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(54) **METAL COORDINATION COMPOUND, LUMINESCENCE DEVICE AND DISPLAY APPARATUS**

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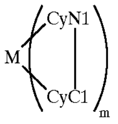
(57) **ABSTRACT**

An electroluminescence device having a layer containing a specific metal coordination compound is provided. The metal coordination compound is represented by formula (1) below:

$$ML_mL'_n \quad (1),$$

wherein M is a metal atom of Ir, Pt, Rh or Pd; L and L' are mutually different bidentate ligands; m is 1, 2 or 3 and n is 0, 1 or 2 with the proviso that m+n is 2 or 3; a partial structure MLm is represented by formula (2) shown below and a partial structure ML'$_n$ is represented by formula (3) or (4) shown below:

(2)



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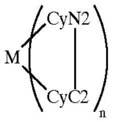

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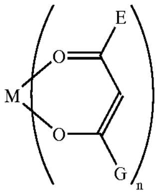
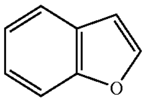


at least one of the optional substituent(s) of the cyclic groups, and the cyclic groups CyCl and CyC2 includes a benzofuran structure capable of having a substituent represented by the following formula (5):



The metal coordination compound having the benzofuran structure is effective in providing high-efficiency luminescence and long-term high luminance.

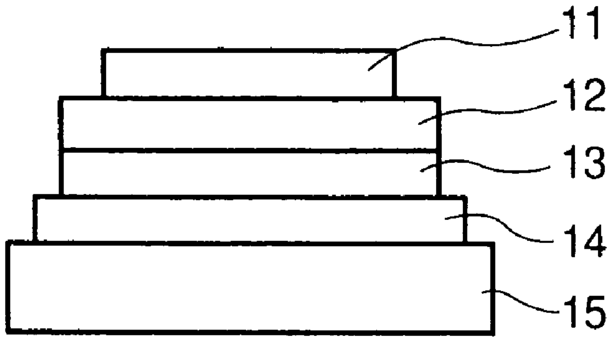


FIG. 1A

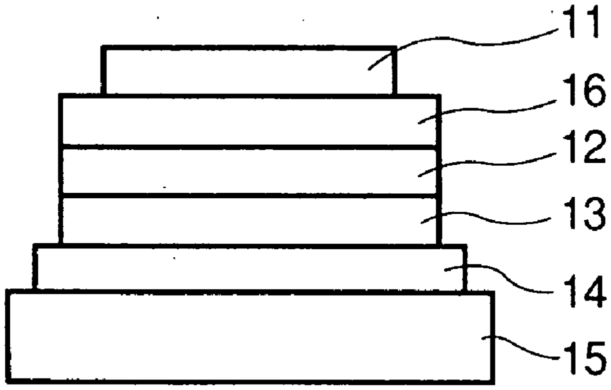


FIG. 1B

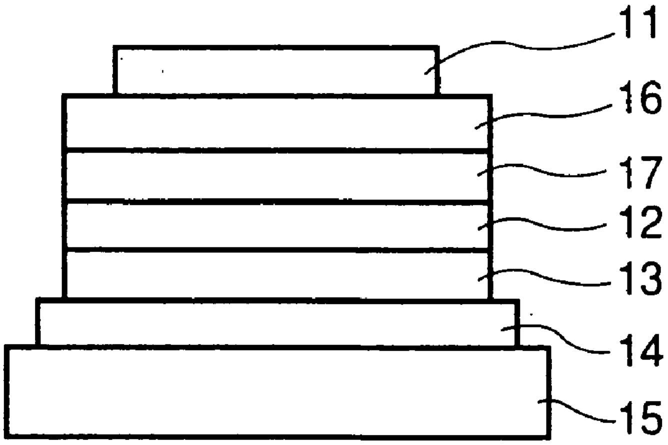


FIG. 1C

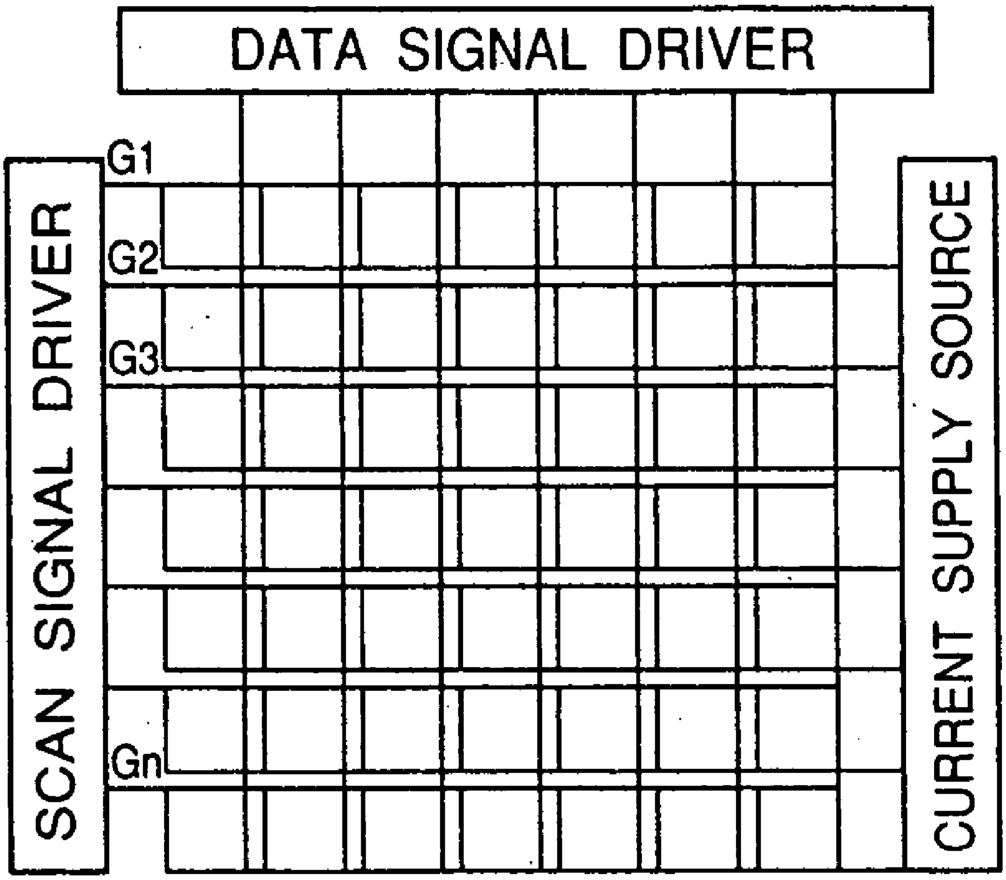

DATA SIGNAL DRIVER
SCAN SIGNAL DRIVER
CURRENT SUPPLY SOURCE
G1
G2
G3
Gn

FIG. 2

METAL COORDINATION COMPOUND, LUMINESCENCE DEVICE AND DISPLAY APPARATUS

FIELD OF THE INVENTION AND RELATED ART

[0001] The present invention relates to an organic luminescence device (also called an organic electroluminescence device or organic EL device) for use in a planar light source, a planar display, etc. Particularly, the present invention relates to a novel metal coordination compound and a luminescence device having a high luminescence efficiency and causing little change with time by using a metal coordination compound represented by formula (1) appearing hereinafter.

[0002] An old example of organic luminescence device is, e.g., one using luminescence of a vacuum-deposited anthracene film (Thin Solid Films, 94 (1982) 171). In recent years, however, in view of advantages, such as easiness of providing a large-area device compared with an inorganic luminescence device, and possibility of realizing desired luminescence colors by development of various new materials and drivability at low voltages, an extensive study thereon for device formation as a luminescence device of a high-speed responsiveness and a high efficiency, has been conducted.

[0003] As precisely described in Macromol. Symp. 125, 1-48 (1997), for example, an organic EL device generally has an organization comprising a pair of upper and lower electrodes formed on a transparent substrate, and organic material layers including a luminescence layer disposed between the electrodes.

[0004] In the luminescence layer, aluminum quinolinol complexes (inclusive of Alq3 shown hereinafter as a representative example) having an electron-transporting characteristic and a luminescence characteristic, are used for example. In a hole-transporting layer, a material having an electron-donative property, such as a triphenyldiamine derivative (inclusive of α-NPD shown hereinafter as a representative example), is used for example.

[0005] Such a device shows a current-rectifying characteristic such that when an electric field is applied between the electrodes, holes are injected from the anode and electrons are injected from the cathode.

[0006] The injected holes and electrons are recombined in the luminescence layer to form excitons, which emit luminescence when they are transitioned to the ground state.

[0007] In this process, the excited states include a singlet state and a triplet state and a transition from the former to the ground state is called fluorescence and a transition from the latter is called phosphorescence. Materials in theses states are called singlet excitons and triplet excitons, respectively.

[0008] In most of the organic luminescence devices studied heretofore, fluorescence caused by the transition of a singlet exciton to the ground state, has been utilized. On the other hand, in recent years, devices utilizing phosphorescence via triplet excitons have been studied.

[0009] Representative published literature may include:

[0010] Article 1: Improved energy transfer in electrophosphorescent device (D. F. O'Brien, et al., Applied Physics Letters, Vol. 74, No. 3, p. 422 (1999)); and

[0011] Article 2: Very high-efficiency green organic light-emitting devices based on electrophosphorescence (M. A. Baldo, et al., Applied Physics Letters, Vol. 75, No. 1, p. 4 (1999)).

[0012] In these articles, a structure including four organic layers sandwiched between the electrodes, and the materials used therein include carrier-transporting materials and phosphorescent materials, of which the names and structures are shown below together with their abbreviations.

[0013] Alq3: aluminum quinolinol complex

[0014] α-NPD: N4,N4'-di-naphthalene-1-yl-N4,N4'-diphenyl-biphenyl-4,4'-diamine

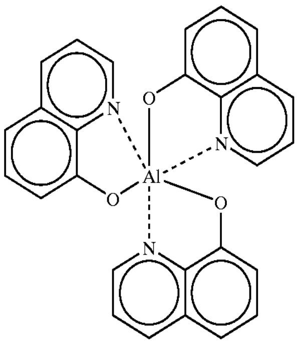
[0015] CBP: 4,4'-N,N'-dicarbazole-biphenyl

[0016] BCP: 2,9-dimethyl-4,7-diphenyl-1, 10-phenanthroline

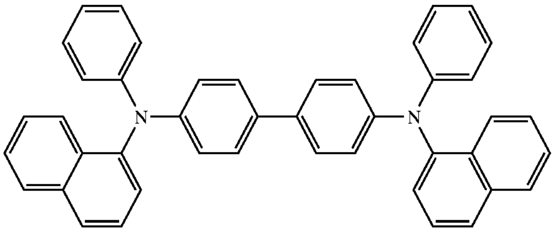
[0017] PtOEP: platinum-octaethylporphyrin complex

[0018] $Ir(ppy)_3$: iridium-phenylpyrimidine complex

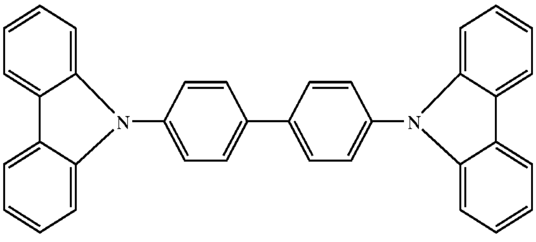
Alq3



α-NPD



CBP



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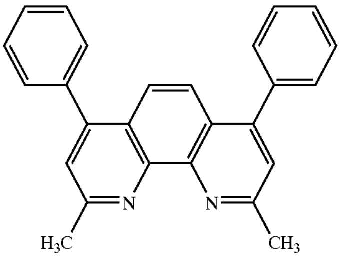
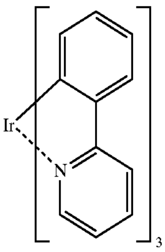
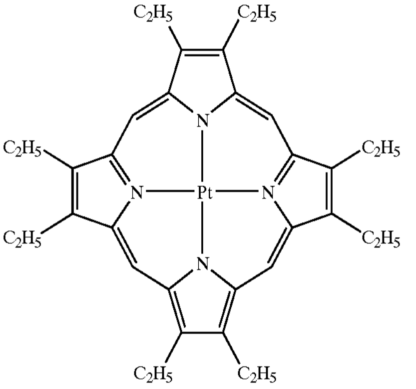
BCP



Ir(ppy)3



PtOEP



[0019] The above-mentioned Articles 1 and 2 both have reported structures, as exhibiting a high efficiency, including a hole-transporting layer comprising α-NPD, an electron-transporting layer comprising Alq3, an exciton diffusion-preventing layer comprising BCP, and a luminescence layer comprising CBP as a host and ca. 6% of PtOEP or Ir(ppy)$_3$ as a phosphorescent material dispersed in mixture therein.

[0020] Such a phosphorescent material is particularly noted at present because it is expected to provide a high luminescence efficiency in principle for the following reasons. More specifically, excitons formed by carrier recombination comprise singlet excitons and triplet excitons in a probability ratio of 1:3. Conventional organic EL devices have utilized fluorescence of which the luminescence efficiency is limited to at most 25%. On the other hand, if phosphorescence generated from triplet excitons is utilized, an efficiency of at least three times is expected, and even an efficiency of 100%, i.e., four times, can be expected in principle, if a transition owing to intersystem crossing from a singlet state having a higher energy to a triplet state is taken into account.

[0021] However, like a fluorescent-type device, such an organic luminescence device utilizing phosphorescence is generally required to be further improved regarding the deterioration of luminescence efficiency and device stability.

[0022] The reason of the deterioration has not been fully clarified, but the present inventors consider as follows based on the mechanism of phosphorescence.

[0023] In the case where the luminescence layer comprises a host material having a carrier-transporting function and a phosphorescent guest material, a process of phosphorescence via triplet excitons may include unit processes as follows:

[0024] 1. transportation of electrons and holes within a luminescence layer,

[0025] 2. formation of host excitons,

[0026] 3. excitation energy transfer between host molecules,

[0027] 4. excitation energy transfer from the host to the guest,

[0028] 5. formation of guest triplet excitons, and

[0029] 6. transition of the guest triplet excitons to the ground state and phosphorescence.

[0030] Desirable energy transfer in each unit process and luminescence are caused in competition with various energy deactivation processes.

[0031] Needless to say, a luminescence efficiency of an organic luminescence device is increased by increasing the luminescence quantum yield of a luminescence center material.

[0032] Particularly, in a phosphorescent material, this may be attributable to a life of the triplet excitons which is longer by three or more digits than the life of a singlet exciton. More specifically, because it is held in a high-energy excited state for a longer period, it is liable to react with surrounding materials and cause polymer formation among the excitons, thus incurring a higher probability of deactivation process resulting in a material change or life deterioration.

[0033] A luminescence device is desired to exhibit high efficiency luminescence and show a high stability. Particularly, it is strongly desired to provide a luminescence material compound which is less liable to cause energy deactivation in a long life of excited energy state and is also chemically stable, thus providing a longer device life.

SUMMARY OF THE INVENTION

[0034] Accordingly, principal objects of the present invention are to provide a luminescence material which exhibits a high luminescence efficiency and retains a high luminance for a long period, and also provide a luminescence device and a display apparatus using the same.

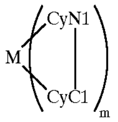
[0035] In the present invention, a metal complex is used as a luminescence material, particularly a novel luminescent metal complex compound comprising iridium as a center metal and a benzofuran structure of formula (5) appearing hereinafter as a part of a ligand or as a substituent of a ligand.

[0036] More specifically, the present invention provides as a luminescence material a metal coordination compound represented by formula (1) below:

$$ML_mL'_n \qquad (1),$$

[0037] wherein M is a metal atom of Ir, Pt, Rh or Pd; L and L' are mutually different bidentate ligands; m is 1, 2 or 3 and n is 0, 1 or 2 with the proviso that m+n is 2 or 3; a partial structure MLm is represented by formula (2) shown below and a partial structure ML_n is represented by formula (3) or (4) shown below:

(2)



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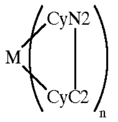
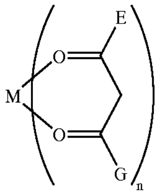


(4)



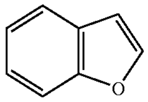
[**0038**] wherein CyN1 and CyN2 are each cyclic group capable of having a substituent, including a nitrogen atom and bonded to the metal atom M via the nitrogen atom; CyC1 and CyC2 are each cyclic group capable of having a substituent, including a carbon atom and bonded to the metal atom M via the carbon atom with the proviso that the cyclic group CyN1 and the cyclic group CyC1 are bonded to each other via a covalent bond and the cyclic group CyN2 and the cyclic group CyC2 are bonded to each other via a covalent bond;

[**0039**] the optional substituent of the cyclic groups is selected from a halogen atom, cyano group, a nitro group, a trialkylsilyl group of which the alkyl groups are independently a linear or branched alkyl group having 1 to 8 carbon atoms, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom, or an aromatic group capable of having a substituent (that is a halogen atom, a cyano atom, a nitro atom, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom);

[**0040**] E and G are independently a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom, or an aromatic group capable of having a substituent (that is a halogen atom, a cyano atom, a nitro atom, a trialkylsilyl group of which the alkyl groups are independently a linear or branched alkyl group having 1-8 carbon atoms, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom; and

[**0041**] at least one of the optional substituent(s) of the cyclic groups, and the cyclic groups CyC1 and CyC2 includes a benzofuran structure capable of having a substituent represented by the following formula (5):

(5)



[**0042**] wherein the benzofuran structure of the formula (5) is bonded to CyN1, CyN2, CyC1 or CyC2 via a single bond at any one of 2- to 7-positions when the benzofuran structure is the optional substituent(s) of the cyclic groups, and the benzofuran structure of the formula (5) is bonded to CyN1 or CyN2 via a single bond at any one of 2- to 7-positions and bonded to the metal atom M via a single bond at any one of 2- to 7-positions when the benzofuran structure is CyC1 or CyC2;

[**0043**] the optional substituent of the benzofuran structure of the formula (5) is selected from a halogen atom, cyano group, a nitro group, a trialkylsilyl group of which the alkyl groups are independently a linear or branched alkyl group having 1 to 8 carbon atoms, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom, or an aromatic group capable of having a substituent (that is a halogen atom, a cyano atom, a nitro atom, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom) with the proviso that an adjacent pair of substituents located at 4- to 7-positions of the benzofuran structure of the formula (5) can be bonded to form a cyclic structure.

[**0044**] Preferred embodiments of the metal coordination compound of the formula (1) according to the present invention include the following:

[**0045**] A metal coordination compound, wherein n is 0 in the formula (1).

[**0046**] A metal coordination compound having a partial structure ML'_n represented by the formula (3) in the formula (1).

[**0047**] A metal coordination compound having a partial structure ML'_n represented by the formula (4) in the formula (1).

[**0048**] A metal coordination compound wherein the cyclic groups CyC1 in the formula (1) and CyC2 in the formula (3) are independently selected from phenyl group, thienyl group, thianaphthyl group, naphthyl group, pyrenyl group, 9-fluorenonyl group, fluorenyl group, dibenzofuranyl group, dibenzothienyl group, carbazolyl group, or benzofuranyl group, as an aromatic cyclic group capable of having a substituent with the proviso that the aromatic cyclic group can include one or two CH groups that can be replaced with a nitrogen atom, particularly selected from phenyl group or benzofuranyl group.

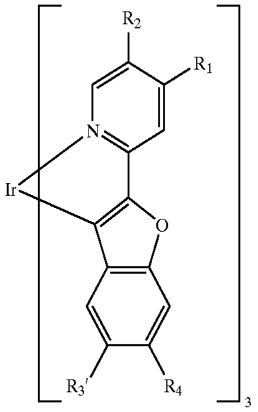
[0049] A metal coordination compound, wherein the cyclic groups CyN1 in the formula (2) and CyN2 in the formula (3) are independently selected from pyridyl group, pyridazinyl group, and pyrimidinyl group, particularly pyridyl group, as an aromatic cyclic group capable of having a substituent.

[0050] A metal coordination compound, wherein the cyclic groups CyN1, CyN2, CyC1 and CyC2 are independently non-substituted, or have a substituent selected from a halogen atom and a linear or branched alkyl group having 1 to 20 carbon atoms {of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CH═CH—, —C≡C—, or a divalent aromatic group capable of having a substituent (that is a halogen atom or a linear or branched alkyl group having 1 to 20 carbon atoms (of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom)), and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom}.

[0051] A metal coordination compound, wherein M in the formula (1) is iridium.

[0052] A metal coordination compound represented by the following formula (6) or (7), particularly the formula (7):

(6)



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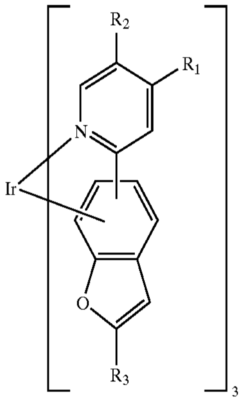


[0053] wherein R_1, R_2, R_3, R'_3 and R_4 are independently

[0054] a hydrogen atom; a fluorine atom; a linear or branched alkyl group of formula: C_nH_{2n+1}— in which n is an integer of 1-20, the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O— and also can include a hydrogen atom that can be optionally replaced with a fluorine atom; a phenyl group capable of having a substituent; or a benzofuranyl group capable of having a substituent; the optional substituent of phenyl group and benzofuranyl group is a fluorine atom or a linear or branched alkyl group of formula: C_nH_{2n+1} — in which n is an integer of 1-20, the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O— and also can include a hydrogen atom that can be optionally replaced with a fluorine atom.

[0055] The present invention also provides an electroluminescence device, comprising: a pair of electrodes disposed on a substrate, and a luminescence unit comprising at least one organic compound disposed between the electrodes, wherein the organic compound comprises a metal coordination compound represented by the formula (1) described above.

[0056] In the luminescence device, a voltage is applied between the electrodes to emit phosphorescence.

[0057] The present invention further provides a picture display apparatus, comprising an electroluminescence device described above and a means for supplying electric signals to the electroluminescence device.

[0058] These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0059] **FIGS. 1A, 1B** and 1C illustrate embodiments of the luminescence device according to the present invention, respectively.

[0060] **FIG. 2** schematically illustrates a panel structure including an EL device and drive means.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0061] Basic structures of organic luminescence (EL) devices formed according to the present invention are illustrated in **FIGS. 1A, 1B** and 1C.

[0062] As shown in these figures, an organic luminescence device generally comprises, on a transparent substrate **15**, a 50 to 200 nm-thick transparent electrode **14**, a plurality of organic film layers and a metal electrode **11** formed so as to cover the organic layers.

[0063] **FIG. 1A** shows an embodiment wherein the organic luminescence device comprises a luminescence layer **12** and a hole-transporting layer **13**. The transparent electrode **14** may comprise ITO, etc., having a large work function so as to facilitate hole injection from the transparent electrode **14** to the hole-transporting layer **13**. The metal electrode **11** comprises a metal material having a small work function, such as aluminum, magnesium or alloys of these elements, so as to facilitate electron injection into the organic luminescence device.

[0064] The luminescence layer **12** comprises a compound (metal coordination compound) according to the present invention. The hole-transporting layer **13** may comprise, e.g., a triphenyldiamine derivative, as represented by α-NPD mentioned above, and also a material having an electron-donative property as desired.

[0065] A device organized above exhibits a current-rectifying characteristic, and when an electric field is applied between the metal electrode **11** as a cathode and the transparent electrode **14** as an anode, electrons are injected from the metal electrode **11** into the luminescence layer **12**, and holes are injected from the transparent electrode **15**. The injected holes and electrons are recombined in the luminescence layer **12** to form excitons having high energy potential, which cause luminescence during transition to the ground state. In this instance, the hole-transporting layer **13** functions as an electron-blocking layer to increase the recombination efficiency at the boundary between the luminescence layer layer **12** and the hole-transporting layer **13**, thereby providing an enhanced luminescence efficiency.

[0066] Further, in the structure of **FIG. 1B**, an electron-transporting layer **16** is disposed between the metal electrode **11** and the luminescence layer **12** in **FIG. 1A**. As a result, the luminescence function is separated from the functions of electron transportation and hole transportation to provide a structure exhibiting more effective carrier blocking, thus increasing the luminescence efficiency. The electron-transporting layer **16**, may comprise, e.g., an oxadiazole derivative.

[0067] **FIG. 1C** shows another desirable form of a four-layer structure, including a hole-transporting layer **13**, a luminescence layer **12**, an exciton diffusion prevention layer **17** and an electron-transporting layer **16**, successively from the side of the transparent electrode **14** as the anode.

[0068] The luminescence materials used in the present invention are most suitably metal coordination compounds represented by the above-mentioned formulae (1) to (5), which are found to cause high-efficiency luminescence, retain high luminance for a long period and show little deterioration by current passage.

[0069] The metal coordination compound of the present invention emits phosphorescence, and its lowest excited state is believed to be an MLCT* (metal-to-ligand charge transfer) excited state or π-π* excited state in a triplet state, and phosphorescence is caused at the time of transition from such a state to the ground state.

[0070] Hereinbelow, methods for measurement of some properties and physical values described herein for characterizing the luminescence material of the present invention will be described.

[0071] (1) Judgment Between Phosphorescence and Fluorescence

[0072] The identification of phosphorescence was effected depending on whether deactivation with oxygen was caused or not. A solution of a sample compound in chloroform after aeration with oxygen or with nitrogen is subjected to photoillumination to cause photo-luminescence. The luminescence is judged to be phosphorescence if almost no luminescence attributable to the compound is observed with respect to the solution aerated with oxygen but photoluminescence is confirmed with respect to the solution aerated with nitrogen. The phosphorescence of all the compounds of the present invention has been confirmed by this method unless otherwise noted specifically.

[0073] (2) Phosphorescence yield (a relative quantum yield, i.e., a ratio of an objective sample's quantum yield Φ (sample) to a standard sample's quantum yield Φ (st)) is determined according to the following formula:

$$\Phi(\text{sample})/\Phi(\text{st})=[\text{Sem}(\text{sample})/I\text{abs}(\text{sample})]/[\text{Sem}(\text{st})/I\text{abs}(\text{st})],$$

[0074] wherein Iabs(st) denotes an absorption coefficient at an excitation wavelength of the standard sample; Sem(st), a luminescence spectral areal intensity when excited at the same wavelength; Iabs(sample), an absorption coefficient at an excitation wavelength of an objective compound; and Sem(sample), a luminescence spectral areal intensity when excited at the same wavelength.

[0075] Phosphorescence yield values described herein are relative values with respect to a phosphorescence yield $\Phi=1$ of Ir(ppy)_3 as a standard sample.

[0076] (3) A Method of Measurement of Phosphorescence Life is as Follows.

[0077] A sample compound is dissolved in chloroform and spin-coated onto a quartz substrate in a thickness of ca. 0.1 μm and is exposed to pulsative nitrogen laser light at an excitation wavelength of 337 nm at room temperature by using a luminescence life meter (made by Hamamatsu Photonics K.K.). After completion of the excitation pulses, the decay characteristic of luminescence intensity is measured.

[0078] When an initial luminescence intensity is denoted by I_0, a luminescence intensity after t(sec) is expressed according to the following formula with reference to a luminescence life z(sec):

$$I=I_0\cdot\exp(-t/\tau).$$

[0079] The luminescence material (metal coordination compound) of the present invention exhibited high phosphorescence quantum yields of 0.11 to 0.9 and short phosphorescence lives of 0.1 to 40 μsec. A short phosphorescence life becomes a condition for causing little energy deactivation and exhibiting an enhanced luminescence efficiency. More specifically if the phosphorescence life is long, the number of triplet state molecules maintained for luminescence is increased, and the deactivation process is liable to occur, thus resulting in a lower luminescence efficiency particularly at the time of a high-current density. The material of the present invention has a relatively short phosphorescence life thus exhibiting a high phosphorescence quantum yield, and is therefore suitable as a luminescence material for an EL device.

[0080] As a result of various studies of ours, it has been found that an organic EL device using the metal coordination compound of the formula (1) as a principal luminescence material causes high-efficiency luminescence, retains high luminance for a long period and shows little deterioration by current passage.

[0081] In the formula (1) representing the metal coordination compound of the present invention, n may preferably 0 or 1, more preferably 0. Further, the partial structure ML'n may preferably comprise the benzofuran structure represented by the above-mentioned formula (5).

[0082] In the present invention, by incorporating the benzofuran structure of the formula (5) into the metal coordination compound of the formula (1), it becomes possible to control an emission wave-length (particularly to provide a long emission wavelength). The presence of the benzofuran structure of the formula (5) is effective in enhancing a solubility of the metal coordination compound of the present invention in an organic solvent, thus facilitating a purification thereof by recrystallization or column chromatography. As a result, the metal coordination compound of the present invention is suitable as a luminescence material for the organic EL device.

[0083] Further, as shown in Examples appearing hereinafter, it has been substantiated that the metal coordination compound of the present invention exhibited an excellent stability in a continuous current passage test. This may be attributable to incorporation of the benzofuran structure of the formula (5) into the molecular structure of the metal coordination compound of the formula (1) according to the present invention. More specifically, a change in intermolecular interaction due to the introduction of the benzofuran structure of the formula (5) allows an intermolecular interact-ion of the metal coordination compound with, e.g., a host material to suppress formation of exciton associates-causing thermal deactivation, thus reducing a quenching process thereby to improve phosphorescence yield and device characteristics.

[0084] In the case where CyN1 (or CyN2) is benzofranyl group and CyC1 (or CyC2) is pyridyl or pyrimidinyl group in the metal coordination compound of formula (1) of the present invention, pyridyl or pyrimidinyl group (CyC1 or CyC2) may preferably have a substituent other than methyl group, methoxy group, butyl group and fluorine atom when benzofuran group (CyN1 or CyN2) is not substituted. In another preferred embodiment in the above case, benzofuran group (CyN1 or CyN2) has a substituent, particularly trifluoromethyl group or an aromatic group. In still another preferred embodiment in the above case, the metal coordination compound has a substituent such as trifluoromethyl group, an aromatic group or a cyclized group (e.g., —(CH=CH)$_2$—).

[0085] The luminescence device according to the present invention may preferably be an electroluminescence device of the type wherein a layer of the metal coordination compound of the formula (1) is disposed between opposing two electrodes and a voltage is applied between the electrodes to cause luminescence, particularly phosphorescence, as shown in **FIGS. 1A, 1B** and 1C.

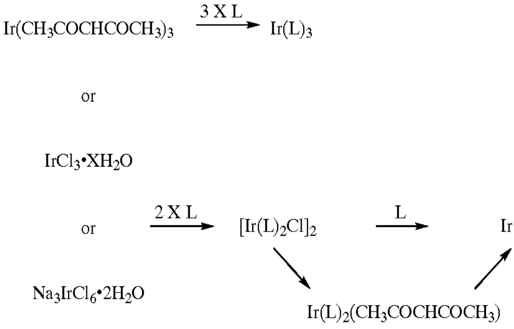
[0086] The luminescence device according to the present invention may be applicable to devices required to allow energy saving and high luminance, such as those for display apparatus and illumination apparatus, a light source for printers, and backlight (unit) for a liquid crystal display apparatus. Specifically, in the case of using the luminescence device of the present invention in the display apparatus, it is possible to provide a flat panel display apparatus capable of exhibiting an excellent energy saving performance, a high visibility and a good lightweight property.

[0087] For the application to a display, a drive system using a thin-film transistor (TFT) drive circuit according to an active matrix-scheme may be used. Hereinbelow, an embodiment of using a device of the present invention in combination with an active matrix substrate is briefly described with reference to **FIG. 2**.

[0088] **FIG. 2** illustrates an embodiment of panel structure comprising an EL device and drive means. The panel is provided with a scanning signal driver, a data signal driver and a current supply source which are connected to gate selection lines, data signal lines and current supply lines, respectively. At each intersection of the gate selection lines and the data signal lines, a display pixel electrode is disposed. The scanning signal drive sequentially selects the gate selection lines G**1**, G**2**, G**3** . . . Gn, and in synchronism herewith, picture signals are supplied from the data signal driver to display a picture (image).

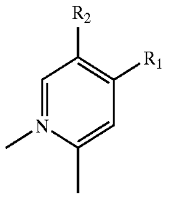
[0089] By driving a display panel including a luminescence layer comprising a luminescence material of the present invention, it becomes possible to provide a display which exhibits a good picture quality and is stable even for a long period display.

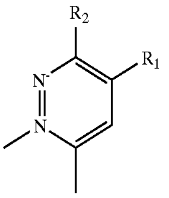
[0090] Some synthetic paths for providing a metal coordination compound represented by the above-mentioned formula (1) are illustrated below with reference to an iridium coordination compound (m+n=3) for example:

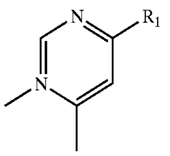


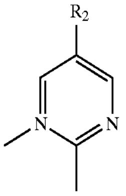
[0091] Other metal coordination compound (M=Pt, Rh and Pd) can also be synthesized in a similar manner.

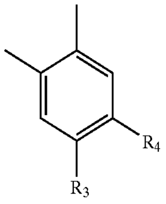
[0092] Some specific structural examples of metal coordination compounds used in the present invention are shown in Tables 1 to Tables 17 appearing hereinafter, which are however only representative examples and are not exhaustive. Pi to Bf6 for CyN1, CyN2, CyC1 and CyC2 shown in Tables 1 to 17 represent partial structures shown below.

Pi:


Pr:


Py1:


Py2:


Ph1:


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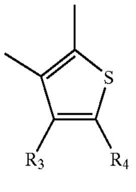

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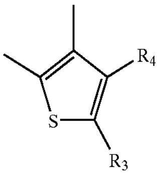
Tn2:



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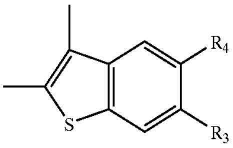
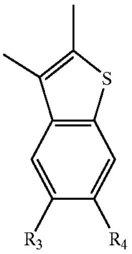
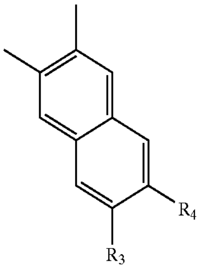


Tn4:



Np1:



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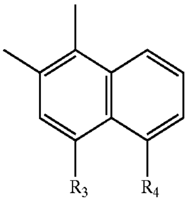
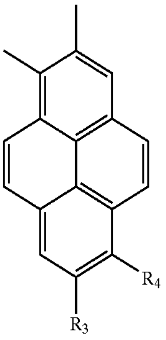
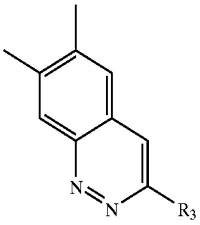


Pe1:



Cn1:



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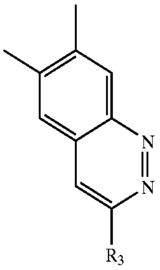

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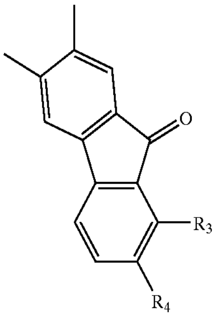

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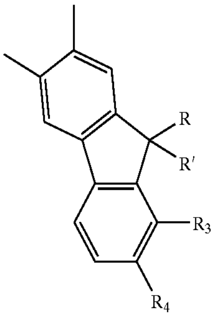

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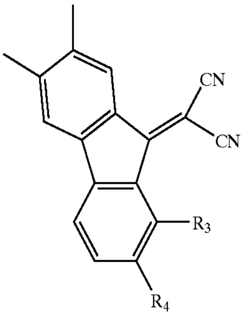

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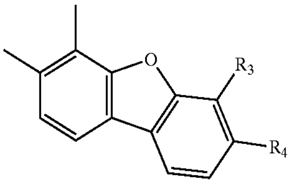
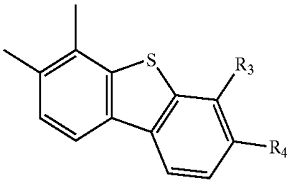
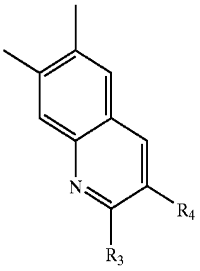


DBT1:



Qn1:



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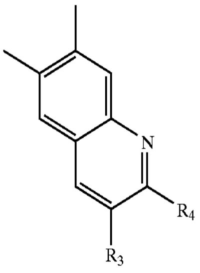

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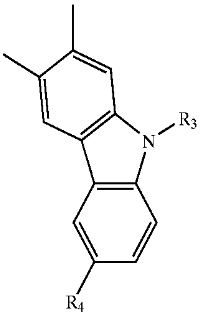
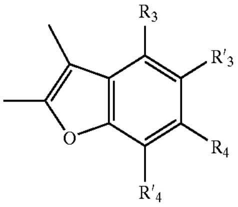
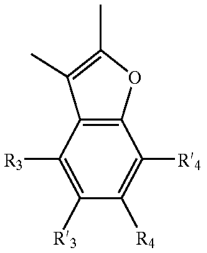
Cz:



Bf1:



Bf2:



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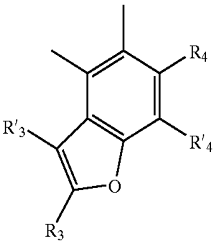

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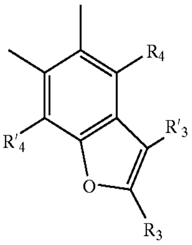
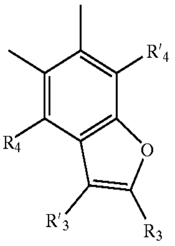


Bf5:



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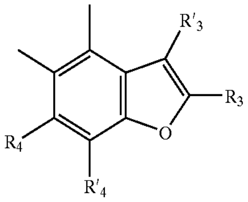
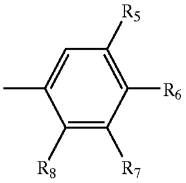
Bf6:



[0093] Further, aromatic group Ph2 to Bf8 as substituents for CyN1, CyN2, CyC1 and CyC2 shown in Tables 1 to 17 represent partial structures shown below.

Ph2:



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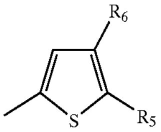
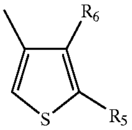
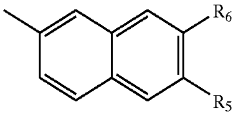


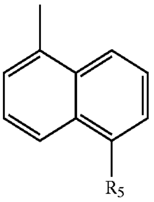
Tn6:



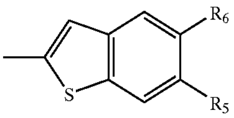
Np3:



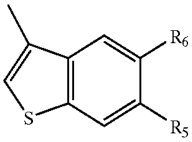
Np4:



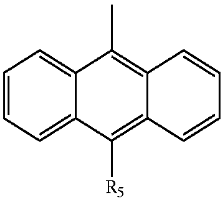
Tn7:



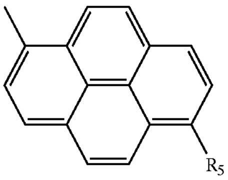
Tn8:



An:



Pe2:



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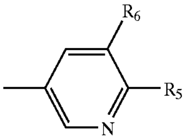
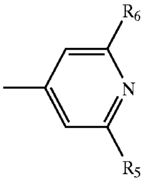
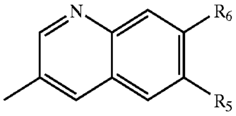
Pi2:



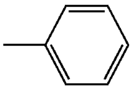
Pi3:



Qn2:



Ph3:



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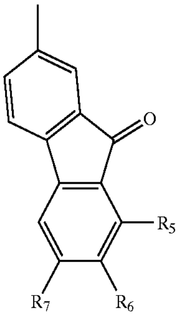

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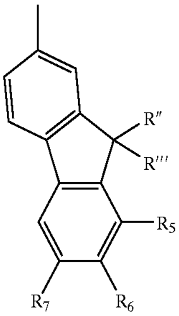


TABLE 1

										CyN1			
						CyN1-R1		CyN1-R2		R5	R6	R7	R8
											CyC1		
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
1	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
2	Ir	3	0	Pi	Bf1	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
3	Ir	3	0	Pi	Bf1	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
4	Ir	3	0	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
5	Ir	3	0	Pi	Bf1	H		NO_2		—	—	—	—
						H	H	H	H	—	—	—	—
6	Ir	3	0	Pi	Bf1	H		Cl		—	—	—	—
						H	H	H	H	—	—	—	—
7	Ir	3	0	Pi	Bf1	H		F	F	—	—	—	—
						H	H	H	H	—	—	—	—
8	Ir	3	0	Pi	Bf1	H		CN		—	—	—	—
						H	H	H	H	—	—	—	—
9	Ir	3	0	Pi	Bf1	H		OCH_3		—	—	—	—
						H	H	H	H	—	—	—	—
10	Ir	3	0	Pi	Bf1	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
11	Ir	3	0	Pi	Bf1	H		Ph2		CF_3	H	H	H
						H	H	H	H	—	—	—	—
12	Ir	3	0	Pi	Bf1	H		Ph2		H	H	F	F
						H	H	H	H	—	—	—	—
13	Ir	3	0	Pi	Bf1	Ph2		H		H	H	H	H
						H	H	H	H	—	—	—	—
14	Ir	3	0	Pi	Bf1	H		Np4		H	—	—	—
						H	H	H	H	—	—	—	—
15	Ir	3	0	Pi	Bf1	Tn7		H		H	H	—	—
						H	H	H	H	—	—	—	—
16	Ir	3	0	Pi	Bf1	H		C_4H_9		—	—	—	—
						H	H	H	H	—	—	—	—
17	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	OCH_3	H	—	—	—	—

TABLE 1-continued

										CyN1			
						CyN1-R1		CyN1-R2		R5	R6	R7	R8
										CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
18	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	Cl	H	—	—	—	—
19	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	F	H	—	—	—	—
20	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	C_8H_{17}	H	—	—	—	—
21	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	NO_2	H	—	—	—	—
22	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	Ph2	H	H	H	H	H
23	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	Ph2	H	H	$Si(C_3H_7)_3$	H	H
24	Ir	3	0	Pi	Bf1	Ph2		H		H	H	H	H
						H	H	Ph2	H	H	H	H	H
25	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	Br	H	—	—	—	—
26	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	Bf7	H	H	H	H	H
27	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	OC_4H_9	H	H	—	—	—	—
28	Ir	3	0	Pi	Bf1	H		Ph2		H	$OCH_2C_5F_{11}$	H	H
						H	H	H	H	—	—	—	—
29	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	Br	H	H	—	—	—	—
30	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	$Si(C_8H1_7)_3$	H	H	—	—	—	—
31	Ir	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	H	H	—	—	—	—

[0094]

TABLE 2

										CyN1			
						CyN1-R1		CyN1-R2		R5	R6	R7	R8
										CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
32	Ir	3	0	Pi	Bf2	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
33	Ir	3	0	Pi	Bf2	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
34	Ir	3	0	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
35	Ir	3	0	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	H	H	—	—	—	—
36	Ir	3	0	Pi	Bf2	H		Np4		H	—	—	—
						H	H	H	H	—	—	—	—
37	Ir	3	0	Pi	Bf2	Tn7		H		H	H	—	—
						H	H	H	H	—	—	—	—
38	Ir	3	0	Pi	Bf2	H		C_4H_9		—	—	—	—
						H	H	H	H	—	—	—	—
39	Ir	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	OCH_3	H	—	—	—	—
40	Ir	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	Ph2	H	H	$Si(C_3H_7)_3$	H	H
41	Ir	3	0	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	Ph2	H	H	H	H	H
42	Ir	3	0	Pi	Bf2	H		Np3		H	H	—	—
						H	H	H	H	—	—	—	—
43	Ir	3	0	Pi	Bf2	H		Np4		H	—	—	—
						H	H	H	H	—	—	—	—
44	Ir	3	0	Pi	Bf2	H		Pe2		H	—	—	—

TABLE 2-continued

No	M	m	n	CyN1	CyC1	CyN1-R1		CyN1-R2		CyN1 R5	CyN1 R6	CyN1 R7	CyN1 R8
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	CyC1 R5	CyC1 R6	CyC1 R7	CyC1 R8
						H	H	H	H	—	—	—	—
45	Ir	3	0	Pi	Bf2	H		Qn2		H	H	—	—
						H	H	H	H	—	—	—	—
46	Ir	3	0	Pi	Bf2	H		An		H	—	—	—
						H	H	H	H	—	—	—	—
47	Ir	3	0	Pi	Bf2	H		Bf7		H	H	H	H
						H	H	H	H	—	—	—	—
48	Ir	3	0	Pi	Bf2	Tn5		H		H	H	—	—
						H	H	H	H	—	—	—	—
49	Ir	3	0	Pi	Bf2	H		Bf8		H	H	H	H
						H	H	H	H	—	—	—	—
50	Ir	3	0	Pi	Bf2	H		Tn6		H	H	—	—
						H	H	H	H	—	—	—	—
51	Ir	3	0	Pi	Bf3	H		H		—	—	—	—
						Ph2	H	H	H	H	OCH_3	H	H
52	Ir	3	0	Pi	Bf3	H		CF_3		—	—	—	—
						Ph2	H	H	H	H	C_6H_{13}	H	H
53	Ir	3	0	Pi	Bf3	H		CF_3		—	—	—	—
						Np3	H	H	H	H	H	—	—
54	Ir	3	0	Pi	Bf3	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
55	Ir	3	0	Pi	Bf3	CF_3		H		—	—	—	—
						C_2H_5	H	H	H	—	—	—	—
56	Ir	3	0	Pi	Bf3	CF_3		CF_3		—	—	—	—
						$C_{10}H_{21}$	H	H	H	—	—	—	—
57	Ir	3	0	Pi	Bf3	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
58	Ir	3	0	Pi	Bf3	H		H		—	—	—	—
						Tn5	H	H	H	H	H	—	—
59	Ir	3	0	Pi	Bf3	H		H		—	—	—	—
						Np3	H	H	H	H	H	—	—
60	Ir	3	0	Pi	Bf3	H		H		—	—	—	—
						Np4	H	H	H	H	—	—	—
61	Ir	3	0	Pi	Bf4	H		CF_3		—	—	—	—
						Ph2	H	H	H	H	C_5H_{13}	H	H

[0095]

TABLE 3

No	M	m	n	CyN1	CyC1	CyN1-R1		CyN1-R2		CyN1 R5	CyN1 R6	CyN1 R7	CyN1 R8
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	CyC1 R5	CyC1 R6	CyC1 R7	CyC1 R8
62	Ir	3	0	Pi	Bf4	H		H		—	—	—	—
						C_8H_{17}	H	H	H	—	—	—	—
63	Ir	3	0	Pi	Bf4	H		H		—	—	—	—
						Ph2	H	H	H	H	H	H	H
64	Ir	3	0	Pi	Bf4	Np4		H		H	—	—	—
						Ph2	H	H	H	H	H	H	H
65	Ir	3	0	Pi	Bf4	FL4		H		H	H	H	—
						Ph2	H	H	H	H	H	H	H
66	Ir	3	0	Pi	Bf4	CF_3		CF_3		—	—	—	—
						$C_{15}H_{31}$	H	H	H	—	—	—	—
67	Ir	3	0	Pi	Bf4	H		H		—	—	—	—
						DBT2	H	H	H	H	H	H	—
68	Ir	3	0	Pi	Bf4	H		Bf7		H	H	H	H
						Ph2	H	H	H	H	H	H	H
69	Ir	3	0	Pi	Bf4	H		Bf8		H	H	H	H
						Ph2	H	H	H	H	H	H	H
70	Ir	3	0	Pi	Bf4	H		Pi3		H	H	—	—
						Ph2	H	H	H	H	H	H	H

TABLE 3-continued

						CyN1-R1		CyN1-R2		CyN1			
										R5	R6	R7	R8
										CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
71	Ir	3	0	Pi	Bf5	H		CF_3		—	—	—	—
						Ph2	H	H	H	H	C_6H_{13}	H	H
72	Ir	3	0	Pi	Bf5	H		H		—	—	—	—
						C_3H_7	H	H	H	—	—	—	—
73	Ir	3	0	Pi	Bf5	CF_3		H		—	—	—	—
						$C_{20}H_{41}$	H	H	H	—	—	—	—
74	Ir	3	0	Pi	Ph1	H		Bf7		H	H	H	H
						H	H	—	—	—	—	—	—
75	Ir	3	0	Pi	Ph1	H		Bf7		H	H	H	H
						H	OCH_3	—	—	—	—	—	—
76	Ir	3	0	Pi	Tn1	H		Bf7		H	H	H	H
						H	H	—	—	—	—	—	—
77	Ir	3	0	Pi	Np2	H		Bf7		H	H	H	H
						H	H	—	—	—	—	—	—
78	Ir	3	0	Pi	Cn1	H		Bf7		H	H	H	H
						H	H	—	—	—	—	—	—
79	Ir	3	0	Pi	DBT1	H		Bf7		H	H	H	H
						H	H	—	—	—	—	—	—
80	Ir	3	0	Pi	Ph1	H		Bf8		H	H	H	H
						H	H	—	—	—	—	—	—
81	Ir	3	0	Pi	Ph1	H		Bf8		H	H	H	H
						H	H	—	—	—	—	—	—
82	Ir	3	0	Pi	Tn2	H		Bf8		H	H	H	H
						H	H	—	—	—	—	—	—
83	Ir	3	0	Pi	Np2	H		Bf8		H	H	F	H
						H	H	—	—	—	—	—	—
84	Ir	3	0	Pi	Cn1	H		Bf8		H	H	H	H
						H	H	—	—	—	—	—	—
85	Ir	3	0	Pi	Cz	H		Bf8		H	H	H	H
						CH3	H	—	—	—	—	—	—
86	Ir	3	0	Pr	Bf1	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
87	Ir	3	0	Py1	Bf1	H		—		—	—	—	—
						H	H	H	H	—	—	—	—
88	Ir	3	0	Py2	Bf1	—		H		—	—	—	—
						H	H	H	H	—	—	—	—
89	Ir	3	0	Pr	Bf2	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
90	Ir	3	0	Py1	Bf2	H		—		—	—	—	—
						H	H	H	H	—	—	—	—
91	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						—(CH=CH)2—		H	H	—	—	—	—
92	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—

[0096]

TABLE 4

						CyN1-R1		CyN1-R2		CyN1			
										R5	R6	R7	R8
										CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
93	Ir	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
94	Ir	3	0	Pi	Bf1	H		CF_3		—	—	—	—
						—(CH=CH)2—		H	H	—	—	—	—
95	Ir	3	0	Pi	Bf1	H		CF_3		—	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—
96	Ir	3	0	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
97	Ir	3	0	Pi	Bf1	H		Np4		H	—	—	—

TABLE 4-continued

										CyN1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
						—(CH=CH)2—		H	H	—	—	—	—
98	Ir	3	0	Pi	Bf1	H		Ph2		H	$OCH{=}CHC_7H_{15}$	H	H
						—(CH=CH)2—		H	H	—	—	—	—
99	Ir	3	0	Pi	Bf1	H		Ph2		H	$OC{\equiv}CC_8H_{17}$	H	H
						H	—(CH=CH)2—		H	—	—	—	—
100	Ir	3	0	Pi	Bf1	Ph2		H		H	H	H	H
						H	H	—(CH=CH)2—		—	—	—	—
101	Ir	3	0	Pi	Bf2	H		H		—	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—
102	Ir	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
103	Ir	3	0	Pi	Bf2	H		H		—	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—
104	Ir	3	0	Pi	Bf2	H		Np4		H	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
105	Ir	3	0	Pi	Bf2	H		Ph2		H	H	F	F
						H	H	—(CH=CH)2—		—	—	—	—
106	Ir	3	0	Pi	Bf1	H		Np3		H	H	—	—
						—(CH=CH)2—		H	H	—	—	—	—
107	Ir	3	0	Pi	Bf1	H		An		H	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—
108	Ir	3	0	Pi	Bf1	H		Pe2		H	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
109	Ir	3	0	Pi	Bf1	H		Cl		—	—	—	—
						—(CH=CH)2—		H	H	—	—	—	—
110	Ir	3	0	Pi	Bf1	H		Tn8		H	H	—	—
						H	—(CH=CH)2—		H	—	—	—	—
111	Ir	3	0	Pi	Bf1	H		Pi3		H	H	—	—
						H	H	—(CH=CH)2—		—	—	—	—
112	Ir	3	0	Pi	Bf1	H		Qn2		H	H	—	—
						—(CH=CH)2—		H	H	—	—	—	—
113	Ir	3	0	Pi	Bf1	H		Ph2		H	$OCOC_7H_{15}$	H	H
						—(CH=CH)2—		H	H	—	—	—	—
114	Ir	3	0	Pi	Bf1	H		Ph2		H	CN	H	H
						H	—(CH=CH)2—		H	—	—	—	—
115	Ir	3	0	Pi	Bf2	H		Tn5		H	H	—	—
						H	—(CH=CH)2—		H	—	—	—	—
116	Ir	3	0	Pi	Bf2	H		Tn6		H	H	—	—
						H	H	—(CH=CH)2—		—	—	—	—
117	Ir	3	0	Pi	Bf2	H		Tn7		H	H	—	—
						H	—(CH=CH)2—		H	—	—	—	—
118	Ir	3	0	Pi	Bf2	H		Pi2		H	H	—	—
						H	H	—(CH=CH)2—		—	—	—	—
119	Ir	3	0	Pi	Bf2	H		Ph2		NO_2	H	H	H
						H	H	—(CH=CH)2—		—	—	—	—
120	Ir	3	0	Pi	Bf2	H		DBF3		H	H	H	—
						H	H	—(CH=CH)2—		—	—	—	—
121	Rh	3	0	Pi	Bf1	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
122	Rh	3	0	Pi	Bf1	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—

[0097]

TABLE 5

										CyN1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
123	Rh	3	0	Pi	Bf1	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—

TABLE 5-continued

										CyN1			
						CyN1-R1		CyN1-R2		R5	R6	R7	R8
										CyC1			
No	M	m	n	CyN1	CyC1	CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
124	Rh	3	0	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
125	Rh	3	0	Pi	Bf1	H		NO_2		—	—	—	—
						H	H	H	H	—	—	—	—
126	Rh	3	0	Pi	Bf1	H		Cl		—	—	—	—
						H	H	H	H	—	—	—	—
127	Rh	3	0	Pi	Bf1	H		F	F	—	—	—	—
						H	H	H	H	—	—	—	—
128	Rh	3	0	Pi	Bf1	H		CN		—	—	—	—
						H	H	H	H	—	—	—	—
129	Rh	3	0	Pi	Bf1	H		OCH_3		—	—	—	—
						H	H	H	H	—	—	—	—
130	Rh	3	0	Pi	Bf1	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
131	Rh	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
132	Rh	3	0	Pi	Bf2	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
133	Rh	3	0	Pi	Bf2	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
134	Rh	3	0	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
135	Rh	3	0	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	H	H	—	—	—	—
136	Rh	3	0	Pi	Bf2	H		Np4		H	—	—	—
						H	H	H	H	—	—	—	—
137	Rh	3	0	Pi	Bf2	Tn7		H		H	H	—	—
						H	H	H	H	—	—	—	—
138	Rh	3	0	Pi	Bf2	H		C_4H_9		—	—	—	—
						H	H	H	H	—	—	—	—
139	Rh	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	OCH_3	H	—	—	—	—
140	Rh	3	0	Pi	Bf2	H		H		—	—	—	—
						H	H	Ph2	H	H	$Si(C_3H_7)_3$	H	H
141	Pt	2	0	Pi	Bf1	H		H		—	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
142	Pt	2	0	Pi	Bf1	H		H		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
143	Pt	2	0	Pi	Bf1	H		H		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
144	Pt	2	0	Pi	Bf2	H		Tn5		H	H	—	—
						H	—(CH═CH)2—		H	—	—	—	—
145	Pt	2	0	Pi	Bf2	H		Tn6		H	H	—	—
						H	H	—(CH═CH)2—		—	—	—	—
146	Pt	2	0	Pi	Bf2	H		Tn7		H	H	—	—
						H	—(CH═CH)2—		H	—	—	—	—
147	Pt	2	0	Pi	Bf2	H		Pi2		H	H	—	—
						H	H	—(CH═CH)2—		—	—	—	—
148	Pd	2	0	Pi	Bf4	H		Pi3		H	H	—	—
						Ph2	H	H	H	H	H	H	H
149	Pd	2	0	Pi	Bf5	H		CF_3		—	—	—	—
						Ph2	H	H	H	H	C_6H_{13}	H	H
150	Pd	2	0	Pi	Bf1	H		H		—	—	—	—
						H	H	Ph2	H	H	$Si(C_3H_7)_3$	H	H

[0098]

TABLE 6

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
151	Ir	2	1	Pi	Bf1	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
152	Ir	2	1	Pi	Bf1	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
153	Ir	2	1	Pi	Bf1	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
154	Ir	2	1	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
155	Ir	2	1	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Np2	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
156	Ir	2	1	Pi	Bf1	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
157	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
158	Ir	2	1	Pi	Bf2	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
159	Ir	2	1	Pi	Bf2	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
160	Ir	2	1	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
161	Ir	2	1	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	CF_3		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0099]

TABLE 7

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
162	Ir	2	1	Pi	Bf2	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
163	Ir	2	1	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
164	Ir	2	1	Pi	Bf2	Tn7		H		H	H	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
165	Ir	2	1	Pi	Bf2	H		C_4H_9		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
166	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	H	Ph2	H	H	$Si(C_3H_7)_3$	H	H
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
167	Ir	2	1	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	Ph2	H	H	H	H	H
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
168	Ir	2	1	Pi	Bf2	H		Qn2		H	H	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
169	Ir	2	1	Pi	Bf2	H		Bf7		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
170	Ir	2	1	Pi	Bf2	H		Bf8		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
171	Ir	2	1	Pi	Bf3	H		H		—	—	—	—
						Ph2	H	H	H	H	OCH_3	H	H
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
172	Ir	2	1	Pi	Bf3	H		CF_3		—	—	—	—
						Np3	H	H	H	H	H	—	—
				Pr	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0100]

TABLE 8

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
173	Ir	2	1	Pi	Bf4	H		CF$_3$		—	—	—	—
						Ph2	H	H	H	H	C$_6$H$_{13}$	H	H
				Py1	Ph1	H		—		—	—	—	—
						H	H	—	—	—	—	—	—
174	Ir	2	1	Pi	Bf4	H		Bf7		H	H	H	H
						Ph2	H	H	H	H	H	H	H
				Py2	Ph1	—		H		—	—	—	—
						H	H	—	—	—	—	—	—
175	Ir	2	1	Pi	Ph1	H		Bf7		H	H	H	H
						H	OCH$_3$	—	—	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
176	Ir	2	1	Pi	Np2	H		Bf7		H	H	H	H
						H	H	—	—	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
177	Ir	2	1	Pi	Tn2	H		Bf8		H	H	H	H
						H	H	—	—	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
178	Ir	2	1	Pi	Cn1	H		Bf8		H	H	H	H
						H	—	—	—	—	—	—	—
				Pi	Ph1	H		Np3		H	H	—	—
						H	H	—	—	—	—	—	—
179	Ir	2	1	Pi	Bf1	H		H		—	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Np2	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
180	Ir	2	1	Pi	Bf1	H		H		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Ph1	H		CF$_3$		—	—	—	—
						H	H	—	—	—	—	—	—
181	Ir	2	1	Pi	Bf1	H		H		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Bf2	H		CF$_3$		—	—	—	—
						H	H	H	H	—	—	—	—
182	Ir	2	1	Pi	Bf1	H		CF$_3$		—	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		CF$_3$		—	—	—	—
						H	H	—	—	—	—	—	—
183	Ir	2	1	Pi	Bf1	H		CF$_3$		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0101]

TABLE 9

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
184	Ir	2	1	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
185	Ir	2	1	Pi	Bf1	H		Np4		H	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
186	Ir	2	1	Pi	Bf1	H		Ph2		H	$OCH{=}CHC_7H_{15}$	H	H
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
187	Ir	2	1	Pi	Bf1	H		Ph2		H	$OC{\equiv}CC_8H_{17}$	H	H
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Np2	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
188	Ir	2	1	Pi	Bf1	Ph2		H		H	H	H	H
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
189	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
190	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
191	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
192	Ir	2	1	Pi	Bf2	H		Np4		H	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
193	Ir	2	1	Pi	Bf2	H		Ph2		H	H	F	F
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
194	Ir	2	1	Pi	Bf1	H		Np3		H	H	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0102]

TABLE 10

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
195	Ir	2	1	Pi	Bf1	H		An		H	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
196	Ir	2	1	Pi	Bf1	H		Pe2		H	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
197	Ir	2	1	Pi	Bf1	H		Cl		—	—	—	—
						—(CH=CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
198	Ir	2	1	Pi	Bf1	H		Tn8		H	H	—	—
						H	—(CH=CH)2—		H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
199	Ir	2	1	Pi	Bf1	H		Pi3		H	H	—	—
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	DBT1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
200	Ir	2	1	Pi	Bf1	H		Qn2		H	H	—	—
						—(CH=CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
201	Ir	2	1	Pi	Bf1	H		Ph2		H	$OCOC_7H_{15}$	H	H
						—(CH=CH)2—		H	H	—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
202	Ir	2	1	Pi	Bf1	H		Ph2		H	CN	H	H
						H	—(CH=CH)2—		H	—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
203	Rh	2	1	Pi	Bf2	H		Tn6		H	H	—	—
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
204	Rh	2	1	Pi	Bf2	H		Ph2		NO_2	H	H	H
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
205	Rh	2	1	Pi	Bf2	H		DBF3		H	H	H	—
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—

[0103]

TABLE 11

												CyN1 CyC1 CyN2 CyC2			
No	M	m	n	CyN1 CyN2	CyC1 CyC2	CyN1-R1 CyN2-R1	CyC1-R3 CyC2-R3	CyC1-R4 CyC2-R4	CyN1-R2 CyN2-R2	CyC1-R'3 CyC2-R'3	CyC1-R'4 CyC2-R'4	R5	R6	R7	R8
206	Rh	2	1	Pi	Bf2	H			H			—	—	—	—
							H	H		Ph2	H	H	$Si(C_3H_7)_3$	H	H
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
207	Rh	2	1	Pi	Bf2	Ph2			H			H	H	H	H
							H	H		Ph2	H	H	H	H	H
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
208	Rh	2	1	Pi	Bf2	H			Pe2			H	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			GF_3			—	—	—	—
							H	H		—	—	—	—	—	—
209	Rh	2	1	Pi	Bf2	H			An			H	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
210	Rh	2	1	Pi	Bf2	H			Bf8			H	H	H	H
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
211	Ir	1	2	Pi	Bf1	H			H			—	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
212	Ir	1	2	Pi	Bf1	CF_3			H			—	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
213	Ir	1	2	Pi	Bf1	CF_3			CF_3			—	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
214	Ir	1	2	Pi	Bf1	H			CF_3			—	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
215	Ir	1	2	Pi	Bf1	H			CF_3			—	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Np2	H			H			—	—	—	—
							H	H		—	—	—	—	—	—
216	Ir	1	2	Pi	Bf2	H			H			—	—	—	—
							H	H		H	H	—	—	—	—
				Pi	Ph1	H			H			—	—	—	—
							H	H		—	—	—	—	—	—

[0104]

TABLE 12

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
217	Ir	1	2	Pi	Bf2	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
218	Ir	1	2	Pi	Bf2	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
219	Ir	1	2	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
220	Ir	1	2	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	CF_3		H		—	—	—	—
						H	H	—	—	—	—	—	—
221	Ir	1	2	Pi	Bf2	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
222	Ir	1	2	Pi	Bf1	H		H		—	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Np2	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
223	Ir	1	2	Pi	Bf1	H		H		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
224	Ir	1	2	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
225	Ir	1	2	Pi	Bf1	H		Np4		H	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
226	Ir	1	2	Pi	Bf1	H		Ph2		H	$OCH{=}CHC_7H_{15}$	H	H
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
227	Ir	1	2	Pi	Bf1	H		Ph2		H	$OC{\equiv}CC_8H_{17}$	H	H
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Np2	H		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0105]

TABLE 13

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
228	Ir	1	2	Pi	Bf1	H		Qn2		H	H	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
229	Ir	1	2	Pi	Bf1	H		Ph2		H	$OCOC_7H_{15}$	H	H
						—(CH═CH)2—		H	H	—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
230	Ir	1	2	Pi	Bf1	H		Ph2		H	CN	H	H
						H	—(CH═CH)2—		H	—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
231	Ir	1	2	Pi	Bf2	H		Tn6		H	H	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
232	Ir	1	2	Pi	Bf2	H		Ph2		NO_2	H	H	H
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
233	Ir	1	2	Pi	Bf2	H		DBF3		H	H	H	—
						H	H	—(CH═CH)2—		—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
234	Ir	1	2	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	Ph2	H	H	H	H	H
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0106]

TABLE 14

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
235	Rh	1	2	Pi	Bf2	H		Pe2		H	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		CF_3		—	—	—	—
						H	H	—	—	—	—	—	—
236	Rh	1	2	Pi	Bf2	H		An		H	—	—	—
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
237	Rh	1	2	Pi	Bf2	H		Bf8		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
238	Rh	1	2	Pi	Bf1	Ph2		H		H	H	H	H

TABLE 14-continued

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1		CyN1-R2		CyN2			
						CyC1-R3	CyC1-R4	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				CyN1	CyC1	CyN2-R1		CyN2-R2		CyC2			
No	M	m	n	CyN2	CyC2	CyC2-R3	CyC2-R4	CyC2-R'3	CyC2-R'4	R5	R6	R7	R8
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
239	Pt	1	1	Pi	Bf2	H		H		—	—	—	—
						H	—(CH=CH)2—		H	—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—
240	Pd	1	1	Pi	Bf2	H		H		—	—	—	—
						H	H	—(CH=CH)2—		—	—	—	—
				Pi	Ph1	H		H		—	—	—	—
						H	H	—	—	—	—	—	—

[0107]

TABLE 15

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1				E			
				CyN1	CyC1	CyC1-R3	CyC1-R4			R5	R6	R7	R8
				E		R"	R"'	CyN1-R2		G			
No	M	m	n	G		R"	R"'	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
241	Ir	2	1	Pi	Bf1	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
				CH_3		—	—			—	—	—	—
				CH_3		—	—			—	—	—	—
242	Ir	2	1	Pi	Bf1	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
				CF_3		—	—			—	—	—	—
				CF_3		—	—			—	—	—	—
243	Ir	2	1	Pi	Bf1	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				CH_3		—	—			—	—	—	—
				CH_3		—	—			—	—	—	—
244	Ir	2	1	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Ph2		—	—			H	H	H	H
				Ph2		—	—			H	H	H	H
245	Ir	2	1	Pi	Bf1	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
				Ph2		—	—			H	C_3H_7	H	H
				Ph2		—	—			H	C_3H_7	H	H
246	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	H	H	H	—	—	—	—
				CH_3		—	—			—	—	—	—
				FL5		CH_3	CH_3			H	H	H	—
247	Ir	2	1	Pi	Bf2	CF_3		H		—	—	—	—
						H	H	H	H	—	—	—	—
				Tn5		—	—			H	H	—	—
				Tn5		—	—			H	H	—	—
248	Ir	2	1	Pi	Bf2	CF_3		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—

TABLE 15-continued

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1				E			
				CyN1	CyC1	CyC1-R3	CyC1-R4	CyN1-R2		R5	R6	R7	R8
				E		R"	R"'			G			
No	M	m	n	G		R"	R"'	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				Tn6		—	—			H	H	—	—
				Tn6		—	—			H	H	—	—
249	Ir	2	1	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				CH_3		—	—			—	—	—	—
				CH_3		—	—			—	—	—	—
250	Ir	2	1	Pi	Bf2	H		Ph2		H	H	H	H
						H	H	H	H	—	—	—	—
				CF_3		—	—			—	—	—	—
				CF_3		—	—			—	—	—	—
251	Ir	2	1	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	H	H	—	—	—	—
				Np3		—	—			CH_3O	H	—	—
				Np3		—	—			CH_3O	H	—	—

[0108]

TABLE 16

										CyN1			
										R5	R6	R7	R8
										CyC1			
										R5	R6	R7	R8
						CyN1-R1				E			
				CyN1	CyC1	CyC1-R3	CyC1-R4	CyN1-R2		R5	R6	R7	R8
				E		R"	R"'			G			
No	M	m	n	G		R"	R"'	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
252	Ir	2	1	Pi	Bf2	Tn7		H		H	H	—	—
						H	H	H	H	—	—	—	—
				Np4		—	—			F	—	—	—
				Np4		—	—			F	—	—	—
253	Ir	2	1	Pi	Bf2	H		C_4H_9		—	—	—	—
						H	H	H	H	—	—	—	—
				Tn7		—	—			CH_3	H	—	—
				Tn7		—	—			CH_3	H	—	—
254	Ir	2	1	Pi	Bf2	H		H		—	—	—	—
						H	H	Ph2	H	H	$Si(C_3H_7)_3$	H	H
				Tn8		—	—			H	H	—	—
				Tn8		—	—			H	H	—	—
255	Ir	2	1	Pi	Bf2	Ph2		H		H	H	H	H
						H	H	Ph2	H	H	H	H	H
				Pe2		—	—			H	—	—	—
				Pe2		—	—			H	—	—	—
256	Ir	2	1	Pi	Bf2	H		Qn2		H	H	—	—
						H	H	H	H	—	—	—	—
				Pi2		—	—			H	H	—	—
				Pi2		—	—			H	H	—	—
257	Ir	2	1	Pi	Bf2	H		Bf7		H	H	H	H
						H	H	H	H	—	—	—	—
				Pi3		—	—			CH_3	CH_3	H	H
				Pi3		—	—			CH_3	CH_3	H	H
258	Ir	2	1	Pi	Bf2	H		Bf8		H	H	H	H
						H	H	H	H	—	—	—	—
				FL4		—	—			H	H	H	—

TABLE 16-continued

										CyN1			
										R5	R6	R7	R8
										CyC1			
						CyN1-R1				R5	R6	R7	R8
										E			
				CyN1	CyC1	CyC1-R3	CyC1-R4	CyN1-R2		R5	R6	R7	R8
				E		R"	R"'			G			
No	M	m	n	G		R"	R"'	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
				FL4		—	—			H	H	H	—
259	Ir	2	1	Pi	Bf3	H		H		—	—	—	—
						Ph2	H	H	H	H	OCH_3	H	H
				FL5		C2H5	C2H5			H	H	H	—
				FL5		(CH2)5Ph3	(CH2)5Ph3			H	H	H	—
260	Ir	2	1	Pi	Bf4	H		CF_3		—	—	—	—
						Ph2	H	H	H	H	C_6H_{13}	H	H
				DBF2		—	—			H	H	H	—
				DBF2		—	—			H	H	H	—
261	Ir	2	1	Pi	Ph1	H		Bf7		H	H	H	H
						H	OCH_3	—	—	—	—	—	—
				DBT3		—	—			H	H	H	—
				DBT3		—	—			H	H	H	—
262	Rh	2	1	Pi	Bf1	H		H		—	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				CH_3		—	—			—	—	—	—
				CH_3		—	—			—	—	—	—

[0109]

TABLE 17

										CyN1			
										R5	R6	R7	R8
										CyC1			
						CyN1-R1				R5	R6	R7	R8
										E			
				CyN1	CyC1	CyC1-R3	CyC1-R4	CyN1-R2		R5	R6	R7	R8
				E		R"	R"'			G			
No	M	m	n	G		R"	R"'	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8
263	Rh	2	1	Pi	Bf1	H		H		—	—	—	—
						H	—(CH═CH)2—		H	—	—	—	—
				CF_3		—	—			—	—	—	—
				CF_3		—	—			—	—	—	—
264	Rh	2	1	Pi	Bf1	H		H		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				Qn2		—	—			H	H	—	—
				Qn2		—	—			H	H	—	—
265	Rh	2	1	Pi	Bf2	H		CF_3		—	—	—	—
						H	H	H	H	—	—	—	—
				Np3		—	—			H	H	—	—
				Np3		—	—			H	H	—	—
266	Pt	1	1	Pi	Bf1	H		CF_3		—	—	—	—
						H	H	—(CH═CH)2—		—	—	—	—
				CH_3		—	—			—	—	—	—
				CH_3		—	—			—	—	—	—
267	Pt	1	1	Pi	Bf1	H		Np4		H	—	—	—
						—(CH═CH)2—		H	H	—	—	—	—
				CF_3		—	—			—	—	—	—
				CF_3		—	—			—	—	—	—
268	Pd	1	1	Pi	Bf1	H		Ph2		H	$OCH{=}CHC_7H_{15}$	H	H
						—(CH═CH)2—		H	H	—	—	—	—
				CH_3		—	—			—	—	—	—
				CH_3		—	—			—	—	—	—

TABLE 17-continued

										CyN1				
										R5	R6	R7	R8	
										CyC1				
										R5	R6	R7	R8	
						CyN1-R1				E				
				CyN1	CyC1	CyC1-R3	CyC1-R4			R5	R6	R7	R8	
				E		R"	R"'	CyN1-R2		G				
No	M	m	n	G		R"	R"'	CyC1-R'3	CyC1-R'4	R5	R6	R7	R8	
269	Pd	1	1	Pi	Bf2	H		CF$_3$		—	—	—	—	
						H	H	H	H	—	—	—	—	
				CF$_3$		—	—			—	—	—	—	
				CF$_3$		—	—							—
270	Ir	1	2	Pi	Bf1	H		Ph2		H	OC≡CC$_8$H$_{17}$	H	H	
						H	—(CH═CH)2—		H	—	—	—	—	
				CH$_3$		—	—			—	—	—	—	
				CH$_3$		—	—			—	—	—	—	

[0110] In the case where the metal coordination compound of the formula (1) is used as a luminescent material, the metal coordination compound used singly (as a single luminescent material) or in combination with another luminescent material (host compound).

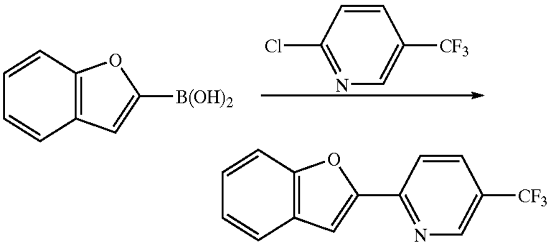
[0111] In the latter case, the resultant luminescence material (composition or mixture) may preferably contain the metal coordination compound of the formula (1) in an amount of at most 50 wt. %, more preferably 0.1-20 wt. %. Above 50 wt. %, a resultant luminescence strength is undesirably be lowered due to quenching with an increasing concentration in some cases.

[0112] Hereinbelow, the present invention will be described more specifically based on Examples.

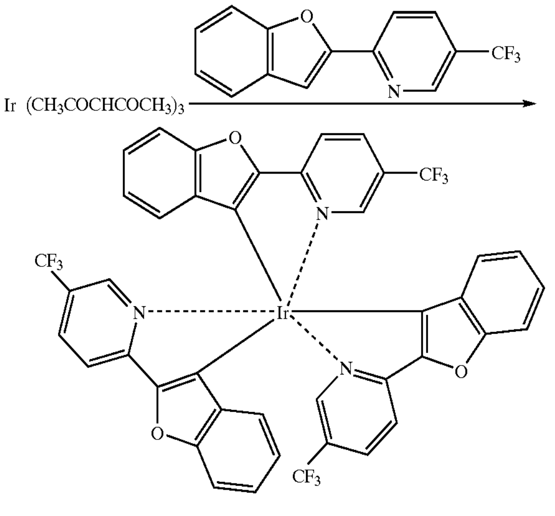
EXAMPLE 1

Synthesis of Example Compound No. 34

[0113]



[0114] In a 100-ml-three-necked flask, 2.80 g (15.4 mM) of 2-chloro-5-trifluoromethylpyridine, 2.50 g (15.4 mM) of 2-benzofuranylboronic acid, 14 ml of toluene, 7 ml of ethanol and 14 ml of 2M-sodium carbonate aqueous solution were placed and stirred at room temperature under nitrogen stream, and 0.55 g (0.48 mM) of tetrakis(triphenylphosphine)palladium (0) was added thereto. Thereafter, reflux under stirring for 4 hours was performed under nitrogen stream. After the reaction, the reaction mixture was cooled on an ice bath and stirred at room temperature after addition of ethyl acetate and saturated saline water. The organic layer was washed with water and dried with anhydrous magnesium sulfate, and the solvent was removed under reduced pressure to obtain a residue. The residue was purified by alumina column chromatography (eluent: toluene) and recrystallized from methanol to obtain 0.72 g of 2-(5-trifluoromethylpyridine-2-yl)benzofuran (Yield: 17.7%).



[0115] In a 100 ml-four-necked flask, 25 ml of glycerol was placed and heated at 130-140° C. under stirring and bubbling with nitrogen for 2 hours. Then, the glycerol was cooled by standing down to 100° C., and 0.70 g (2.66 mM) of 2-(5-trifluoromethylpyridine-2-yl)benzofuran and 0.23 g (0.47 mM) of iridium (III) acetylacetonate were added, followed by 7 hours and 10 minutes of heating at 192-230° C. under stirring and nitrogen stream. The reaction product was cooled to room temperature and injected into 150 ml of 1N-hydrochloric acid to form a precipitate, which was filtered out, washed with water, and dissolved in acetone to remove the insoluble content. The acetone was distilled off under reduced pressure to obtain a residue. The residue was washed with methanol and purified by silica gel column chromatography with toluene as the eluent to obtain 0.11 g (yield=23.4%) of red powdery tris[2-(benzofuran-2-yl)-5-trifluoromethyl-pyridine-C^3,N]iridium (III).

[0116] A toluene solution of the compound exhibited a photoluminescence spectrum showing λmax (maximum emission wavelength)=622 nm and a quantum yield of 0.12.

EXAMPLES 2-10

[0117] Each of luminescence devices having a layer structure shown in **FIG. 1B** were prepared in the following manner.

[0118] On a 1.1 mm-thick glass substrate (transparent substrate **15**), a 100 nm-thick film (transparent electrode **14**) of ITO (indium tin oxide) was formed by sputtering, followed by patterning to form a stripe electrode including 100 lines each having a width of 100 nm and a spacing with an adjacent line of 10 nm (i.e., electrode pitch of 110 nm).

[0119] On the ITO-formed substrate, three organic layers and two metal electrode layers shown below were successively formed by vacuum (vapor) deposition using resistance heating in a vacuum chamber (10^{-4} Pa).

[0120] Organic layer **1** (hole transport layer **13**) (40 nm): α-NPD

[0121] Organic layer **2** (luminescence layer **12**) (30 nm): co-deposited film of CBP:metal complex (metal coordination compound shown in Table 18) (95:5 by weight)

[0122] Organic layer **3** (electron transport layer **16**) (30 nm): Alq3

[0123] Metal electrode layer **1** (metal electrode **11**) (15 nm): Al—Li alloy (Li=1.8 wt. %)

[0124] Metal electrode layer **2** (metal electrode **11**) (100 nm): Al

[0125] The above-deposited metal electrode layers **1** and **2** (Al—Li layer and Al layer) had a stripe electrode pattern including 100 lines each having a width of 100 nm and a spacing of 10 nm (electrode pitch=110 nm) and arranged so that the stripe electrode pattern intersected with that of the ITO electrode at right angles to form a matrix of pixels each having an effective electrode area of 3 mm^2 comprising 20 ITO lines-bundled together at a lead-out portion and 15 Al (Al—Li) lines bundled together at a lead-out portion.

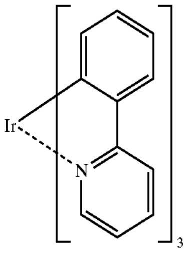
[0126] Each of the thus-prepared luminescence devices was taken out of the vacuum-chamber and was subjected to a continuous energization (current passage) test in an atmosphere of dry nitrogen gas stream so as to remove device deterioration factors, such as oxygen and moisture (water content).

[0127] The continuous energization test was performed by continuously applying a voltage at a constant current density of 70 mA/cm^2 to the luminescence device having the ITO (transparent) electrode (as an anode) and the Al (metal) electrode (as a cathode), followed by measurement of emission luminance (brightness) with time so as to determine a time (luminance half-life) required for decreasing an initial luminance (80-250 cd/m^2) to ½ thereof.

[0128] The results are shown in Table 18 appearing hereinafter.

COMPARATIVE EXAMPLE 1

[0129] A comparative luminescence device was prepared and evaluated in the same manner as in Examples 2-10 except that the Ir complexes (metal coordination compounds shown in Table 185) was changed to Ir-phenylpyrimidine complex ($Ir(ppy)_3$) shown below.



[0130] The results are also also shown in Table 18 below.

TABLE 18

Ex. No.	Compound No.	Luminance half-life (Hr)
Ex. 2	4	800
Ex. 3	10	900
Ex. 4	31	750
Ex. 5	34	900
Ex. 6	92	800
Ex. 7	115	650
Ex. 8	135	750
Ex. 9	156	850
Ex. 10	238	600
Comp. Ex. 1	$Ir(ppy)_3$	350

[0131] As is apparent from Table 18, compared with the conventional luminescence device using $Ir(ppy)_3$, the luminescence devices using the metal coordination compounds of formula (1) according to the present invention provide longer luminance half-lives, thus resulting in an EL device having a high durability (luminance stability) based on a good stability of the metal coordination compound of formula (1) of the present invention.

EXAMPLE 11

[0132] A color organic EL display apparatus shown in **FIG. 2** was prepared in the following manner.

[0133] An active matrix substrate had a planar structure basically similar to a structure described in U.S. Pat. No. 6,114,715.

[0134] Specifically, on a 1.1 mm-thick glass substrate, top gate-type TFTs of polycrystalline silicon were formed in an ordinary manner and thereon, a flattening film was formed with contact holes for electrical connection with a pixel electrode (anode) at respective source regions, thus preparing an active matrix substrate with a TFT circuit.

[0135] On the active matrix substrate, a 700 nm-thick pixel electrode (anode) of ITO having a large work function was formed in a prescribed pattern. On the ITO electrode, prescribed organic layers and a 100 nm-thick Al electrode (cathode) were successively formed by vacuum deposition with a hard mask, followed by patterning to form a matrix of color pixels (128×128 pixels).

[0136] The respective organic layers corresponding to three color pixels (red (R) green (G) and blue (B)) were consisting of the following layers.

[0137] <R pixel region>

[0138] α-NPD (40 nm)/CBP: Ex. Comp. No. 34 (93:7 by weight) (30 nm)/BCP (20 nm)/Alq 3 (40 nm)

[0139] <G pixel region>

[0140] α-NPD (50 nm)/Alq 3 (50 nm)

[0141] <B pixel region>

[0142] α-NPD (50 nm)/BCP (20 nm)/Alq 3 (50 nm)

[0143] When the thus-prepared color organic EL display apparatus was driven, desired color image data can be displayed stably with good image qualities.

EXAMPLE 12

Synthesis of Ex. Comp. No. 31

[0144] It is easy to synthesize the following compound in the same manner as in Example 1 except for using 2-bromopyridine (made by Tokyo Kasei Kogyo K.K.) instead of 2-chloro-5-trifluoromethylpyridine in Example 1.

[0145] Tris[2-(benzofuran-2-yl)pyridine-C^3,N]iridium (III).

EXAMPLE 13

Synthesis of Ex. Comp. No. 32

[0146] It is easy to synthesize the following compound in the same manner as in Example 1 except for using 2-chloro-4-trifluoromethylpyridine (made by Florochem USA) instead of 2-chloro-5-trifluoromethylpyridine in Example 1.

[0147] Tris[2-(benzofuran-2-yl)-4-trifluoromethyl-pyridine-C^3,N]iridium (III).

EXAMPLE 14

Synthesis of Ex. Comp. No. 33

[0148] It is easy to synthesize the following compound in the same manner as in Example 1 except for using 2-chloro-4,5-bis(trifluoro-methyl)pyridine (made by Oakwood Products Inc.) instead of 2-chloro-5-trifluoromethylpyridine in Example 1.

[0149] Tris[2-(benzofuran-2-yl)-4,5-bis(trifluoro-methyl)pyridine-C^3, N]iridium (III).

EXAMPLE 15

Synthesis of Ex. Comp. No. 35

[0150] It is easy to synthesize the following compound in the same manner as in Example 16 except for using 4-phenyl-2-bromopyridine (made by General Intermediates of Canada) instead of 2-chloro-5-trifluoromethylpyridine in Example 1.

[0151] Tris[2-(benzofuran-2-yl)-4-pyridine-C^3,N]-iridium (III).

EXAMPLE 16

Synthesis of Ex. Comp. No. 36

[0152] It is easy to synthesis the following compound in the same manner as in Example 1 except that 2-(benzofuran-2-yl)-5-bromopyridine was synthesized from 2,5-dibromopyridine (made by Tokyo Kasei Kogyo K.K.) and 2-benzofuranboronic acid (made by Aldrich Co.) and is reacted with 1-naphthylboronic acid (made by Tokyo Kasei Kogyo) to obtain 2-(benzofuran-2-yl)-5-(naphthalene-1-yl)pyridine, which is used instead of 2-(5-trifluoromethylpyridine-2-yl)benzofuran.

[0153] Tris[2-(benzofuran-2-yl)-5-(naphthalene-1-yl)pyridine-C^3,N]iridium (III).

EXAMPLE 17

Synthesis of Ex. Comp. No. 42

[0154] It is easy to synthesize the following compound in the same manner as in Example 16 except for using 2-naphthylboronic acid (made by Tokyo Kasei Kogyo K.K.) instead of 1-naphthylboronic acid in Example 16.

[0155] Tris[2-(benzofuran-2-yl)-5-(naphthalene-2-yl)pyridine-C^3,N]iridium (III).

EXAMPLE 18

Synthesis of Ex. Comp. No. 47

[0156] It is easy to synthesize the following compound in the same manner as in Example 1 except for reacting 2 equivalent amount of 2-benzofuran boronic acid (made by Aldrich Co.) with 2,5-dibromopyridine (made by Tokyo Kasei Kogyo K.K.) to synthesis 2,5-bis(benzofuran-2-yl)pyridine, which is used instead of 2-(5-trifluoromethylpyridine-2-yl)benzofuran, in Example 1.

[0157] Tris[2,5-bis(benzofuran-2-yl)pyridine-C^3,N]iridium (III).

EXAMPLE 19

Synthesis of Ex. Comp. No. 50

[0158] It is easy to synthesis the following compound in the same manner as in Example 1 except that 2-(benzofuran-2-yl)-5-bromopyridine was synthesized from 2,5-dibromopyridine (made by Tokyo Kasei Kogyo K.K.) and 2-benzofuranboronic acid (made by Aldrich Co.) and is reacted with 3-thiopheneboronic acid (made by Aldrich Co.) to obtain 2-(benzofuran-2-yl)-5-(thiophene-3-yl)pyridine, which is used instead of 2-(5-trifluoromethylpyridine-2-yl)benzofuran.

[0159] Tris[2-(benzofuran-2-yl)-5-(thiophene-3-yl)pyridine-C^3, N]iridium (III).

EXAMPLE 20

[0160] An organic EL device shown in **FIG. 1C** was prepared in the following manner.

[0161] On a 100 nm-thick patterned ITO electrode (anode) formed on a 1.1 mm-thick no-alkali glass substrate, a 40 nm-thick charge transport layer of α-NPD was formed by vacuum deposition (10^{-4} Pa) at a deposition rate of 0.1

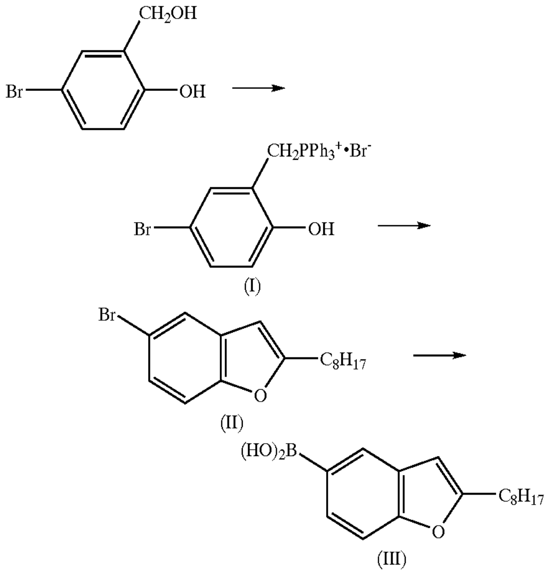
nm/sec. On the charge transport layer, a 40 nm-thick luminescence layer (co-deposited film) of CBP: iridium complex of Ex. Comp. No. 34 prepared in Example 1 (97:3 by weight) was formed by co-vacuum deposition at deposition rates of 0.1 nm/sec (for CBP) and 0.08 nm/sec (for the iridium complex) by controlling heating conditions of deposition vessel. On the luminescence layer, a 10 nm-thick exciton diffusion prevention layer of BCP (Bathocuproine) was formed by vacuum deposition at a deposition rate of 0.1 nm/sec, and or the exciton diffusion prevention layer, a 20 nm-thick electron transport layer of Alq 3 was formed by vacuum deposition at a deposition rate of 0.1 nm/sec. Thereafter, or the electron transport layer, a 150 nm-thick aluminum electrode (cathode) was formed by vacuum deposition at a deposition rate of 1 nm/sec.

[0162] The thus-prepared organic EL device exhibited an EL spectrum showing λmax=625 nm and luminescent efficiencies of 1.5 lm/W at a luminance of 100 cd/m^2.

EXAMPLE 21

Synthesis of Ex. Comp. No. 62

[0163]



[0164] In a 2 liter-three-necked flask, 145.8 g (718 mM) of 5-bromo-2-hydroxybenzyl alcohol, 246.5 g (718 mM) of triphenyl phosphine.HBr, and 730 ml of acetonitrile were placed and refluxed under stirring for 3 hours. The reaction liquid was cooled down to room temperature to precipitate a crystal of 5-bromo-2-hydroxybenzyltriphenylphosphonium bromide (I), which was recovered by filtration (Yield: 362.0 g (95.5%)).

[0165] In a 1 liter-three-necked flask, 50.0 g (94.7 mM) o the phosphonium bromide (I), 31.1 g (104 mM) of 1-nonanoic acid anhydride, 450 ml of toluene and 39.6 g (392 mM) of triethylamine were placed and refluxed under stirring for 6 hours. The reaction liquid was cooled down to room temperature to precipitate a crystal, which was filtered out. The solvent of the filtrate was distilled off under reduced pressure to obtain a residue. The residue was purified by silica gel column chromatography (eluent: hexane) to a colorless oily product of 2-octyl-5-bromobenzofuran (II) (Yield: 25.1 g (85.8%)).

[0166] In a 500 ml-three-necked flask, 19.0 g (61.5 mM) of 2-octyl-5-bromobenzofuran (II) and 190 ml of anhydrous tetrahydrofuran (THF) were placed. To the mixture, 45 ml (72.0 mM) of 1.6 M-n-butyllithium solution in hexane was added dropwise under argon stream at −70° C. or below in 30 min., followed by stirring at that temperature for 4 hours. To the resultant mixture, a solution of 17.8 g (171 mM) of trimethylborate in 70 ml of anhydrous THF was added dropwise at −70° C. or below in 20 min., and stirred at that temperature for 2 hours. The system was heated up to room temperature and stirred for 17 hours. To the reaction mixture, 100 ml of 10%-hydrochloric acid was added dropwise, followed by extraction with ether. The organic layer was washed with water and dried with anhydrous sodium sulfate, followed by distilling-off of the solvent under reduced pressure to obtain a residue. The residue was purified by silica gel column chromatography (eluent: hexane/ethyl acetate=4/1) to obtain a white crystal of 2-octylbenzofuran-5-boronic acid (III) (Yield: 10.8 g (64.1%)).

[0167] It is easy to synthesize the following compound in the same manner as in Example 1 except for using 2-octylbenzofuran-5-boronic acid (III) instead of 2-benzofuran boronic acid in Example 1.

[0168] Tris[2-(2-octylbenzofuran-5-yl)pyridine-C^3,N]iridium (III).

EXAMPLE 22

Synthesis of Ex. Comp. No. 61

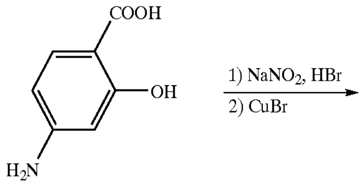
[0169] It is easy to synthesis the following compound in the same manner as in Example 1 except for using, instead of 2-(5-trifluoromethylpyridine-2-yl)benzofuran, 2-phenyl-5-(5-trifluoromethylpyridine-2-yl)benzofuran synthesized in the same manner as in Example 21 except that 2-phenyl-5-bromobenzofuran was synthesized from benzoic acid chloride used instead of 1-nonanoic acid and 2-phenyl-5-(5-trifluoromethyl-pyridine-2-yl)benzofuran was synthesized from 2-phenyl-5-bromobenzofuran.

[0170] Tris[2-(2-phenylbenzofuran-5-yl)-5-trifluoro-methylpyridine-C^3,N]iridium (III).

EXAMPLE 23

Synthesis of Ex. Comp. No. 72

[0171] 4-bromo-2-hydroxybenzyl alcohol (IV) is synthesized from 4-aminosalicylic acid (made by Aldrich Co.) in the following reaction scheme, and 4-bromo-2-hydroxybenzyltriphenylphosphon bromide (V) is synthesized in the same manner as in Example 21.



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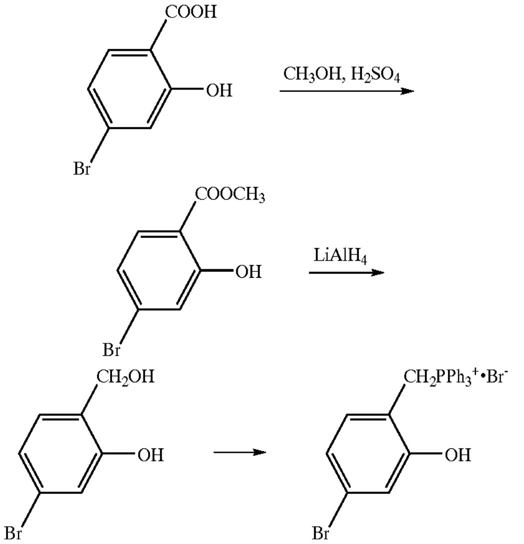


(IV)

(V)

[0172] It is easy to synthesize the following compound in the same manner as in Example 21 except for using 1-butanoic acid anhydrate instead of 1-nonanoic acid anhydrate in Example 21.

[0173] Tris[2-(2-propylbenzofuran-6-yl)pyridine-C^5,N] iridium (III).

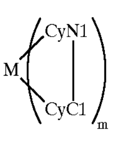
[0174] As described above, according-to the present invention, the metal coordination compound of the formula (1) characterized by the benzofuran structure of the formula (5) as a partial structure is an excellent material which exhibits a high emission quantum efficiency. The electroluminescence device (luminescence device) of the present invention using, as a luminescent center material, the metal coordination compound of the formula (1) is an excellent device which not only allows high-efficiency luminescence but also retains a high luminance for a long period and shows little deterioration by current passage. Further, the display apparatus using the electroluminescence device of the present invention exhibits excellent display performances.

What is claimed is:

1. A metal coordination compound represented by formula (1) below:

$$ML_mL'L_n \qquad (1),$$

wherein M is a metal atom of Ir, Pt, Rh or Pd; L and L' are mutually different bidentate ligands; m is 1, 2 or 3 and n is 0, 1 or 2 with the proviso that m+n is 2 or 3; a partial structure MLm is represented by formula (2) shown below and a partial structure ML'$_n$ is represented by formula (3) or (4) shown below:



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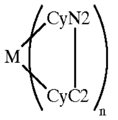

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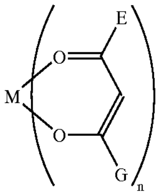


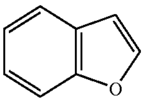
(4)

wherein CyN1 and CyN2 are each cyclic group capable of having a substituent, including a nitrogen atom and bonded to the metal atom M via the nitrogen atom; CyC1 and CyC2 are each cyclic group capable of having a substituent, including a carbon atom and bonded to the metal atom M via the carbon atom with the proviso that the cyclic group CyN1 and the cyclic group CyC1 are bonded to each other via a covalent bond and the cyclic group CyN2 and the cyclic group CyC2 are bonded to each other via covalent bond;

the optional substituent of the cyclic groups is selected from a halogen atom, cyano group, a nitro group, a trialkylsilyl group of which the alkyl groups are independently a linear or branched alkyl group having 1 to 8 carbon-atoms, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom, or an aromatic group capable of having a substituent (that is a halogen atom, a cyano atom, a nitro atom, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom);

E and G are independently a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom, or an aromatic group capable of having a substituent (that is a halogen atom, a cyano atom, a nitro atom, a trialkylsilyl group of which the alkyl groups are independently a linear or branched alkyl group having 1-8 carbon atoms, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH═CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom; and

at least one of the optional substituent(s) of the cyclic groups, and the cyclic groups CyC1 and CyC2 includes a benzofuran structure capable of having a substituent represented by the following formula (5):



wherein the benzofuran structure of the formula (5) is bonded to CyN1, CyN2, CyC1 or CyC2 via a single bond at any one of 2- to 7-positions when the benzofuran structure is the optional substituent(s) of the cyclic groups, and the benzofuran structure of the formula (5) is bonded to CyN1 or CyN2 via a single bond at any one of 2- to 7-positions and bonded to the metal atom M via a single bond at any one of 2- to 7-positions when the benzofuran structure is CyC1 or CyC2;

the optional substituent of the benzofuran structure of the formula (5) is selected from a halogen atom, cyano group, a nitro group, a trialkylsilyl group of which the alkyl groups are independently a linear or branched alkyl group having 1 to 8 carbon atoms, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH=CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom, or an aromatic group capable of having a substituent (that is a halogen atom, a cyano atom, a nitro atom, a linear or branched alkyl group having 1 to 20 carbon atoms of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CO—O—, —O—CO—, —CH=CH— or —C≡C—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom) with the proviso that an adjacent pair of substituents located at 4- to 7-positions of the benzofuran structure of the formula (5) can be bonded to form a cyclic structure.

2. A metal coordination compound according to claim 1, wherein n is 0 in the formula (1).

3. A metal coordination compound according to claim 1, including a partial structure ML'_n represented by the formula (3) in the formula (1).

4. A metal coordination compound according to claim 1, including a partial structure ML'_n represented by the formula (4) in the formula (1).

5. A metal coordination compound according to claim 1, wherein the cyclic groups CyC1 and CyC2 are independently selected from phenyl group, thienyl group, thianaphthyl group, naphthyl group, pyrenyl group, 9-fluorenonyl group, fluorenyl group, dibenzofuranyl group, dibenzothienyl group, carbazolyl group, or benzofuranyl group, as an aromatic cyclic group capable of having a substituent with the proviso that the aromatic cyclic group can include one or two CH groups that can be replaced with a nitrogen atom.

6. A metal coordination compound according to claim 5, wherein the cyclic groups CyC1 and Cy2 are independently phenyl group or benzofuranyl group.

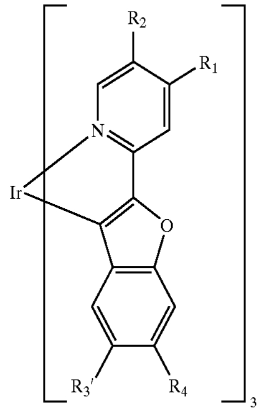
7. A metal coordination compound according to claim 1, wherein the cyclic groups CyN1 and CyN2 are independently selected from pyridyl group, pyridazinyl group, and pyrimidinyl group, as an aromatic cyclic group capable of having a substituent.

8. A metal coordination compound according to claim 7, wherein the aromatic cyclic group is pyridyl group.

9. A metal coordination compound according to claim 1, wherein the cyclic groups CyN1, CyN2, CyC1 and CyC2 are independently non-substituted, or have a substituent selected from a halogen atom and a linear or branched alkyl group having 1 to 20 carbon atoms, {of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, —S—, —CO—, —CH=CH—, —C≡C—, or a divalent aromatic group capable of having a substituent (that is a halogen atom or a linear or branched alkyl group having 1 to 20 carbon atoms (of which the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O—, and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom)), and the alkyl group can include a hydrogen atom that can be optionally replaced with a fluorine atom}.

10. A metal coordination compound according to claim 1, wherein M in the formula (1) is iridium.

11. A metal coordination compound according to claim 1, which is represented by the following formula (6) or (7):



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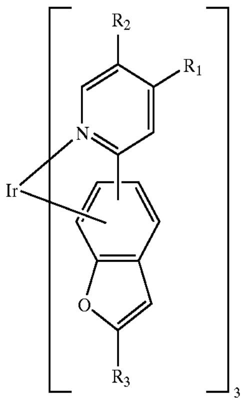


(7)

wherein R_1, R_2, R_3, R'_3 and R_4 are independently a hydrogen atom; a fluorine atom; a linear or branched alkyl group of formula: C_nH_{2n+1}— in which n is an integer of 1-20, the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O— and also can include a hydrogen atom that can be optionally replaced with a fluorine atom; a phenyl group capable of having a substituent; or a benzofuranyl group capable of having a substituent; the optional substituent of phenyl group and benzofuranyl group is a fluorine atom or a linear or branched alkyl group of formula: C_nH_{2n+1}— in which n is an integer of 1-20, the alkyl group can include one or non-neighboring two or more methylene groups that can be replaced with —O— and also can include a hydrogen atom that can be optionally replaced with a fluorine atom.

12. An electroluminescence device, comprising: a pair of electrodes disposed on a substrate, and a luminescence unit comprising at least one organic compound disposed between the electrodes, wherein the organic compound comprises a metal coordination compound represented by the formula (1) in claim 1.

13. An electroluminescence device according to claim 12 wherein a voltage is applied between the electrodes to emit phosphorescence.

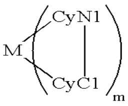
14. A picture display apparatus, comprising an electroluminescence device according to claim 12, and a means for supplying electric signals to the electroluminescence device.

* * * * *

专利名称(译)	金属配位化合物，发光装置和显示装置		
公开(公告)号	US20050027123A1	公开(公告)日	2005-02-03
申请号	US10/924903	申请日	2004-08-25
[标]申请(专利权)人(译)	佳能株式会社		
申请(专利权)人(译)	佳能株式会社		
当前申请(专利权)人(译)	佳能株式会社		
[标]发明人	TAKIGUCHI TAKAO OKADA SHINJIRO TSUBOYAMA AKIRA MIURA SEISHI MORIYAMA TAKASHI KAMATANI JUN FURUGORI MANABU		
发明人	TAKIGUCHI, TAKAO OKADA, SHINJIRO TSUBOYAMA, AKIRA MIURA, SEISHI MORIYAMA, TAKASHI KAMATANI, JUN FURUGORI, MANABU		
IPC分类号	H01L51/50 C07F15/00 C09K11/06 H01L51/00 H01L51/30		
CPC分类号	C07F15/0033 C09K11/06 C09K2211/1007 C09K2211/1011 C09K2211/1014 C09K2211/1029 Y10S428/917 C09K2211/185 H01L51/0084 H01L51/0085 H01L51/0087 H01L51/5012 C09K2211/1088		
优先权	2001072665 2001-03-14 JP 2002043536 2002-02-20 JP		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种具有含有特定金属配位化合物的层的电致发光器件。金属配位化合物由下式（1）表示： MLmL'n（1）， 其中M是Ir，Pt，Rh或Pd的金属原子; L和L'是相互不同的二齿配体; m为1,2或3，n为0,1或2，条件是m + n为2或3;部分结构MLm由下面所示的式（2）表示，部分结构ML'n由下面所示的式（3）或（4）表示： 至少一个环状基团的任选取代基，并且环状基团CyCl和CyC2包括能够具有由下式（5）表示的取代基的苯并呋喃结构： 具有苯并呋喃结构的金属配位化合物可有效地提供高效发光和长期高亮度。



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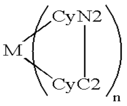

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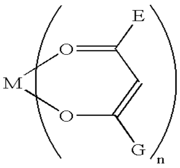

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