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(54) **Iridium-based luminescent compounds having phenylpyridine moieties with organosilicon group, and organic electroluminescence devices using the compounds as colour-emitting materials**

Lumineszente Iridiumverbindungen, enthaltend mit Organosilanverbindungen substituierte Phenylpyridingruppen, und diese verwendende organische lichtemittierende Vorrichtungen

Composés luminescents à base d'Iridium possédant des groupements phénylpyridine avec un groupe organosilicique et dispositif électroluminescent organique utilisant les composés comme matériaux émettant de la couleur.

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(56) References cited:
- **PATENT ABSTRACTS OF JAPAN vol. 2003, no. 08, 6 August 2003 (2003-08-06) & JP 2003 113161 A (MITSUBISHI MATERIALS CORP), 18 April 2003 (2003-04-18)**
- **PATENT ABSTRACTS OF JAPAN vol. 2003, no. 07, 3 July 2003 (2003-07-03) & JP 2003 073665 A (SANYO ELECTRIC CO LTD), 12 March 2003 (2003-03-12)**
- **PATENT ABSTRACTS OF JAPAN vol. 2002, no. 08, 5 August 2002 (2002-08-05) & JP 2002 105055 A (FUJI PHOTO FILM CO LTD), 10 April 2002 (2002-04-10)**

EP 1 642 951 B1

Description

[0001] This application claims the benefit of Korean Patent Application No. 10-2004-0078721 filed on October 4, 2004, which is hereby incorporated by reference as if fully set forth herein.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to green light-emitting compounds. More particularly, the present invention relates to iridium-based luminescent compounds having phenylpyridine moieties with an organosilicon group, and organic electroluminescence devices using the compounds as color-producing materials.

Discussion of the Related Art

[0003] Generally, electroluminescence (EL) devices are self-emissive display devices and are advantageous in terms of broad viewing angle, high contrast, and rapid response time. Such EL devices are classified into inorganic EL devices and organic EL devices according to the kind of materials for the formation of emitter layers. Organic EL devices have excellent luminance, driving voltage and response rate characteristics and easily produce various colors, when compared to inorganic EL devices.

[0004] General organic EL devices comprise a substrate, an anode, a hole injecting layer, a hole transport layer, a light-emitting layer, an electron transport layer, and a cathode formed in this order from the bottom. The hole transport layer, the light-emitting layer, and the electron transport layer are organic thin films made of organic compounds.

[0005] The fabrication of an organic EL device will be briefly explained below.

[0006] (1) First, an anode material is coated on a transparent substrate to form an anode. Indium tin oxide (ITO) is mainly used as the anode material.

[0007] (2) A hole injecting layer (HIL) is formed to a thickness of 10~30 nm on the anode. Copper phthalocyanine (CuPc) is mainly used as a material for the hole injecting layer.

[0008] (3) A hole transport layer is formed on the hole injecting layer. The hole transport layer is formed by depositing 4,4'-bis[N-(1-naphthyl)-N-phenylamino]-biphenyl (NPB) to a thickness of about 30 nm to about 60 nm on the hole injecting layer.

[0009] (4) An organic light-emitting layer is formed on the hole transport layer. If needed, a dopant is added to a material for the organic light-emitting layer. For green light emission, tris(8-hydroxyquinoline aluminum) (Alq_3) as a material for the organic light-emitting layer is deposited to a thickness of about 30 nm to about 60 nm on the hole transport layer, and N-methylquinacridone (MQD) is mainly used as a dopant.

[0010] (5) An electron transport layer (ETL) and an electron injecting layer (EIL) are sequentially formed on the organic light-emitting layer. Alternatively, an electron injecting/transport layer is formed on the organic light-emitting layer. In the case of green light emission, since Alq_3 has superior electron transport ability, the use of the electron injecting/transport layer may be unnecessary.

[0011] (6) A cathode material is coated on the electron injecting layer, and finally the resulting structure is covered with a protective film.

[0012] The operational principle of the organic EL device having the structure described above is as follows.

[0013] When a voltage is applied between the anode and the cathode, holes injected from the anode migrate to the light emitting layer via the hole transport layer while electrons injected from the cathode migrate to the light emitting layer via the electron transport layer. The carriers are recombined with each other in the light emitting layer to form excitons, and then the excitons fall from the excited state to the ground state to allow fluorescent molecules present in the light-emitting layer to emit light, achieving the formation of images.

[0014] However, although conventional luminescent compounds that have been used as materials for organic light-emitting layers show superior luminescent properties, there is the disadvantage of poor luminescent efficiency due to triplet-triplet annihilation. Accordingly, there is room for improvement in the efficiency of conventional luminescent compounds.

SUMMARY OF THE INVENTION

[0015] Accordingly, the present invention is directed to iridium-based luminescent compounds having phenylpyridine moieties with an organosilicon group and organic electroluminescence devices using the compounds as color-producing materials that substantially obviate one or more problems due to limitations and disadvantages of the related art.

[0016] An object of the present invention is to provide luminescent compounds with markedly improved luminescent efficiency.

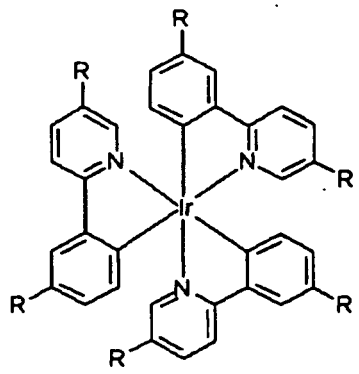
[0017] Another object of the present invention is to provide organic electroluminescence devices using the compounds as color-producing materials.

[0018] Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0019] To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, luminescent

compounds have the structure of Formula 1 below:

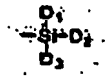
[0020] Formula 1



(1),

wherein the R is formula 2 below;

[0021] Formula 2



[0022] wherein D_1, D_2 and D_3 are each independently selected from the group consisting of $C_{1\sim18}$ alkyl, $C_{1\sim18}$ alkoxy, substituted or unsubstituted $C_{1\sim18}$ alkyl and allyl, and substituted or unsubstituted $C_{6\sim19}$ fluorinated alkyl and allyl groups

[0023] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are Intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWING

[0024] The accompanying drawings, which are included to provide a further understanding of the invention and are Incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[0025] FIG. 1 is a diagram showing the structure of a general OLED;

[0026] FIG. 2 is a diagram showing the synthesis procedure of the organic luminescent compound represented by Formula 4 according to the present invention;

[0027] FIG. 3 is a mass spectrum of the organic luminescent compound represented by Formula 4 according to the present invention;

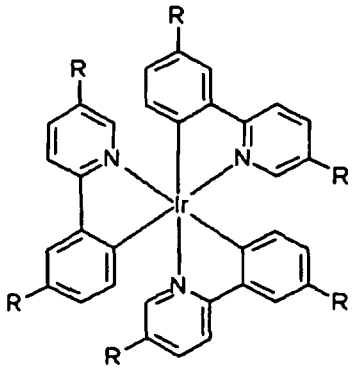
[0028] FIG. 4 is a UV/PL spectrum of the organic luminescent compound represented by Formula 4 according to the present invention; and

[0029] FIGs. 5 and 6 are graphs showing the characteristics of an OLED wherein the organic luminescent compound represented by Formula 4 according to the present invention is used as a material for a light-emitting layer.

DETAILED DESCRIPTION OF THE INVENTION

[0030] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0031] Luminescent compounds of the present invention are represented by Formula 1 below:



(1),

[0032] wherein R is Formula 2 below:

(2)

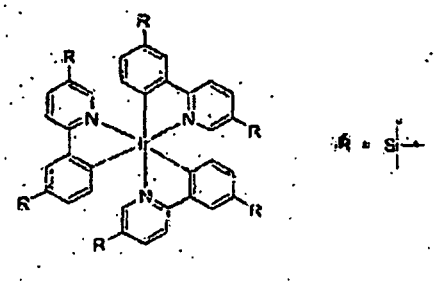
[0033] wherein D_1, D_2 and D_3 are each independently selected from the group consisting of $C_{1\sim18}$ alkyl, $C_{1\sim18}$ alkoxy, substituted or unsubstituted $C_{1\sim18}$ alkyl and allyl, and substituted or unsubstituted $C_{6\sim18}$ fluorinated alkyl and allyl groups

[0034] The luminescent compounds of Formula 1 are used as green light-emitting agents and show superior luminescent efficiency. In addition, the luminescent compounds of Formula 1 are useful as color-producing materials for display devices. Organic electroluminescence devices of the present invention comprise organic films, e.g., light-emitting layers, made of the luminescent compounds of Formula 1. The organic electroluminescence devices of the present invention show markedly improved luminescent efficiency and luminance characteristics, as compared to organic electroluminescence devices using common iridium-based compounds having phenylpyridine moieties.

[0035] Among the luminescent compounds of Formula 1, preferred is the organic luminescent compound of Formula 4 (wherein the R are trimethylsilane, in Formula 1)

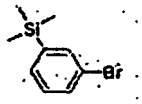
below:

[0036] Formula 4



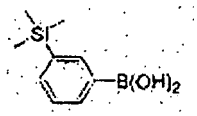
[0037] The compound of Formula 4 is prepared through the following synthesis procedure.

[0038] 1. Synthesis of compound (A)



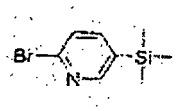
[0039] 1,3-Dibromobenzene was dissolved in diethyl ether, and then 1.2 equivalents of n-butyl lithium was slowly added thereto at -78°C. The diethyl ether used herein was dried using sodium before use. The reaction mixture was stirred at room temperature for 40 minutes. Thereafter, the reaction mixture was cooled to - 78°C, and then 1.2 equivalents of chlorotrimethyl silane were added thereto. The resulting mixture was stirred at room temperature for 10 hours. Water was added to the reaction mixture to quench the reaction. The reaction mixture was extracted using diethyl ether, followed by distillation in vacuo, to afford the compound (A) (yield: 73%).

[0040] 2. Synthesis of compound (B)



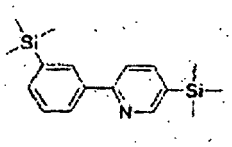
[0041] 1,3-Dibromopyridine was dissolved in diethyl ether, and then 1.2 equivalents of n-butyl lithium was slowly added thereto at -78°C. The diethyl ether used herein was dried using sodium before use. The reaction mixture was stirred at room temperature for 40 minutes. Thereafter, the reaction mixture was cooled to - 78°C, and then 2 equivalents of triethylborate were added thereto. The resulting mixture was stirred at room temperature for 12 hours. The reaction mixture was slowly poured into a 1N HCl solution, and extracted with ethyl acetate to afford the compound (B) (yield: 35%).

[0042] 3. Synthesis of compound (C)



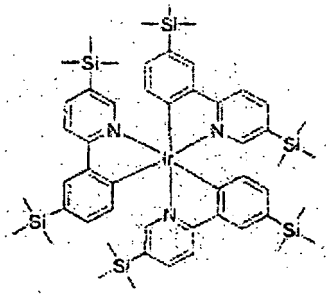
[0043] 1,3-Dibromopyridine was dissolved in diethyl ether, and then 1.2 equivalents of n-butyl lithium was slowly added thereto at -78°C. The diethyl ether used herein was dried using sodium before use. The reaction mixture was stirred at this temperature for 40 minutes. 1.2 Equivalents of chlorotrimethyl silane were added to the reaction mixture. The resulting mixture was stirred at room temperature for 10 hours. Water was poured into the reaction mixture to quench the reaction. The reaction mixture was extracted using diethyl ether, followed by distillation in vacuo, to afford the compound (C) (yield: 73%).

[0044] 4. Synthesis of compound (D)



[0045] 1.2 Equivalents of the compound (B) and one equivalent of the compound (C) were added to a 2M solution of K_2CO_3 (THF) under a stream of nitrogen gas. The reaction mixture was refluxed for 5 hours. The reaction mixture was slowly poured into a 1N HCl solution to quench the reaction, and extracted with diethyl ether, affording the compound (D) (yield: 92%).

[0046] 5. Synthesis of compound of Formula 4



[0047] One equivalent of iridium (III) acetylacetonate was added to ethylene glycol under a stream of nitrogen gas. After the mixture was stirred at 80°C for 30 minutes, 5 equivalents of the compound (D) were added thereto. The resulting mixture was refluxed for 20 hours. The reaction mixture was allowed to cool to room temperature. The reaction mixture was poured into a 1N HCl solution and stirred to obtain a precipitate. The precipitate was filtered, washed with water, and purified by chromatography on silica gel using dichloromethane as an eluting solvent, affording the compound of Formula 4 (yield: 24%). The structure of the compound of Formula 4 was

identified by mass spectrometry. The mass spectrum is shown in FIG. 3.

[0048] Example

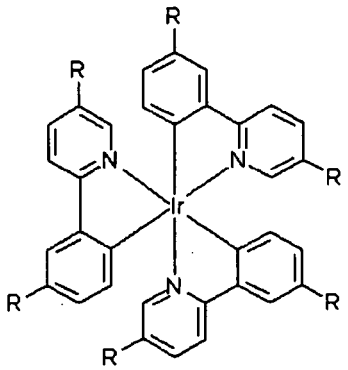
[0049] Indium tin oxide (ITO) was coated on a glass substrate, patterned so that the light-emitting area was 3mm x 3mm, and washed. After the substrate was placed in a vacuum chamber at a basic pressure of 1 x 10^{-6} torr, CuPC (200 Å), NPB (400 Å), a light-emitting layer (200 Å), BCP (100 A), Alq_3 (200 Å), LiF (5 Å), and Al (1000 Å) were deposited in this order on the ITO to fabricate an OLED. The light-emitting layer was formed by depositing CBP as a host and the compound of Formula 4 (8%) as a dopant. The OLED was measured to have a driving voltage of 9.71V, a luminance of 955 nits and a color coordinate (0.316, 0.603) at 11.1 mA/cm2.

[0050] The graphs shown in FIGs. 5 and 6 indicate that the OLED of the present invention shows superior luminescent properties.

[0051] The luminescent compound of the present invention show markedly improved luminescent efficiency, and the OLED using the luminescent compound as a material for the light-emitting layer show superior luminescent properties, i.e., high external quantum efficiency, high luminance, and low driving voltage.

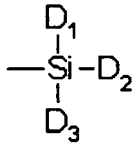
Claims

1. An iridium-based luminescent compound of Formula 1 below:



(1),

wherein the R is formula 2 below;



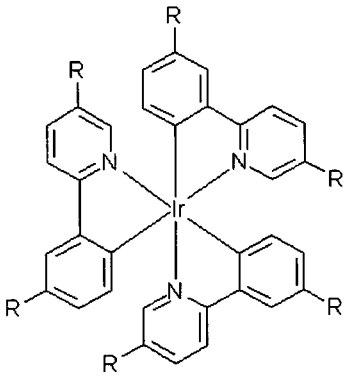
(2)

wherein D1, D2 and D3 are each independently selected from the group consisting of $C_{1\sim18}$ alkyl, $C_{1\sim18}$ alkoxy, substituted or unsubstituted $C_{1\sim18}$ alkyl and allyl, and substituted or unsubstituted $C_{6\sim18}$ fluorinated alkyl and allyl groups.

2. An organic electroluminescence device using the iridium-based luminescent compound according to claim 1 as a color-producing material.

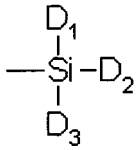
Patentansprüche

1. Lumineszente Verbindung auf Iridiumbasis der folgenden Formel 1:



(1),

worin R die folgende Formel 2 aufweist

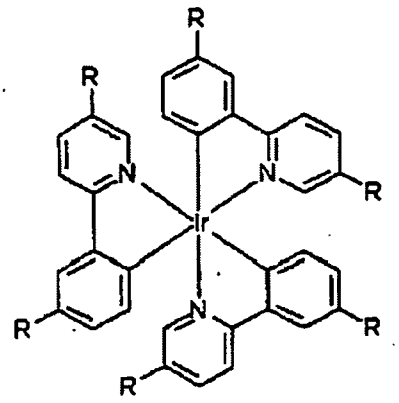


worin D1, D2 und D3 jeweils unabhängig voneinander gewählt sind aus der Gruppe, bestehend aus C_{1-18}-Alkyl, C_{1-18}-Alkoxy, substituiertes oder unsubstituiertes C_{1-18}-Alkyl und -Allyl, und substituierten oder unsubstituierten fluorierten C_{6-18}-Alkyl- und -Allylgruppen.

2. Organische elektrolumineszente Vorrichtung unter Verwendung der lumineszenten Verbindung auf Iridiumbasis nach Anspruch 1 als farberzeugendes Material.

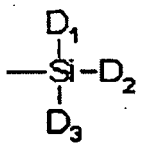
Revendications

1. Composé luminescent à base d'iridium de formule 1 ci-dessous :



(1),

dans laquelle le R est de formule 2 ci-dessous ;



(2)

dans laquelle D1, D2 et D3 sont chacun indépendamment les uns des autres choisis dans le groupe constitué par les groupes alkyle en C_{1-18}, alcoxy en C_{1-18}, alkyle et allyle en C_{1-18} substitués ou non substitués, et alkyle et allyle fluorés en C_{1-18} substitués ou non substitués.

2. Dispositif électroluminescent organique utilisant le composé luminescent à base d'iridium selon la revendication 1 comme matériau producteur de couleurs.

FIG. 1
Related Art

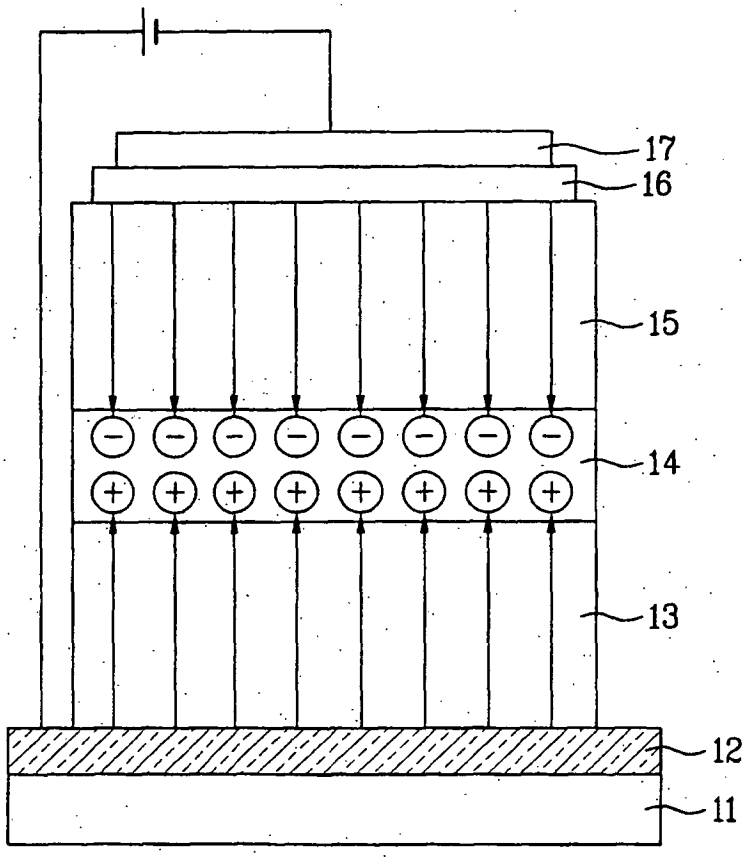


FIG. 2

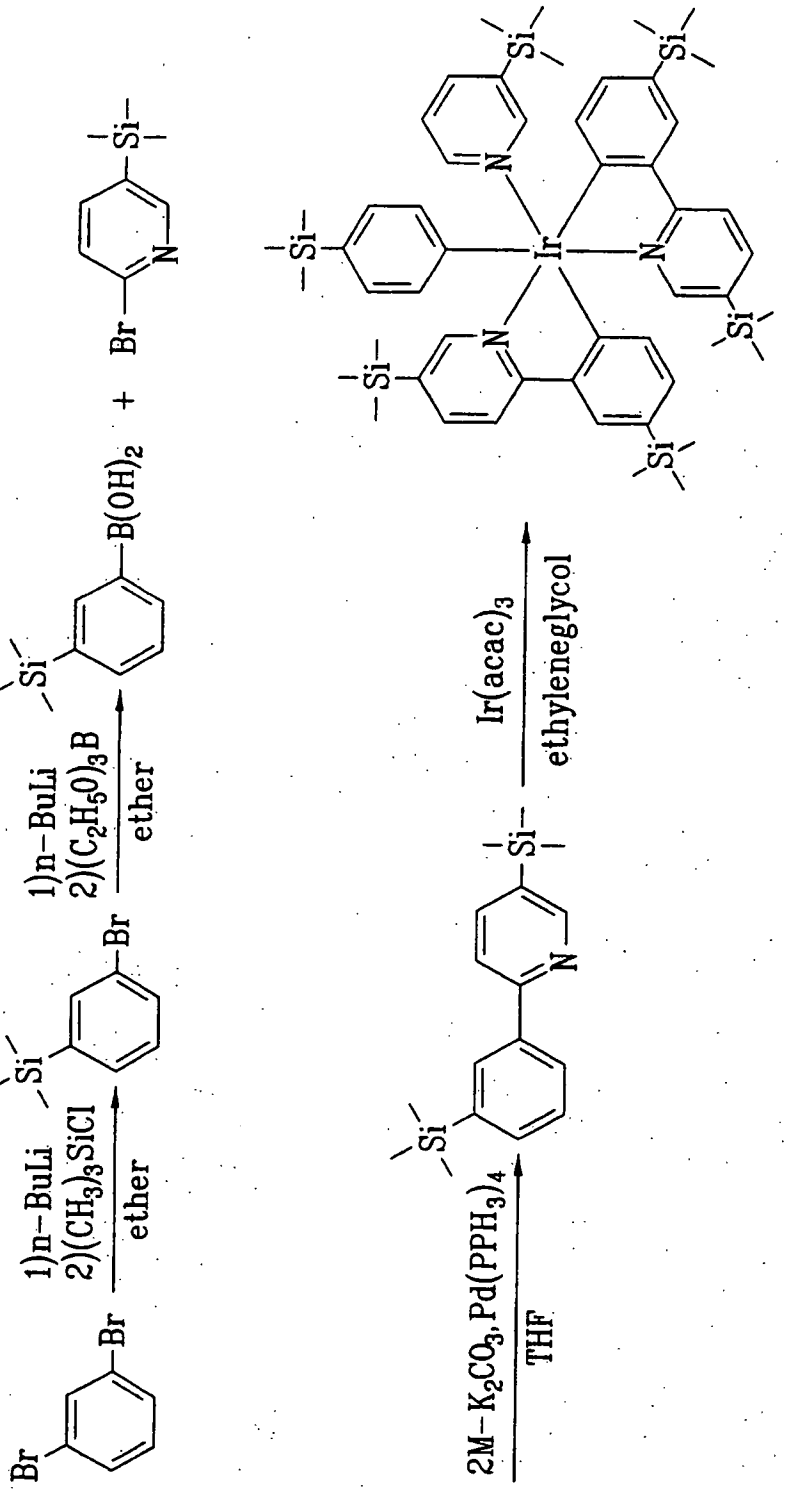

1)n-BuLi
2)(CH3)3SiCl
ether
1)n-BuLi
2)(C2H5O)3B
ether
2M-K2CO3, Pd(PPH3)4
THF
Ir(acac)3
ethyleneglycol
Br
Si
N
B(OH)2
Ir

FIG. 3

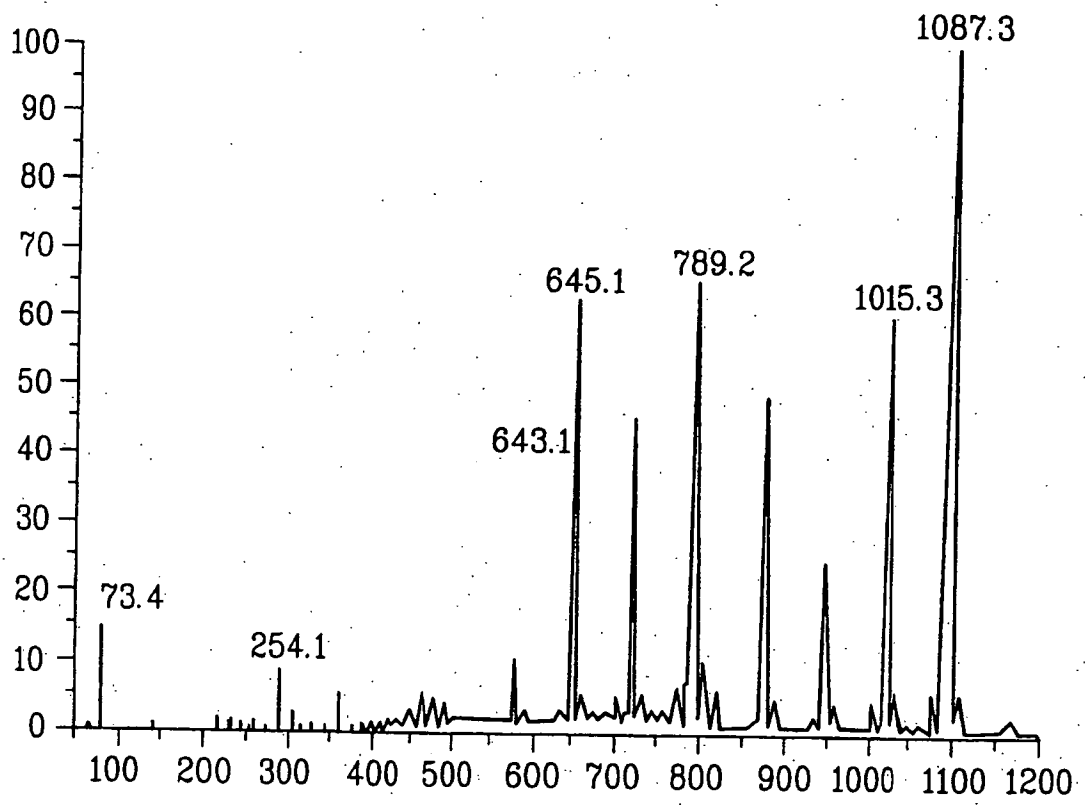

100
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
73.4
254.1
643.1
645.1
789.2
1015.3
1087.3

FIG. 4

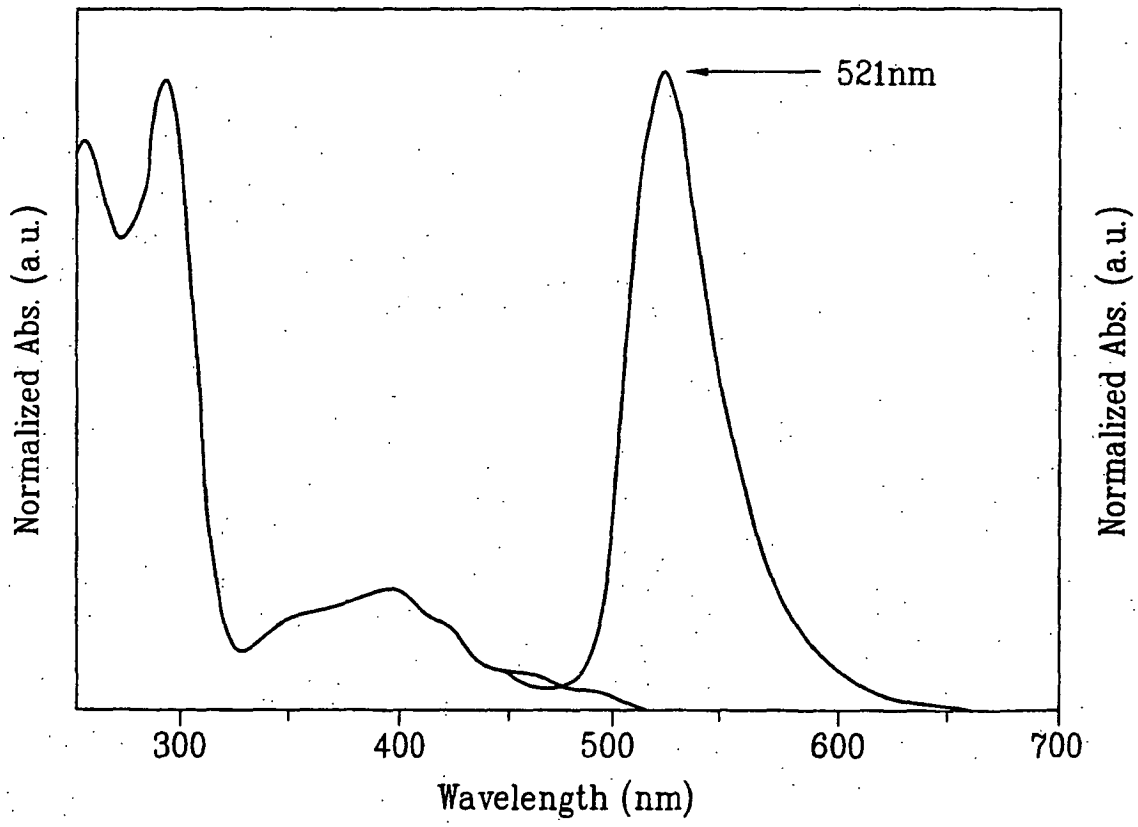

521nm
Normalized Abs. (a.u.)
Normalized Abs. (a.u.)
300
400
500
600
700
Wavelength (nm)

FIG. 5

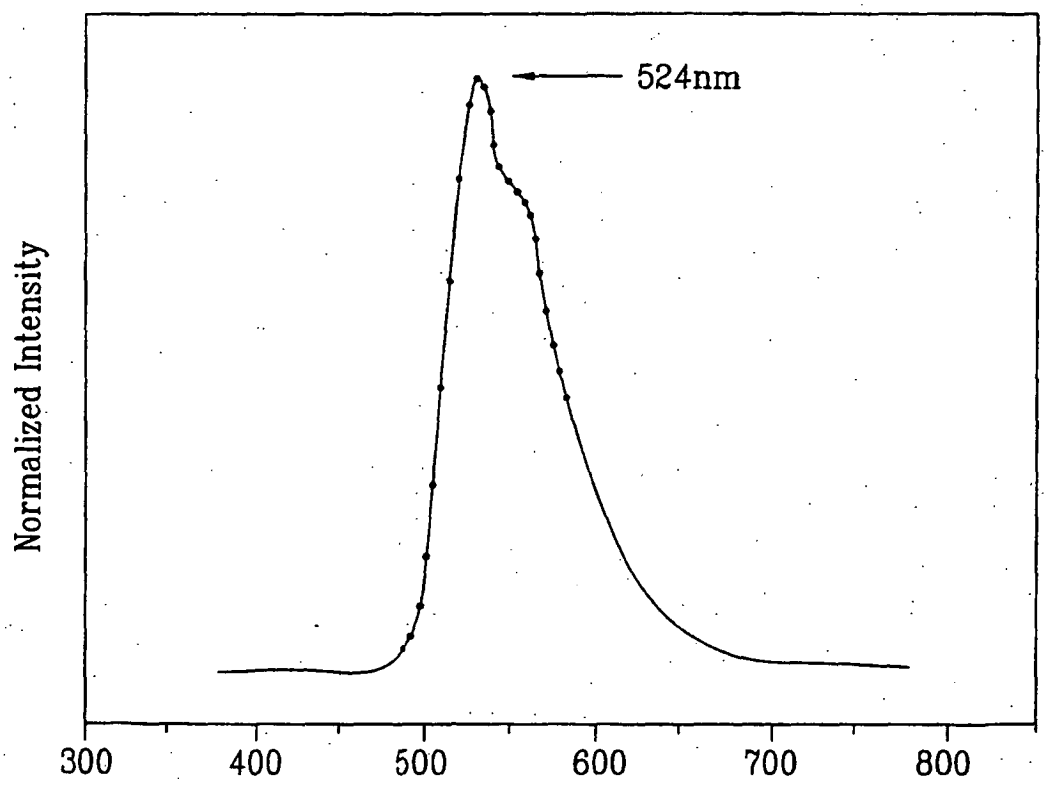
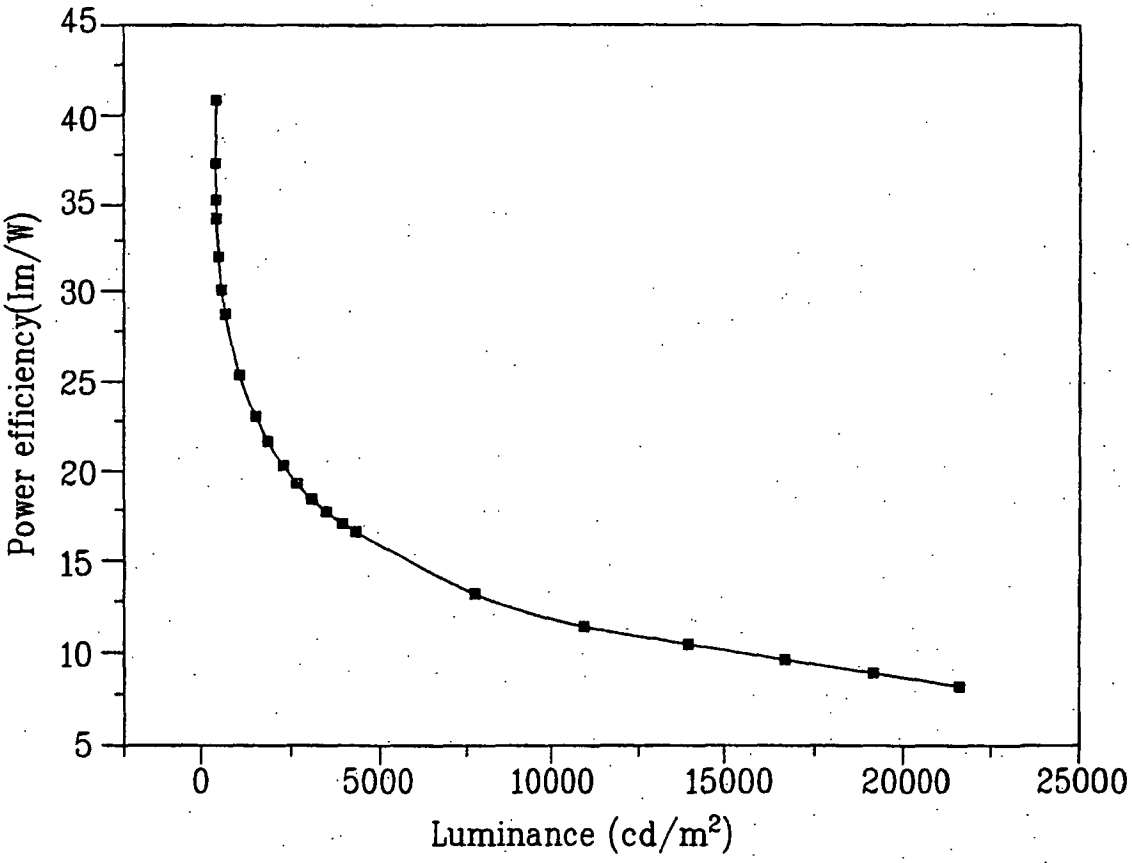


FIG. 6


45
40
35
30
25
20
15
10
5
Power efficiency(lm/W)
0
5000
10000
15000
20000
25000
Luminance (cd/m²)

REFERENCES CITED IN THE DESCRIPTION

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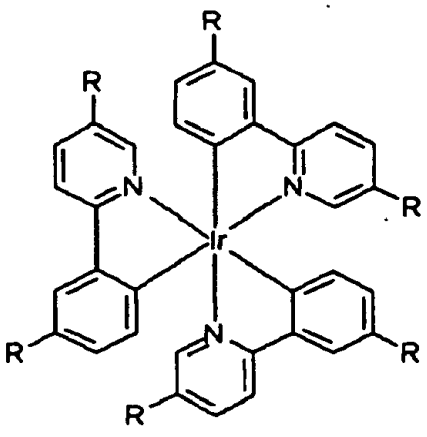
Patent documents cited in the description

- KR 1020040078721 **[0001]**

专利名称(译)	具有苯基吡啶部分和有机硅基团的铱基发光化合物，以及使用该化合物作为发色材料的有机电致发光器件		
公开(公告)号	EP1642951B1	公开(公告)日	2010-05-05
申请号	EP2005021642	申请日	2005-10-04
申请(专利权)人(译)	LG电子株式会社.		
当前申请(专利权)人(译)	LG DISPLAY CO.，LTD.		
[标]发明人	SEO JEONG DAE PARK CHUN GUN KWON SOON KI KIM YUN HI JUNG SUNG OUK AHN JUN HWAN KIM HYUNG SUN		
发明人	SEO, JEONG DAE PARK, CHUN GUN KWON, SOON KI KIM, YUN HI JUNG, SUNG-OUK AHN, JUN HWAN KIM, HYUNG SUN		
IPC分类号	C09K11/06 H05B33/14 H01L51/30 C07F15/00		
CPC分类号	C07F15/0033 C09K11/06 C09K2211/1029 C09K2211/185 H01L51/0085 H01L51/0094 H01L51/5012 H05B33/14 Y10S428/917		
优先权	1020040078721 2004-10-04 KR		
其他公开文献	EP1642951A2 EP1642951A3		
外部链接	Espacenet		

摘要(译)

公开了具有带有机硅基团的苯基吡啶部分的铱基发光化合物，以及使用该化合物作为产色材料的有机电致发光器件。发光化合物具有下式1的结构：其中L1，L2，L3，R1，R2和R3可以彼此相同或不同，各自独立地选自芳基，烷氧基，烷基，和式2和3的基团：其中D1，D2和D3各自独立地选自C1-18烷基，C1-18烷氧基，取代或未取代的C1-18烷基和烯丙基，和取代或未取代的C6~ 18个氟化烷基和烯丙基;其中D4，D5和D6各自独立地选自C1-18烷基，C1-18烷氧基，取代或未取代的C1-18烷基和烯丙基，和取代或未取代的C6-18氟代烷基和烯丙基。



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