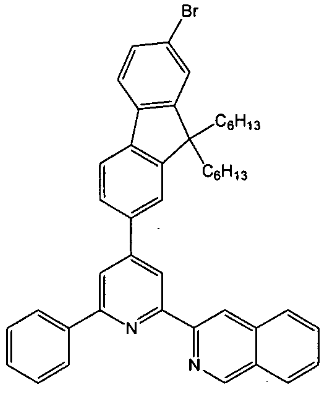
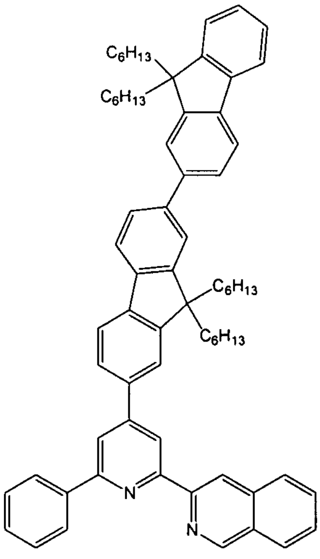
13. A compound having the following structure:



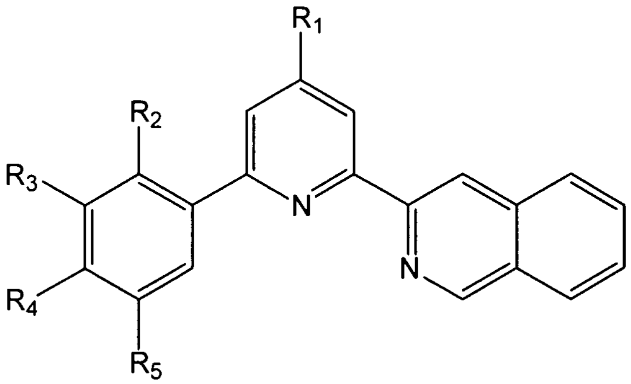
wherein $R_1 - R_5$ are independently hydrogen, halogen, hydroxyl, an unsubstituted alkyl, a substituted alkyl, cycloalkyl, an unsubstituted aryl, a substituted aryl, acyl, alkoxy, acyloxy, amino, nitro, acylamino, aralkyl, cyano, carboxyl, thio, styryl, aminocarbonyl, carbamoyl, aryloxycarbonyl, phenoxycarbonyl, or an alkoxycarbonyl group.

14. A compound having one of the following structures:

 Ligand 1	 Ligand 2
 Ligand 3	 Ligand 4
 Ligand 5	 Ligand 6
 Ligand 7	 Ligand 8

 Ligand 9	 Ligand 10
 Ligand 11	 Ligand 12
 Ligand 13	

15. A method for making an organic light emitting device comprising steps of: reacting a ligand having the following structure:



wherein $R_1 - R_5$ are independently hydrogen, halogen, hydroxyl, an unsubstituted alkyl, a substituted alkyl, cycloalkyl, an unsubstituted aryl, a substituted aryl, acyl, alkoxy, acyloxy, amino, nitro, acylamino, aralkyl, cyano, carboxyl, thio, styryl, aminocarbonyl, carbamoyl, aryloxycarbonyl, phenoxycarbonyl, or an alkoxycarbonyl group, with potassium tetrachloroplatinate (K_2PtCl_4), to obtain a platinum complex; and applying a layer of the complex as an emission layer of a light emitting device or doping the complex in an emission layer of a light emitting device.

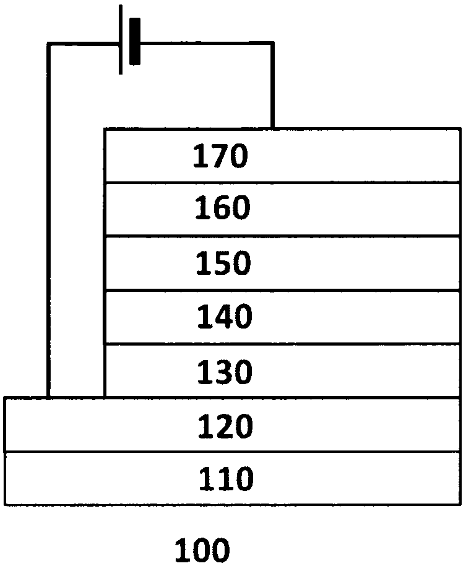


Figure 1

ITO / NPB (40nm) / CBP : Complex 1 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

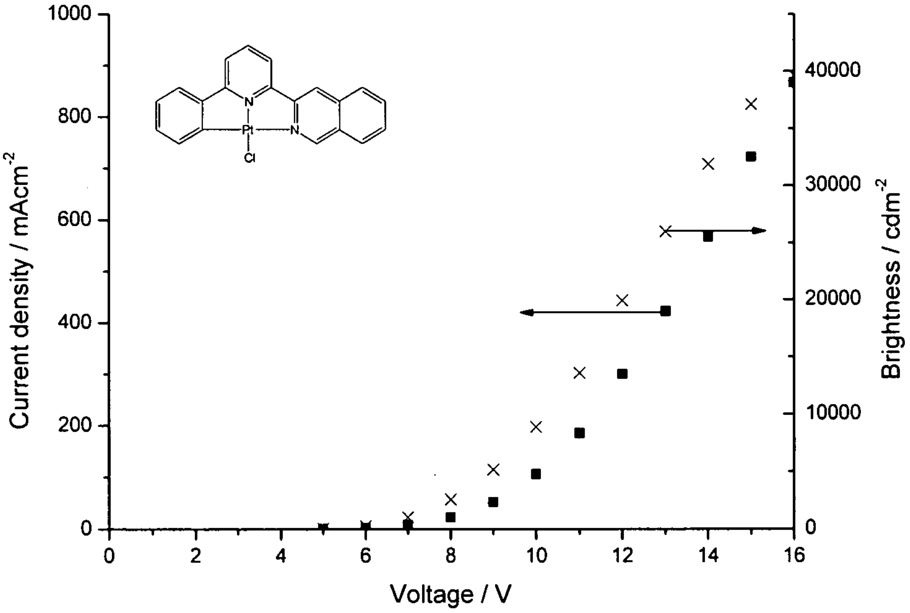
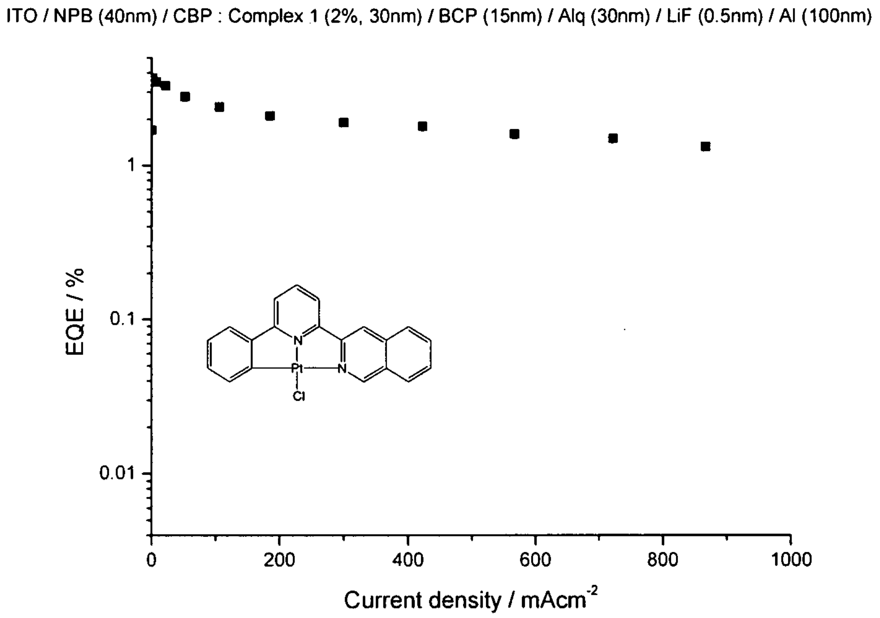
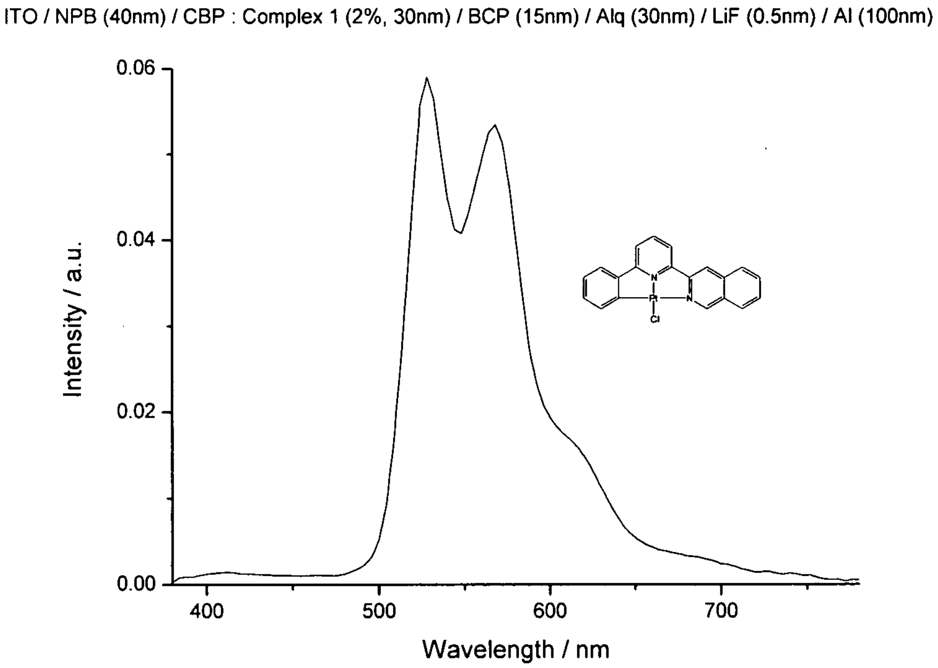


Figure 2



ITO / NPB (40nm) / CBP : Complex 1 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 3



ITO / NPB (40nm) / CBP : Complex 1 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 4

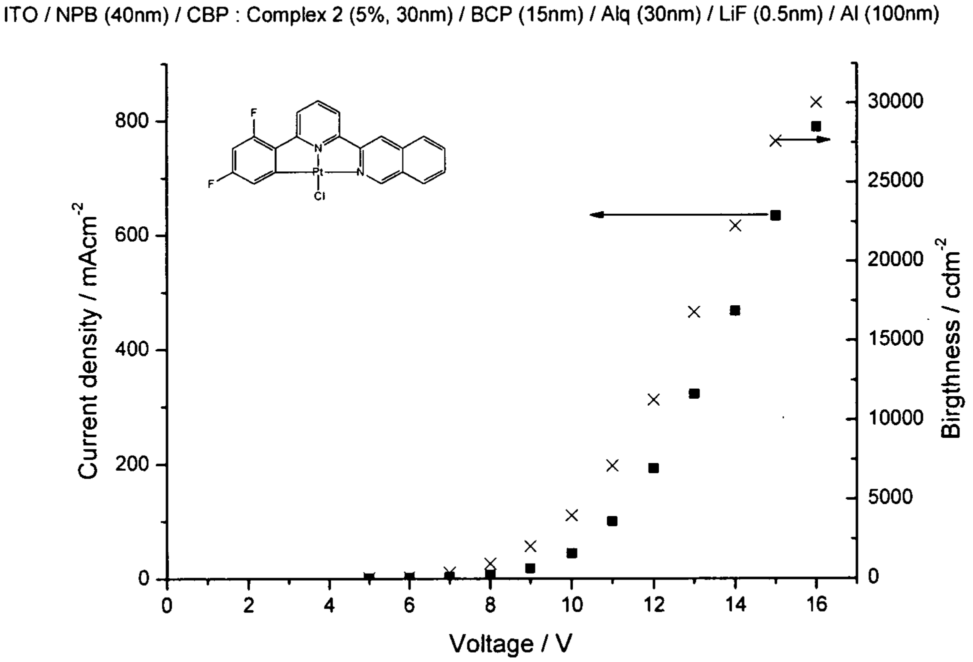


Figure 5

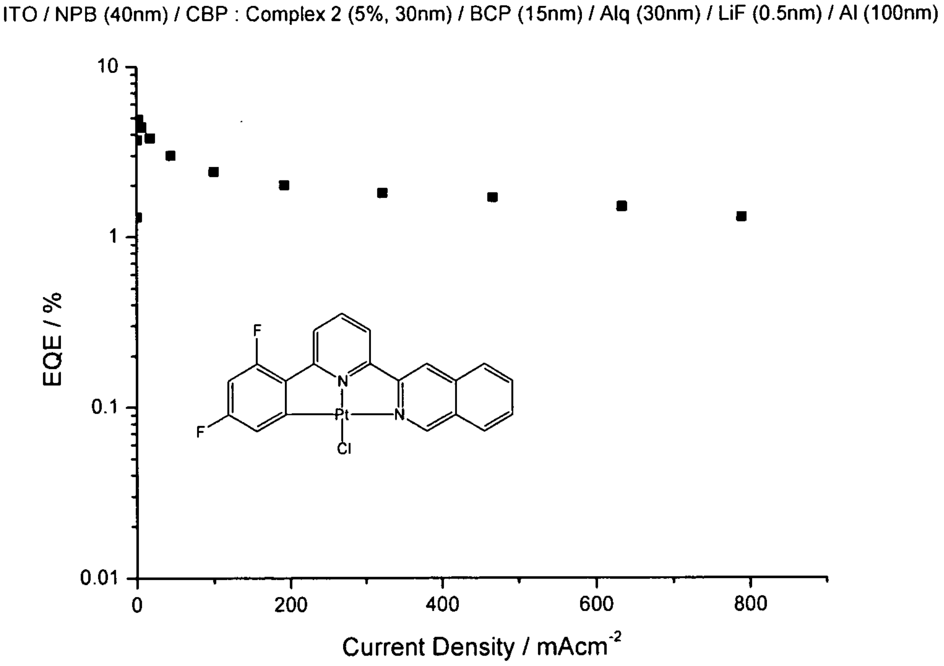


Figure 6

ITO / NPB (40nm) / CBP : Complex 2 (5%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

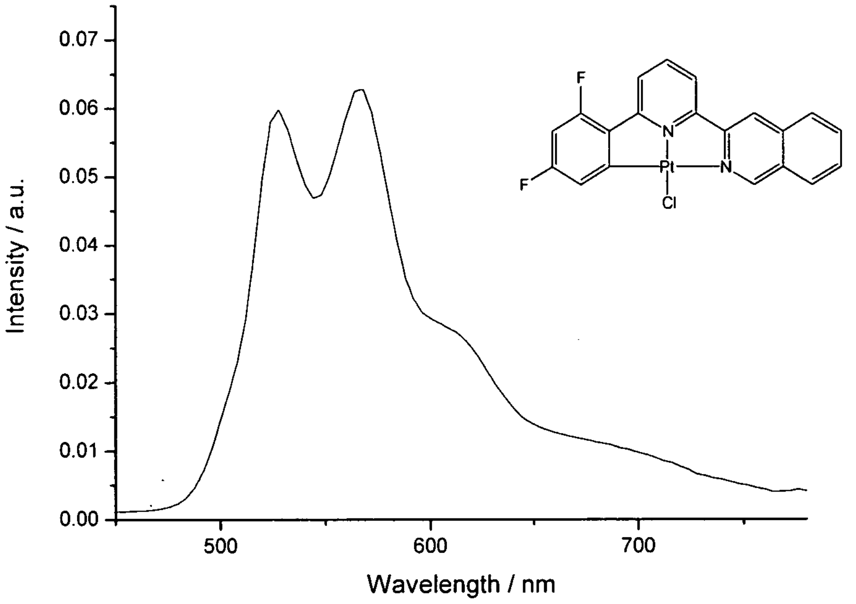


Figure 7

ITO / NPB (40nm) / CBP : Complex 3 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

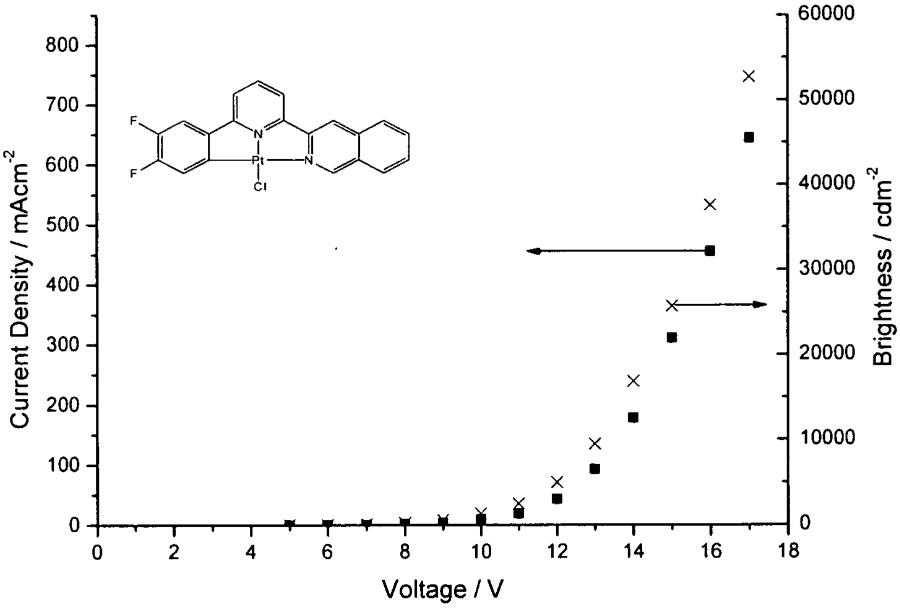


Figure 8

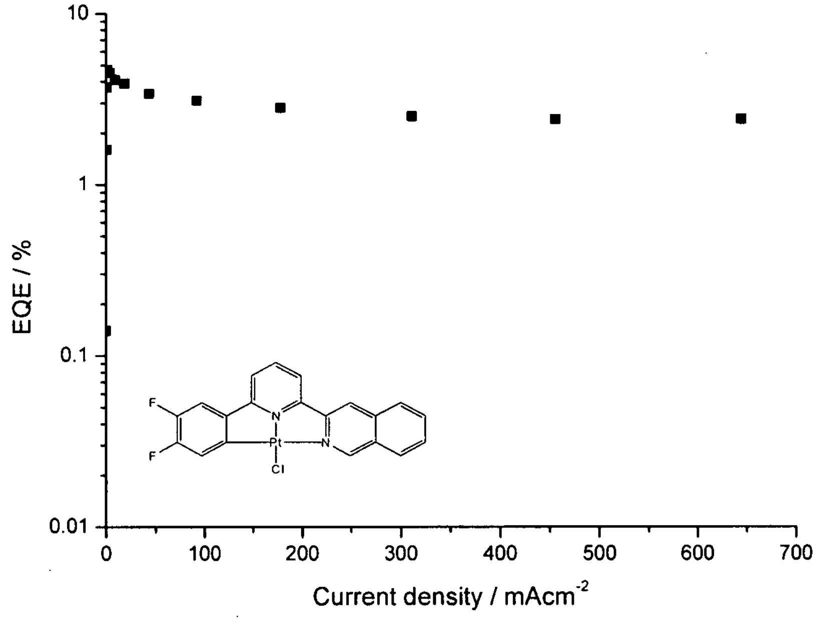

ITO / NPB (40nm) / CBP : Complex 3 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 9

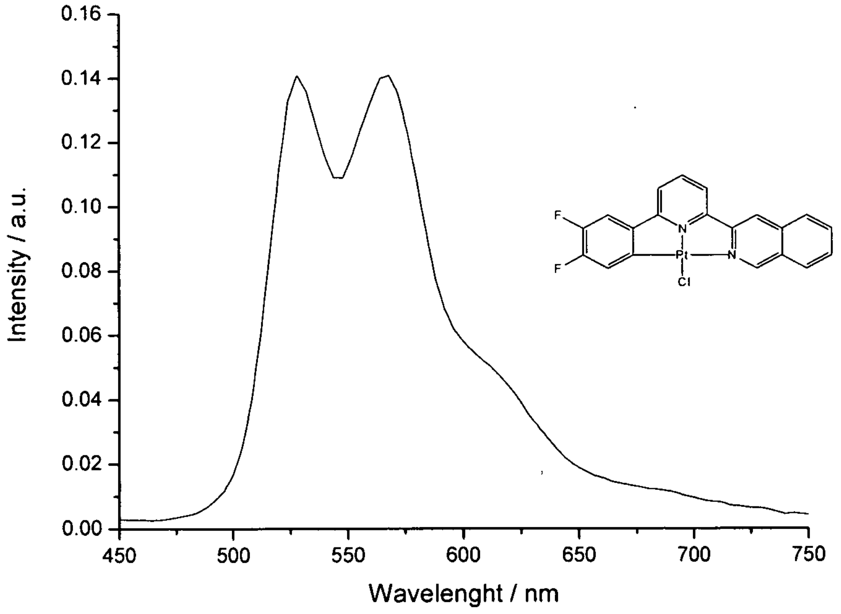

ITO / NPB (40nm) / CBP : Complex 3 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 10

ITO / NPB (40nm) / CBP : Complex 4 (4%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

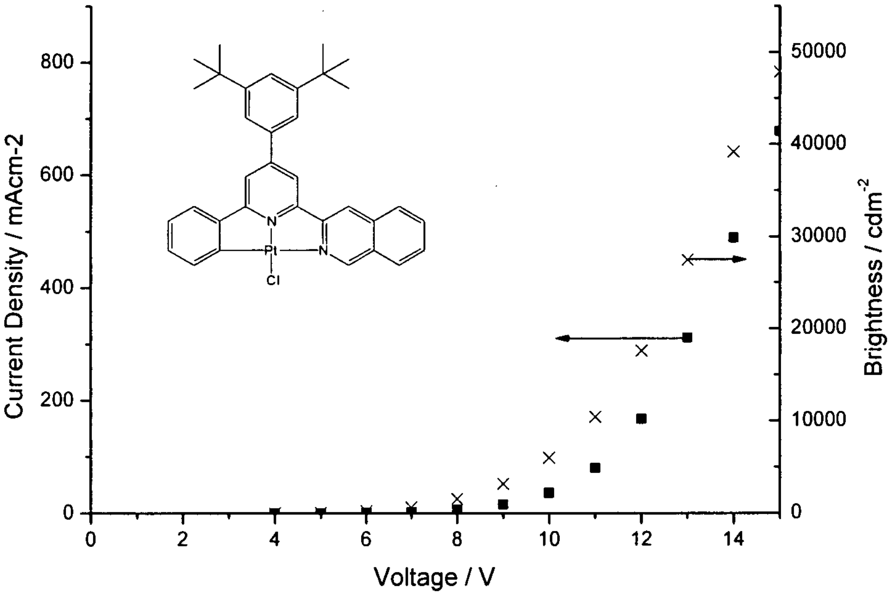


Figure 11

ITO / NPB (40nm) / CBP : Complex 4 (4%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

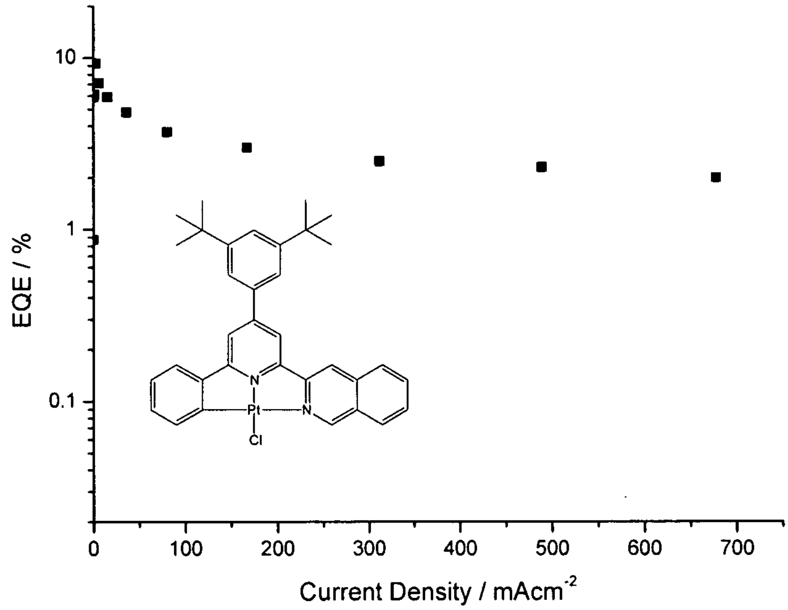


Figure 12

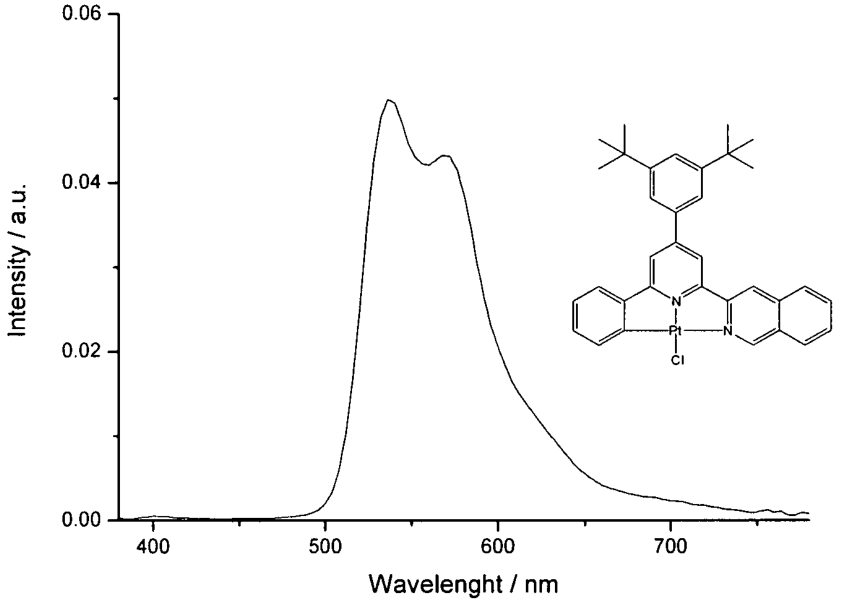

ITO / NPB (40nm) / CBP : Complex 4 (4%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 13

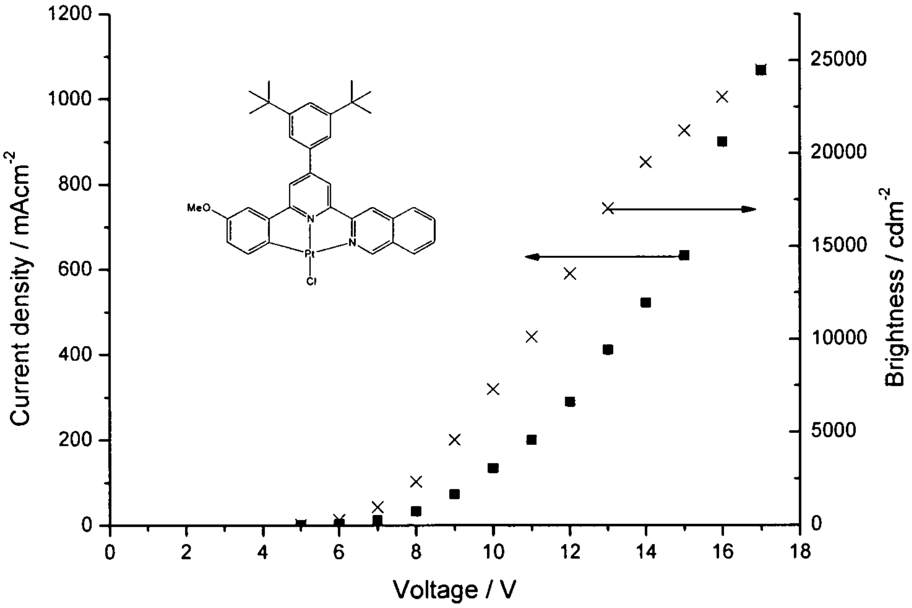

ITO / NPB (40nm) / CBP : Complex 5 (4%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 14

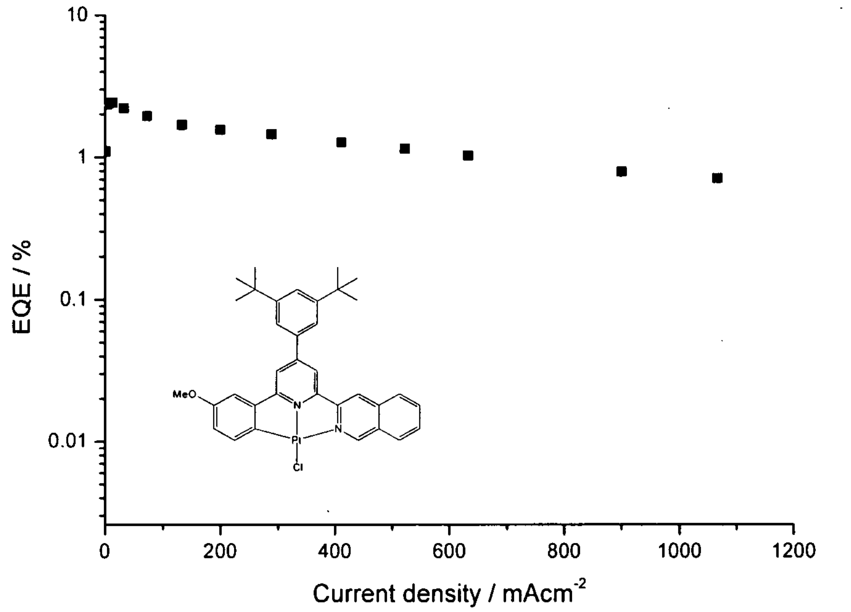

ITO / NPB (40nm) / CBP : Complex 5 (4%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 15

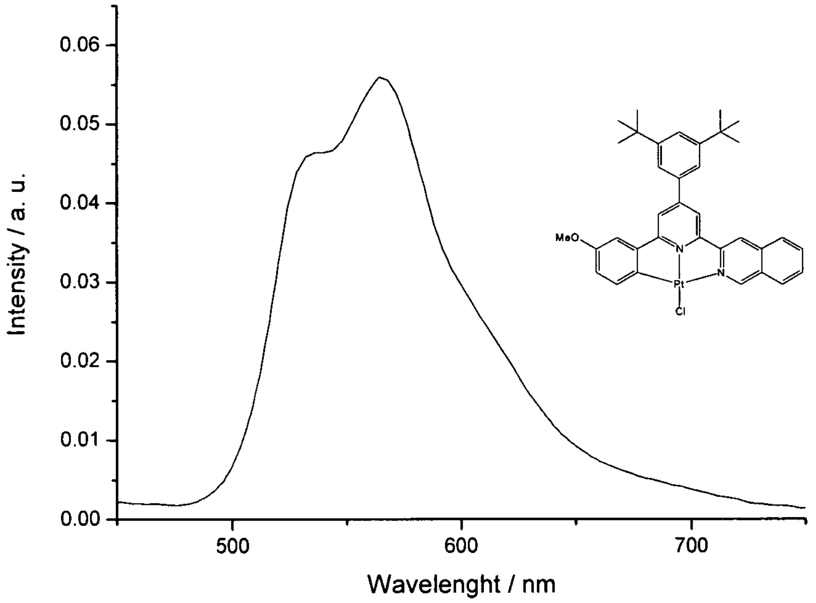

ITO / NPB (40nm) / CBP : Complex 5 (4%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 16

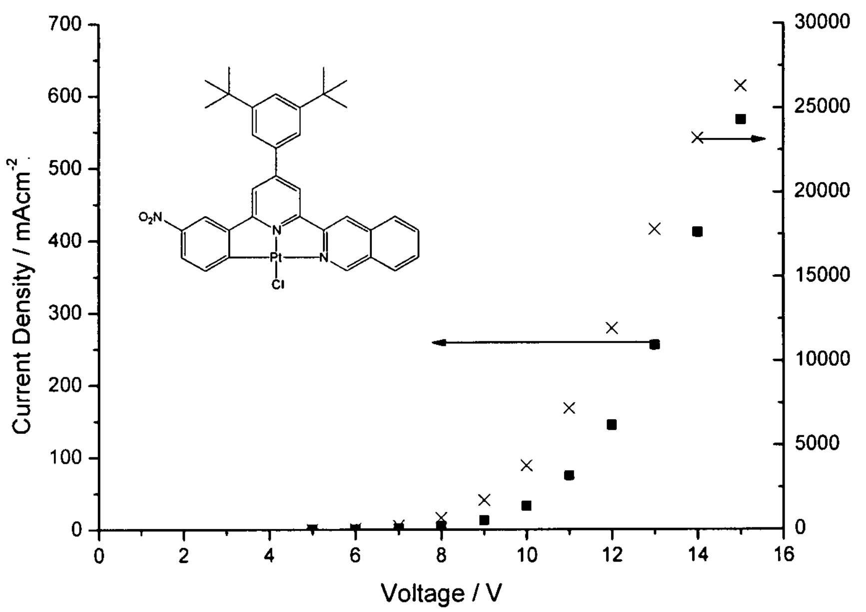

ITO / NPB (40nm) / CBP : Complex 6 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 17

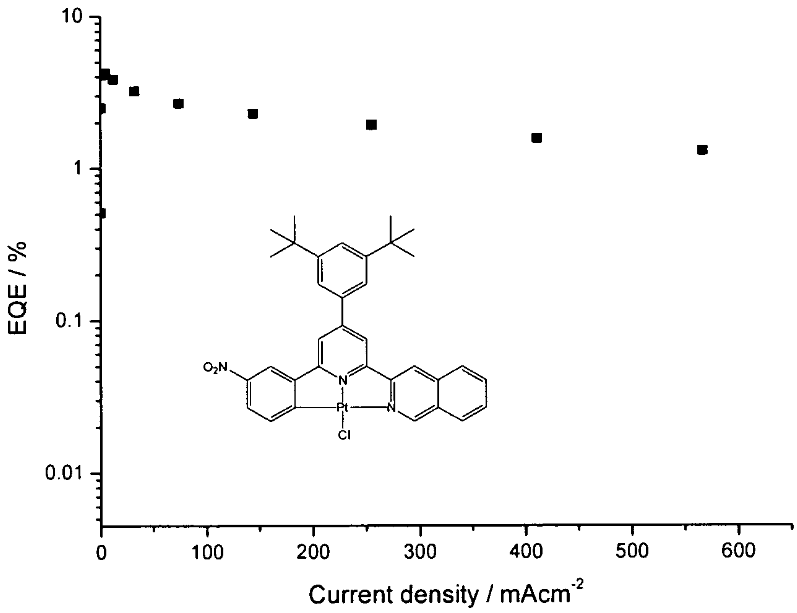

ITO / NPB (40nm) / CBP : Complex 6 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 18

ITO / NPB (40nm) / CBP : Complex 6 (2%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

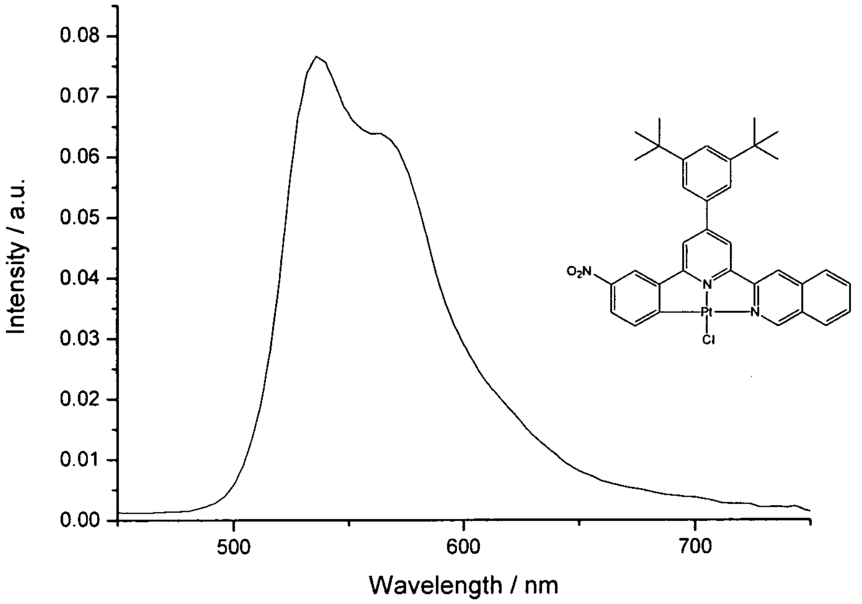


Figure 19

ITO / NPB (40nm) / CBP : complex 14 (8%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

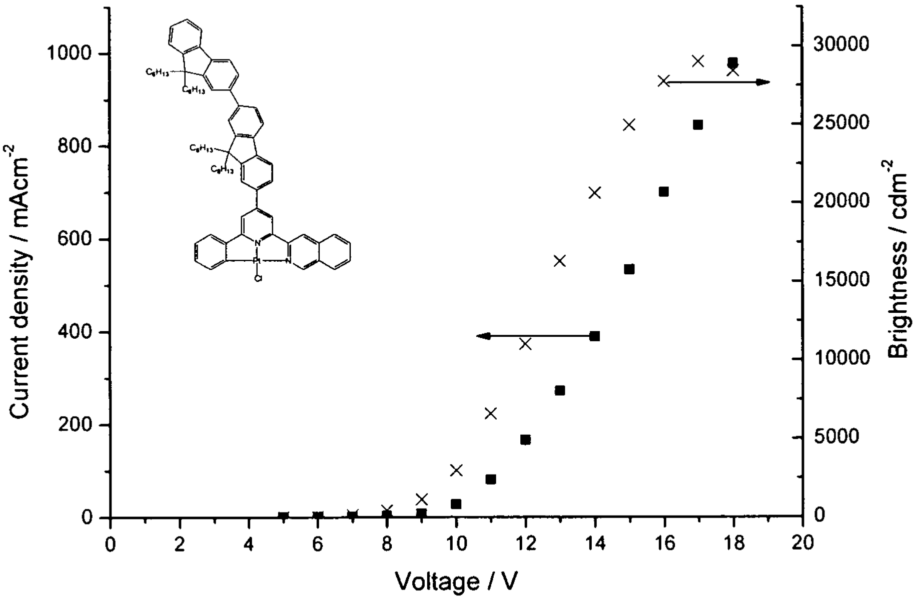


Figure 20

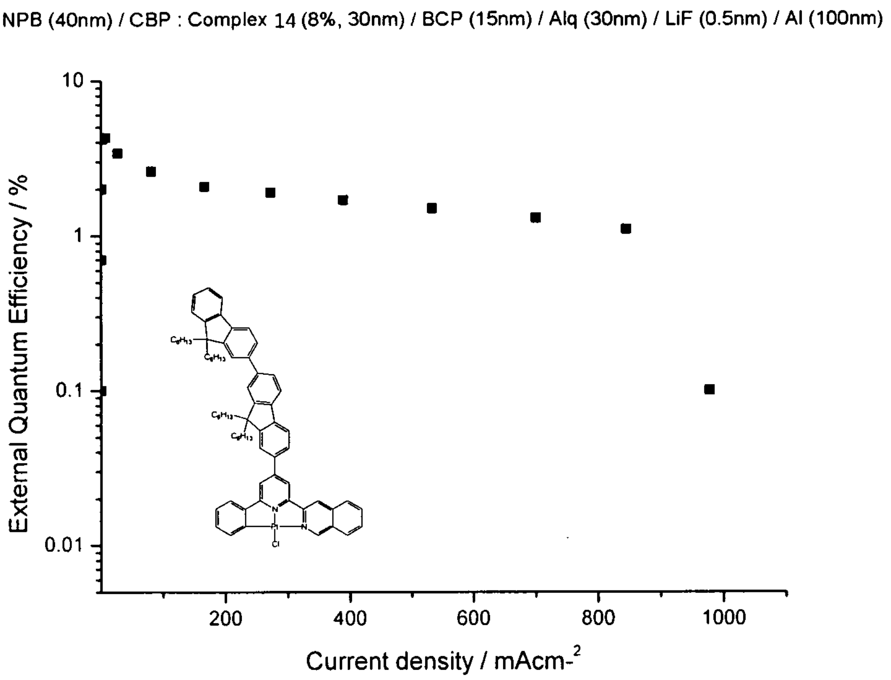

ITO / NPB (40nm) / CBP : Complex 14 (8%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 21

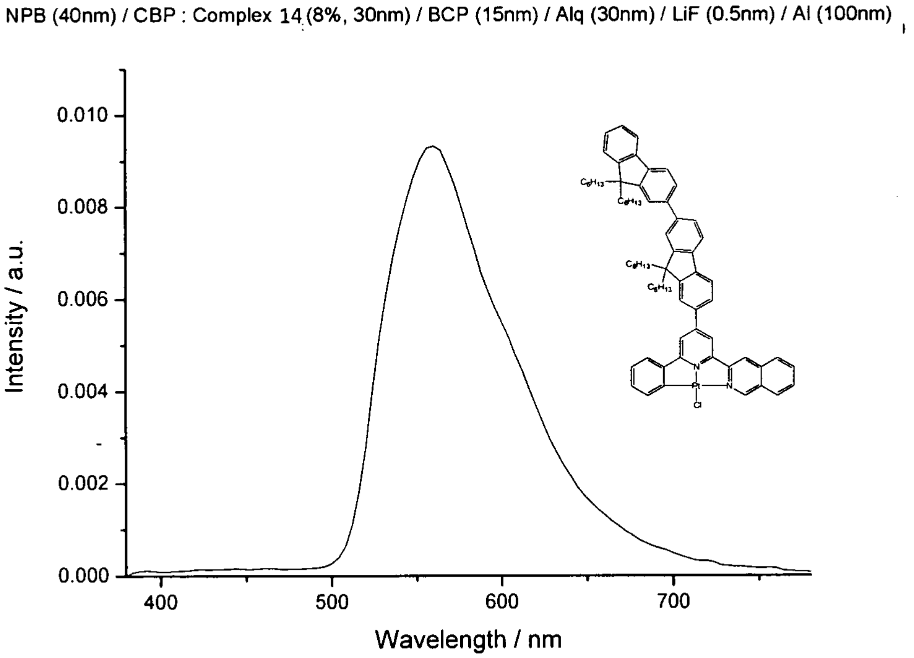

ITO / NPB (40nm) / CBP : Complex 14 (8%, 30nm) / BCP (15nm) / Alq (30nm) / LiF (0.5nm) / Al (100nm)

Figure 22

ITO / NPB (40nm) / CBP : Complex 13 (3.5%, 20nm) / BCP (40nm) / LiF (0.5nm) / Al (100nm)

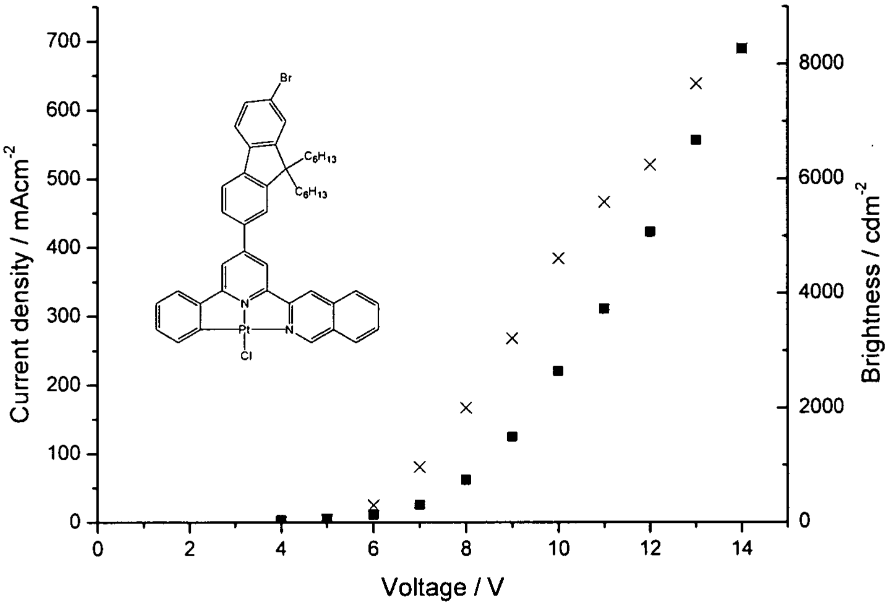


Figure 23

ITO / NPB (40nm) / CBP : Complex 13 (3.5%, 20nm) / BCP (40nm) / LiF (0.5nm) / Al (100nm)

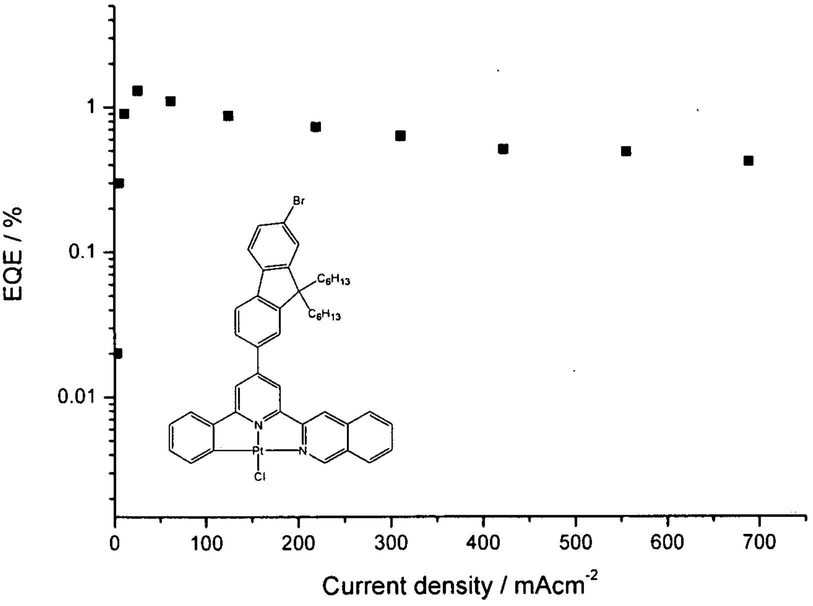


Figure 24

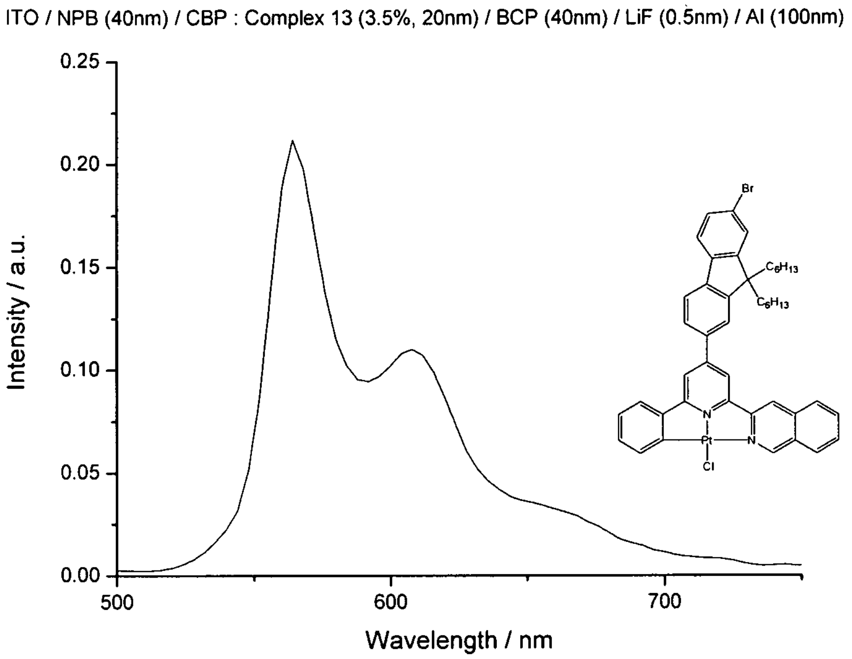

ITO / NPB (40nm) / CBP : Complex 13 (3.5%, 20nm) / BCP (40nm) / LiF (0.5nm) / Al (100nm)

Figure 25

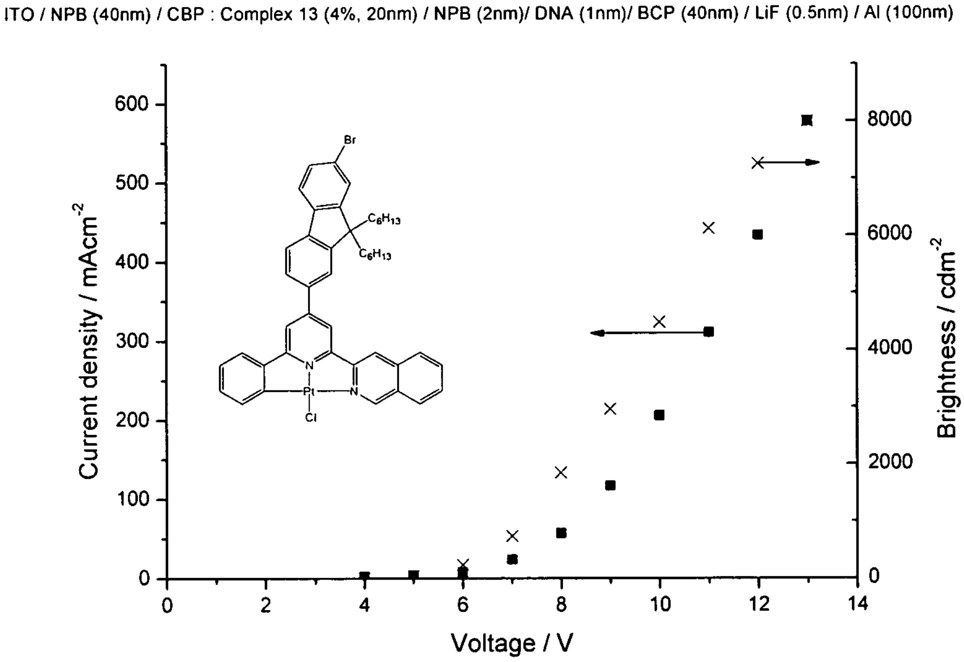
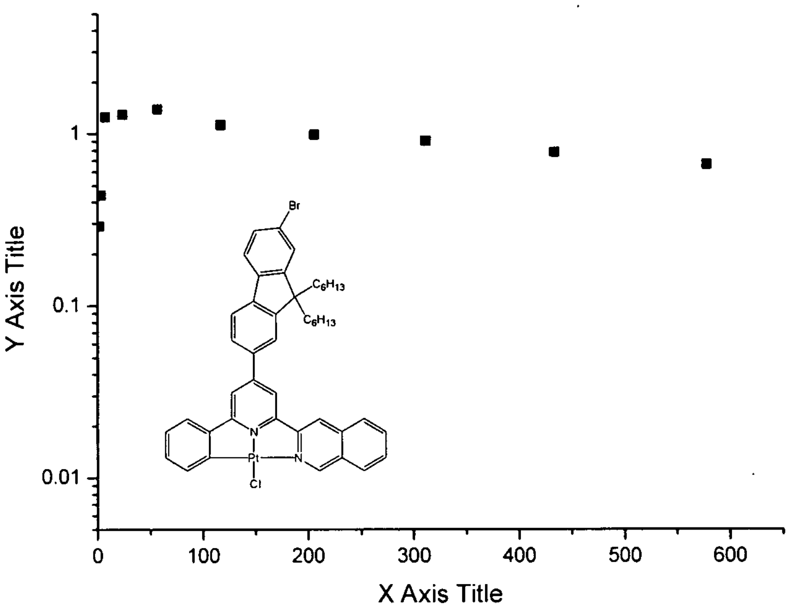
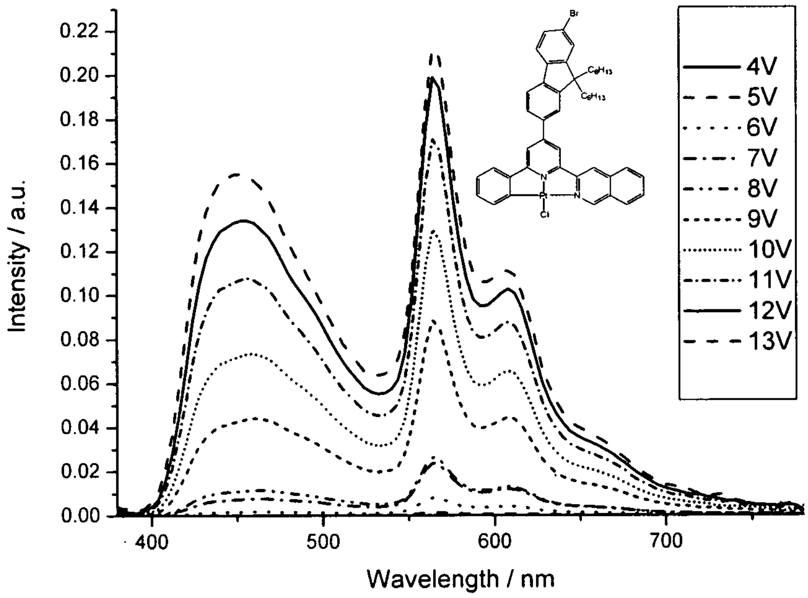

ITO / NPB (40nm) / CBP : Complex 13 (4%, 20nm) / NPB (2nm)/ DNA (1nm)/ BCP (40nm) / LiF (0.5nm) / Al (100nm)

Figure 26



ITO / NPB (40nm) / CBP : Complex 13 (4%, 20nm) / NPB (2nm)/ DNA (1nm)/ BCP (40nm) / LiF (0.5nm) / Al (100nm)

Figure 27



ITO / NPB (40nm) / CBP : Complex 13 (4%, 20nm) / NPB (2nm)/ DNA (1nm)/ BCP (40nm) / LiF (0.5nm) / Al (100nm)

Figure 28

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2010/000696

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: C07F17/-; C09K11/-; H01L51/-

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

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

WPI; EPODOC; CNPAT; CNKI; ISI; STN: platinum, Pt, complex??, OLED, +luminescen??, light, ligand?, tridentate, cyclometal+, isoquinoline, pyridine, benzene, phenyl

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US20080309227A1 (CHE, C. M.) 18 Dec. 2008 (18.12.2008) see paragraphs [0013], [0049]-[0050], [0061]-[0064], [0068] in description and figures 2-3	1-15
A	US7026480B2 (UNIV. HONG KONG) 11 Apr. 2006 (11.04.2006), see table I in description	1-15
A	KUI, Steven C. F., et al., Structures, Photoluminescence, and Reversible Vapoluminescence Properties of Neutral Platinum(II) Complexes Containing Extended π-Conjugated Cyclometalated Ligands, J. AM. CHEM. SOC., 06 Jun. 2006 (06.06.2006) , Vol. 128, No. 25, pages 8297-8309	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“& ”document member of the same patent family

Date of the actual completion of the international search 03 Aug. 2010 (03.08.2010)	Date of mailing of the international search report **02 Sep. 2010 (02.09.2010)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer CHEN, Ning Telephone No. (86-10)-82245651

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2010/000696

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US20080309227A1	18.12.2008	None	
US7026480B2	11.04.2006	US2002179885A1	05.12.2002
		CN1381545A	27.11.2002
		JP2002363552A	18.12.2002
		TW243197B1	11.11.2005
		CN1267525C	02.08.2006
		JP3965319B2	29.08.2007

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2010/000696

Continuation of: **A. CLASSIFICATION OF SUBJECT MATTER**

C07F17/02 (2006.01)i

C09K11/06 (2006.01)i

H01L51/50 (2006.01)i

H01L51/54 (2006.01)i