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(54) **ANTHRACENE COMPOUND AND ORGANIC LIGHT EMITTING DIODE INCLUDING THE SAME**

(71) Applicant: **LG DISPLAY CO., LTD.**, Seoul (KR)

(72) Inventors: **Hyoseok KIM**, Gyeonggi-do (KR); **Jeongdae SEO**, Incheon (KR); **Eunju JEON**, Gyeonggi-do (KR); **Shinhan KIM**, Gyeonggi-do (KR)

(73) Assignee: **LG DISPLAY CO., LTD.**, Seoul (KR)

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USPC **257/40**; 546/285; 546/255; 546/257; 546/173

(57) **ABSTRACT**

An anthracene compound and organic light emitting diode including the same are disclosed. The organic light emitting diode includes, at least two stacks formed between a first electrode and a second electrode and a charge generation layer (CGL) including an N-type CGL and a P-type CGL formed between the stacks, wherein the N-type CGL is formed of the anthracene compound.

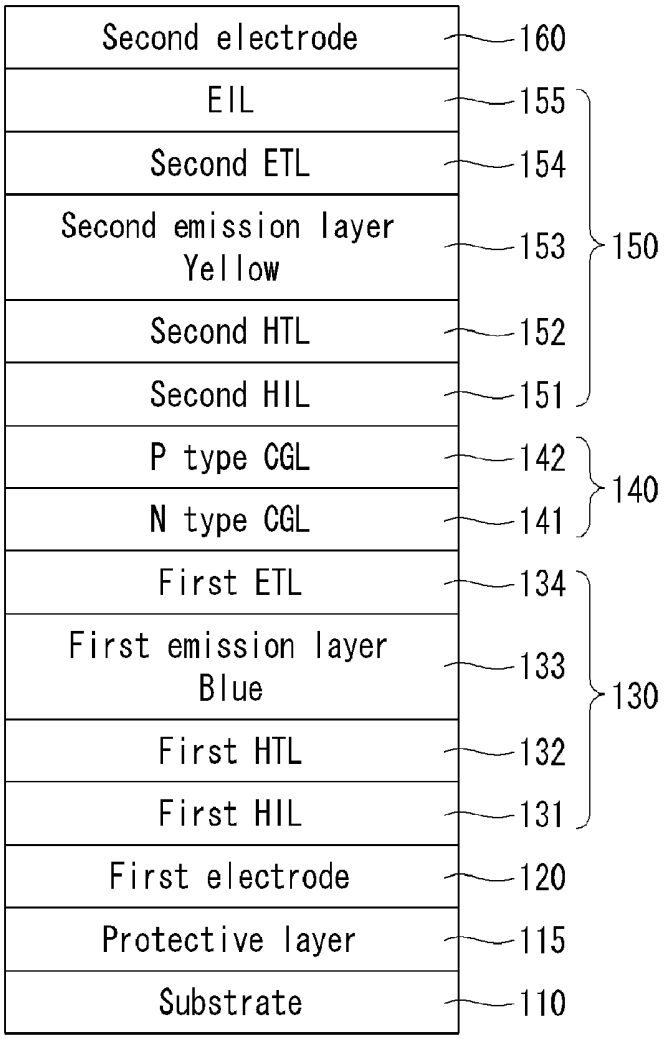


FIG. 1

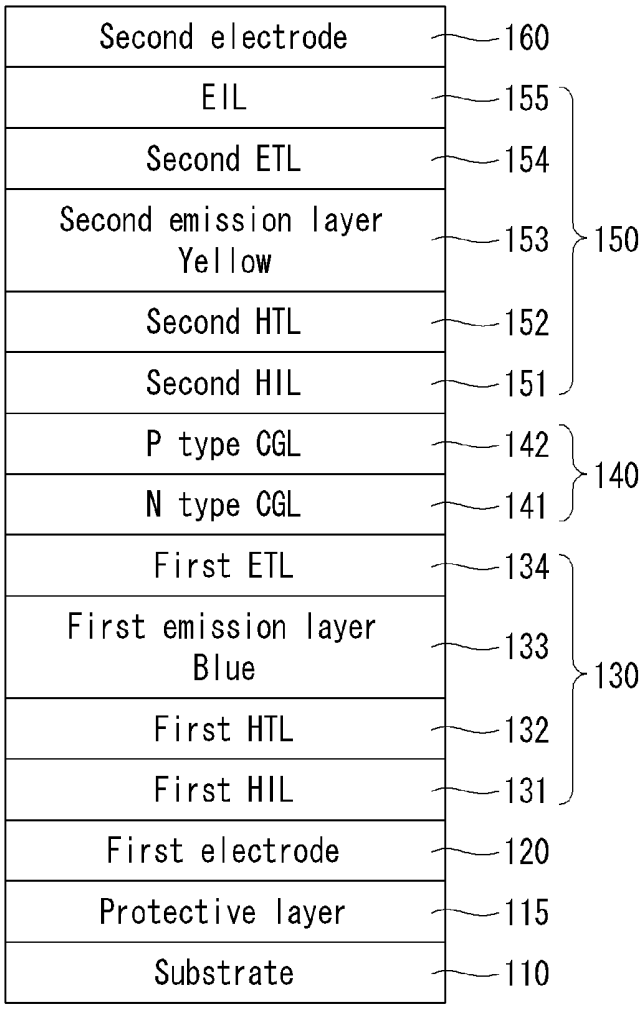

Second electrode
160
EIL
155
Second ETL
154
Second emission layer
Yellow
153
150
Second HTL
152
Second HIL
151
P type CGL
142
140
N type CGL
141
First ETL
134
First emission layer
Blue
133
130
First HTL
132
First HIL
131
First electrode
120
Protective layer
115
Substrate
110

FIG. 2

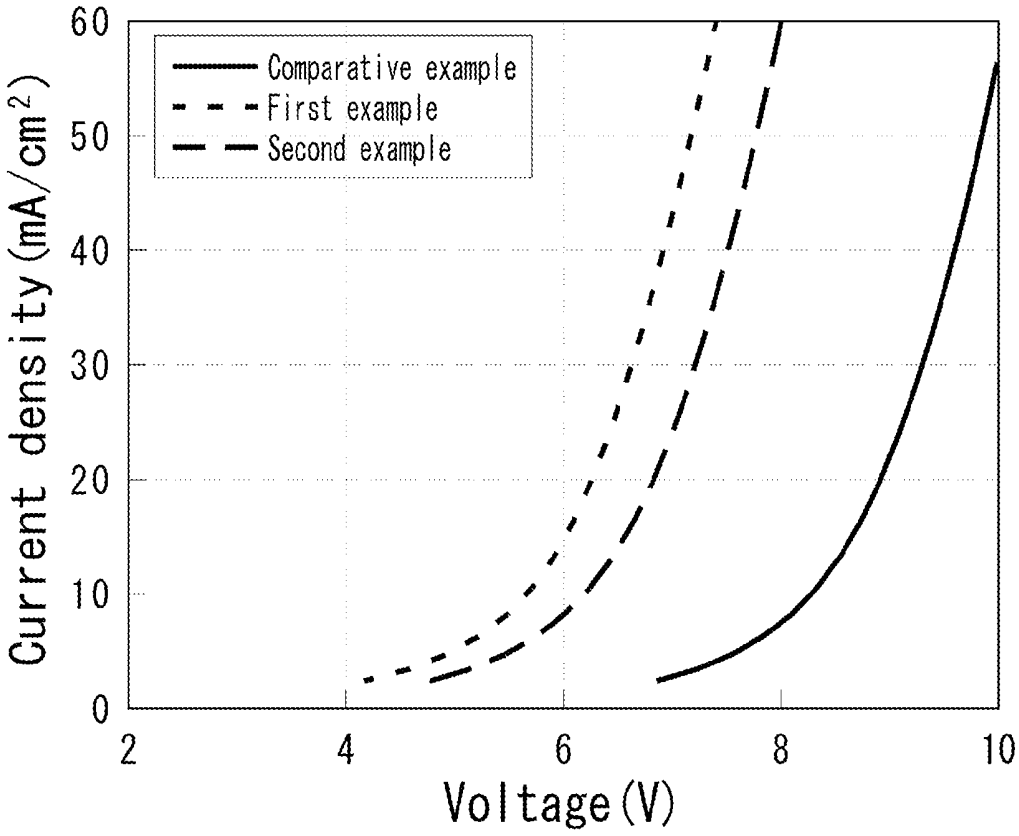
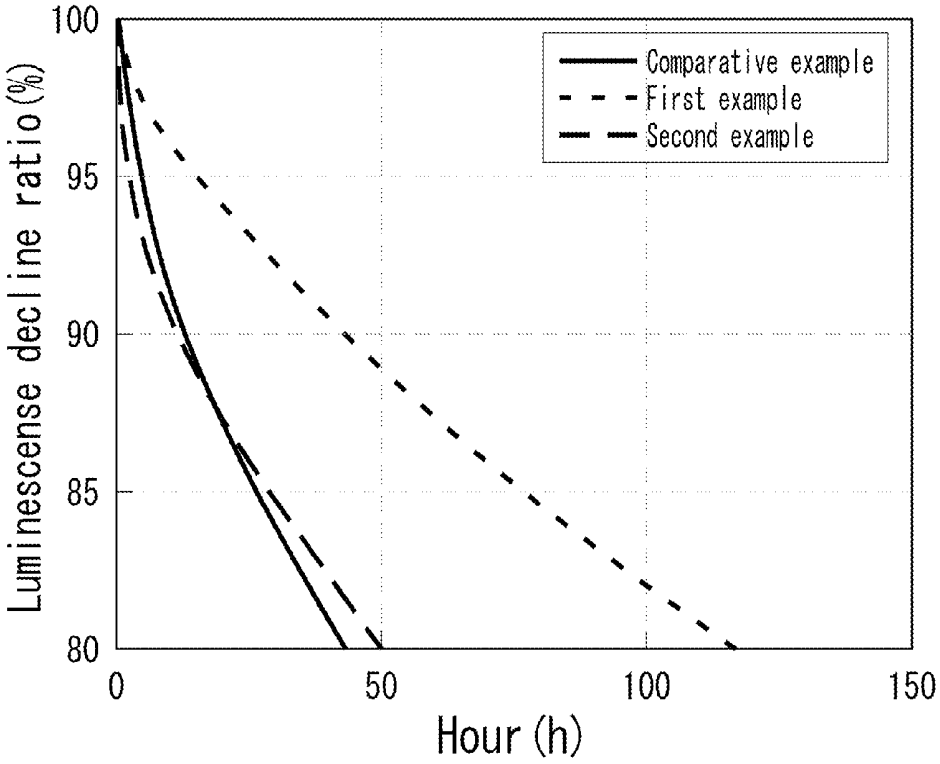

Comparative example
First example
Second example
Current density (mA/cm²)
Voltage (V)
0
10
20
30
40
50
60
2
4
6
8
10

FIG. 3


100
95
90
85
80
Luminescense decline ratio (%)
0
50
100
150
Hour (h)
Comparative example
First example
Second example

ANTHRACENE COMPOUND AND ORGANIC LIGHT EMITTING DIODE INCLUDING THE SAME

[0001] This application claims the benefit of Korean Patent Application No. 10-2012-0097356 filed on Sep. 3, 2012, which is incorporated herein by reference for all purposes as if fully set forth herein.

BACKGROUND OF INVENTION

[0002] 1. Field of the Invention

[0003] This document relates to an organic light emitting diode (OLED), and more particularly, to an organic light emitting diode (OLED) including an anthracene compound.

[0004] 2. Discussion of the Related Art

[0005] Recently, the importance of flat panel displays (FPD) is increasing with the development of multimedia. Therefore, various displays such as liquid crystal displays (LCD), plasma display panels (PDP), field emission displays (FED), and organic light emitting diodes (OLED) are commercialized.

[0006] In particular, an OLED has high response speed of no more than 1 ms, uses a small amount of power, and is self-emissive. In addition, since there is no problem in a viewing angle, the OLED is advantageous as a moving picture display medium regardless of the size of an apparatus. In addition, since the OLED may be manufactured at a low temperature and has simple manufacturing processes based on a conventional semiconductor process technology, the OLED is spotlighted as a next generation FPD.

[0007] The OLED includes a light emitting layer between an anode electrode and a cathode electrode so that holes supplied from the anode electrode and electrons supplied from the cathode electrode are combined with each other in the light emitting layer to form excitons that are pairs of holes and electrons. Light is emitted by energy generated by the excitons returning to a ground state.

[0008] The OLED is developed to have various structures. Among them, a tandem-type OLED in which a number of light emitting layers are laminated is developed. The tandem-type OLED has a structure in which a plurality of stacks each formed of a hole injection layer (HIL)/a hole transport layer (HTL)/a light emitting layer/an electron transport layer (ETL)/an electron injection layer (EIL) are laminated between the anode electrode and the cathode electrode. In particular, a charge generation layer (CGL) formed of an N-type CGL and a P-type CGL is provided between the stacks to generate charges or to inject charges into the light emitting layers.

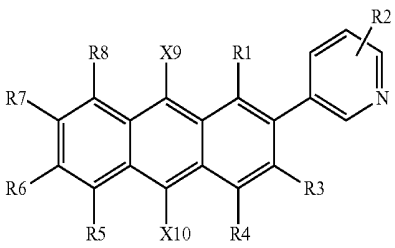
[0009] However, in the CGL, due to a difference in an energy level between the N-type CGL and the P-type CGL, a characteristic in which electrons generated in an interface between the P-type CGL and an adjacent hole injection layer by charge generation are injected into the N-type CGL is deteriorated. In addition, when the conventional N-type CGL is doped with an alkali metal, the alkali metal is diffused into the P-type CGL so that the life of the OLED is reduced.

SUMMARY

[0010] The present invention has been made in an effort to provide an anthracene compound and an organic light emitting diode (OLED) including the same in which a new N-type CGL is provided so that the driving voltage of the OLED is reduced, that the emission efficiency of the OLED is improved, and that the life of the OLED is increased.

[0011] In one aspect, there is An anthracene compound represented by formula 1,

[FORMULA 1]



[0012] wherein each of R1 to R8 is one selected from the group consisting of a hydrogen-containing alkyl or heteroalkyl group having 1 to 20 carbon atoms, an aryl group having 5 to 20 carbon atoms, and a nitrogen, sulfur, or oxygen-containing heteroaryl group having 4 to 20 carbon atoms, and wherein each of X9 and X10 is one selected from the group consisting of a nitrogen, sulfur, or oxygen-containing heteroaryl group having 4 to 20 carbon atoms and an aryl group having 6 to 20 carbon atoms.

[0013] In another aspect, there is an organic light emitting diode (OLED) includes at least two stacks formed between a first electrode and a second electrode and a charge generation layer (CGL) including an N-type CGL and a P-type CGL formed between the stacks, wherein the N-type CGL is formed of the anthracene compound.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention. In the drawings:

[0015] FIG. **1** is a view illustrating an organic light emitting diode (OLED) according to an embodiment of the present invention;

[0016] FIG. **2** is a graph illustrating current density in accordance with the driving voltage of the OLED manufactured in accordance with the embodiment of the present invention; and

[0017] FIG. **3** is a graph illustrating a life reduction ratio in accordance with time of the OLED manufactured in accordance with the embodiment of the present invention.

DETAILED DESCRIPTION

[0018] Reference will now be made in detail to embodiments of the 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. It will be paid attention that detailed description of known arts will be omitted if it is determined that the arts can mislead the embodiments of the invention.

[0019] FIG. **1** is a view illustrating an organic light emitting diode (OLED) according to an embodiment of the present invention. Hereinafter, an OLED in which two stacks are

laminated will be taken as an example. However, the present invention is not limited to the above.

[0020] Referring to FIG. **1**, an OLED **100** according to an embodiment of the present invention may be a white OLED including yellow light and blue light. In detail, the OLED **100** includes a first electrode **120** positioned on a substrate **110**, a first stack **130** positioned on the first electrode **120** and including a first light emitting layer **133**, a charge generation layer (CGL) **140** positioned on the first stack **130**, a second stack **150** positioned on the CGL **140** and including a second light emitting layer **153**, and a second electrode **160** positioned on the second stack **150**.

[0021] The substrate **110** may be formed of transparent glass, plastic, or a conductive material. The first electrode **120** as an anode electrode for injecting holes may be a transparent electrode that transmits light. The first electrode **120** is formed of one of indium tin oxide (ITO), indium zinc oxide (IZO), and zinc oxide (ZnO). A reflecting layer **115** may be further provided between the substrate **110** and the first electrode **120**. The reflecting layer **115** for reflecting light upward may be formed of one of Al, Ag, and Ni under the first electrode **120**.

[0022] The first stack **130** positioned on the first electrode **120** may include the first light emitting layer **133** for emitting blue light. In the first stack **130**, since only a blue light emitting layer is included as the first light emitting layer **133** so that only blue light is emitted, stability of blue may be improved. In the first light emitting layer **133** for emitting blue light, fluorescent blue dopant may be mixed with one host. For example, in the first light emitting layer **133**, fluorescent blue dopant such as 1,6-Bis(diphenylamine)pyrene or TBPe(tetrakis(t-butyl)perylene) may be mixed with a host material such as AND(9,10-di(2-naphthyl)anthracene) or DPVBi(4,4'-bis(2,2-diphenylethen-1-yl)-diphenyl). In addition, the fluorescent blue dopant may be deep blue dopant or sky blue dopant. The deep blue dopant may be 4'-N,N-diphenylaminostyryl-triphenyl(DPA-TP), 2,5,2',5'-tetrastyryl-biphenyl (TSB), or an anthracene derivative. The sky blue dopant may be p-bis(p-N,N-diphenyl-aminostyryl)benzene or phenylcyclopentadiene.

[0023] The first stack **130** may further include a first hole injection layer **131** and a first hole transport layer **132** formed between the first electrode **120** and the first light emitting layer **133** and a first electron transport layer **134** formed between the first light emitting layer **133** and the CGL **140**.

[0024] The hole injection layer **131** for smoothly injecting holes from the first electrode **120** to the first light emitting layer **133** may be formed of at least one selected from the group consisting of cupper phthalocyanine (CuPc), poly(3,4)-ethylenedioxythiophene (PEDOT), polyaniline (PANI), and N,N-dinaphthyl-N,N'-diphenyl benzidine (NPD). However, the present invention is not limited to the above.

[0025] The first hole transport layer **132** for smoothly transporting holes may be formed of at least one selected from the group consisting of N,N-dinaphthyl-N,N'-diphenyl benzidine (NPD), N,N'-bis-(3-methylphenyl)-N,N'-bis-(phenyl)-benzidine (TPD), s-TAD, and 4,4',4"-Tris(N-3-methylphenyl-N-phenyl-amino)-triphenylamine (MTDATA). However, the present invention is not limited to the above.

[0026] The first electron transport layer **134** for smoothly transporting electrons may be formed of at least one selected from the group consisting of Alq3(tris(8-hydroxyquinolino) aluminum), PDB, TAZ, Spiro-PBD, BAlq, and SAlq. However, the present invention is not limited to the above.

[0027] On the other hand, the CGL **140** positioned on the first stack **130** is a PN conjunction CGL in which an N-type CGL **141** and a P-type CGL **142** are in conjunction with each other. The PN conjunction CGL **140** generates charges or divides charges into holes and electrons to inject charges into the light emitting layers. That is, the N-type CGL **141** supplies electrons to the first light emitting layer **133** adjacent to the first electrode and the P-type CGL **142** supplies holes to the second light emitting layer **153** adjacent to the second electrode **160** so that the emission efficiency of the OLED including a plurality of light emitting layers may be increased and that the driving voltage of the OLED may be reduced.

[0028] The N-type CGL **141** is formed of an anthracene compound and will be described in detail later. The P-type CGL **142** may be formed of an organic material doped with a metal or P-type dopant. Here, the metal may be formed of one or at least two alloys selected from the group consisting of Al, Cu, Fe, Pb, Zn, Au, Pt, W, In, Mo, Ni, and Ti. In addition, the P-type dopant used for the organic material doped with the P-type dopant and a host may be formed of commonly used materials. For example, the P-type dopant may be one material selected from the group consisting of 2,3,5,6-thetrafluore-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ), a derivative of tetracyanoquinodimethane, iodine, FeCl3, FeF3, and SbCl5. The host may be one material selected from the group consisting of N,N'-di(naphthalene-1-i1)-N,N-diphenyl-benzidine (NPB), N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1-biphenyl-4,4'-diamine (TPD), and N,N',N'-tetranaphthyl-benzidine (TNB).

[0029] On the other hand, the second stack **150** positioned on the CGL **140** may include the second light emitting layer **153** for emitting yellow light. In the second light emitting layer **153**, yellow dopant may be included in a host or red and green dopants may be included in one host.

[0030] For example, when the yellow dopant is included in the host in the second light emitting layer **153**, the same material as the above-described host of the first light emitting layer **133** may be used as the host and the blue dopant and Irpq2acac (bis(phenylquinoline) iridium acetylacetonate) may be used as yellow phosphor dopant. When the red and green dopants are included in one host in the second light emitting layer **153**, Ir(piq)2acac (bis(phenylisoquinoline) iridium acetylacetonate) may be used as red phosphor dopant included in the host and Irppy3(tris(phenylpyridine)iridium) may be used as green phosphor dopant.

[0031] The second stack **150** further includes a second hole injection layer **151** and a second hole transport layer **152** formed between the CGL **140** and the second light emitting layer **153** and a second electron transport layer **154** and an electron injection layer **155** formed between the second light emitting layer **153** and the second electrode **160**. The second hole injection layer **151**, the second hole transport layer **152**, and the second electron transport layer **154** are the same as the above-described first hole injection layer **131**, first hole transport layer **132**, and first electron transport layer **134** and description thereof will be omitted.

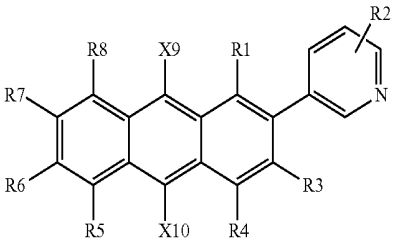
[0032] The electron injection layer **155** for smoothly injecting electrons may be formed of at least one selected from the group consisting of Alq3(tris(8-hydroxyquinolino)aluminum), PBD, TAZ, Spiro-PBD, BAlq, or SAlq. However, the present invention is not limited to the above. In addition, the electron injection layer **155** may be a metal halide compound,

for example, at least one selected from the group consisting of MgF_2, LiF, NaF, KF, RbF, CsF, FrF, and CaF_2. However, the present invention is not limited to the above.

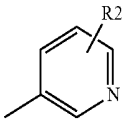
[0033] The second electrode (cathode) **160** may be formed of a transparent material so that light emitted from the light emitting layers **133** and **153** may be emitted to the entire surface. For example, the second electrode **160** may be one of ITO, IZO, and ZnO.

[0034] The N-type CGL **141** according to the present invention is formed of the anthracene compound represented by the formula 1.

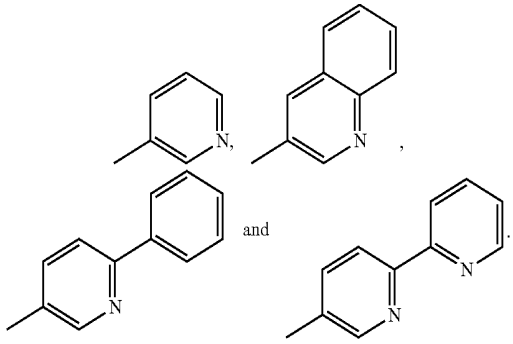
[FORMULA 1]



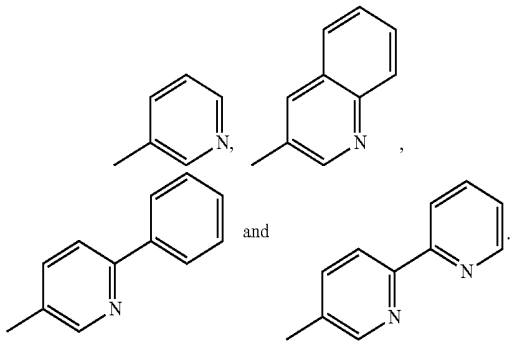
[0035] In the formula 1, each of R1 to R8 is one selected from a hydrogen-containing alkyl or heteroalkyl group having 1 to 20 carbon atoms, an aryl group having 5 to 20 carbon atoms, and a nitrogen, sulfur, or oxygen-containing heteroaryl group having 4 to 20 carbon atoms and each of X9 and X10 is one selected from a nitrogen, sulfur, or oxygen-containing heteroaryl group having 4 to 20 carbon atoms and an aryl group having 6 to 20 carbon atoms.



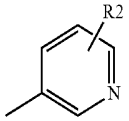
is one selected from the group consisting of



R6 is one selected from the group consisting of hydrogen,



[0036] For example, the anthracene compound represented by the formula 1 may be formed of the following compounds NC01 to NC20 through various combinations of



and R6 as illustrated in the table 1.

TABLE 1

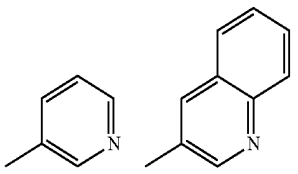
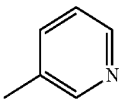
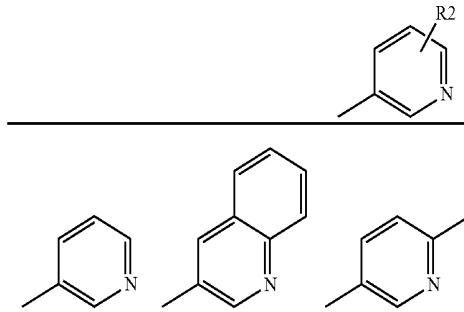
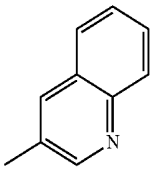
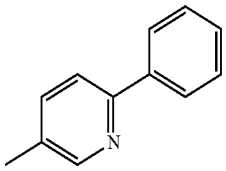
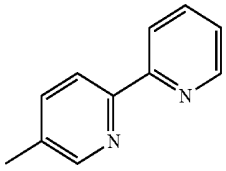
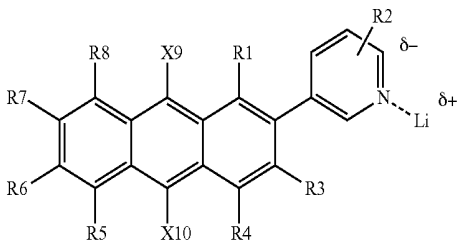
R6			
—H	NC01	NC02	NC03	NC04
	NC05	NC06	NC07	NC08

TABLE 1-continued

R6				
	NC09	NC10	NC11	NC12
	NC13	NC14	NC15	NC16
	NC17	NC18	NC19	NC20

[0037] The anthracene compound according to the present invention may be doped with an alkali metal. Therefore, as illustrated in formula 2, since SP2-nitrogen of the anthracene compound is a reactive site having relatively abundant electrons, SP2-nitrogen is bonded with Li to form a gap state. Electrons may be easily transported from the P-type CGL to the N-type CGL by the formed gap state.

[FORMULA 2]

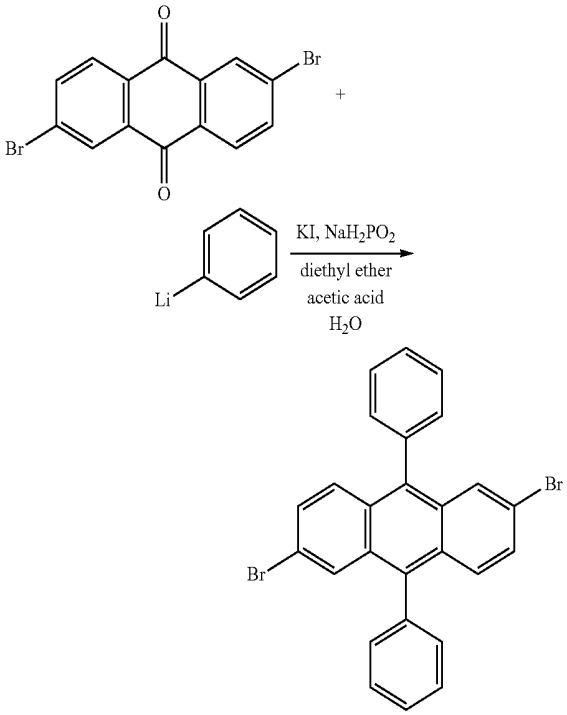


[0038] Therefore, the alkali metal doped on the conventional N-type CGL is diffused into the P-type CGL to prevent the life from being reduced and to easily transport electrons.

[0039] Hereinafter, a composition example of the anthracene compound used for the N-type CGL according to the present invention and an OLED including the compound will be described in detail with reference to the following composition example and the embodiment. The following embodiment is only an embodiment and the present invention is not limited to the following embodiment.

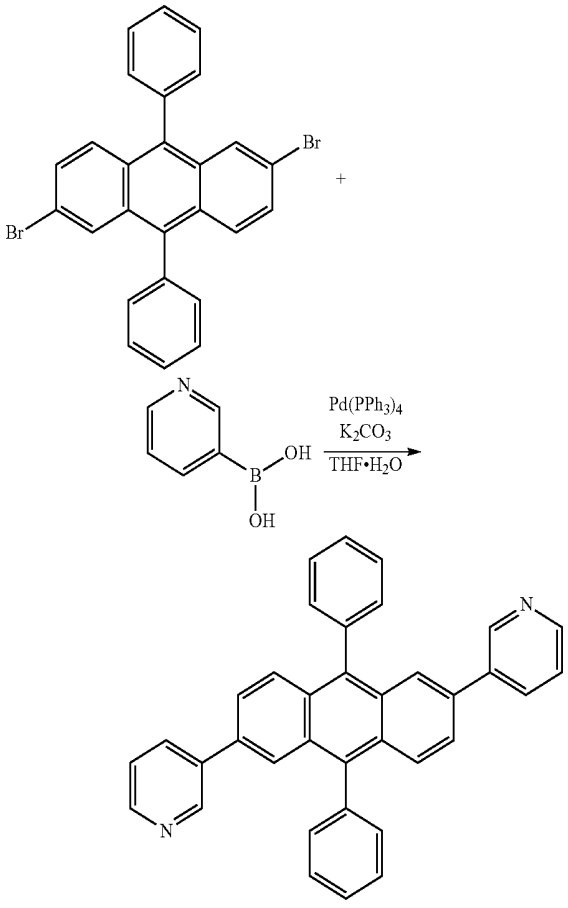
COMPOSITION EXAMPLE

[0040] 1) composition of 2,6-dibromo-9,10-diphenylanthracene



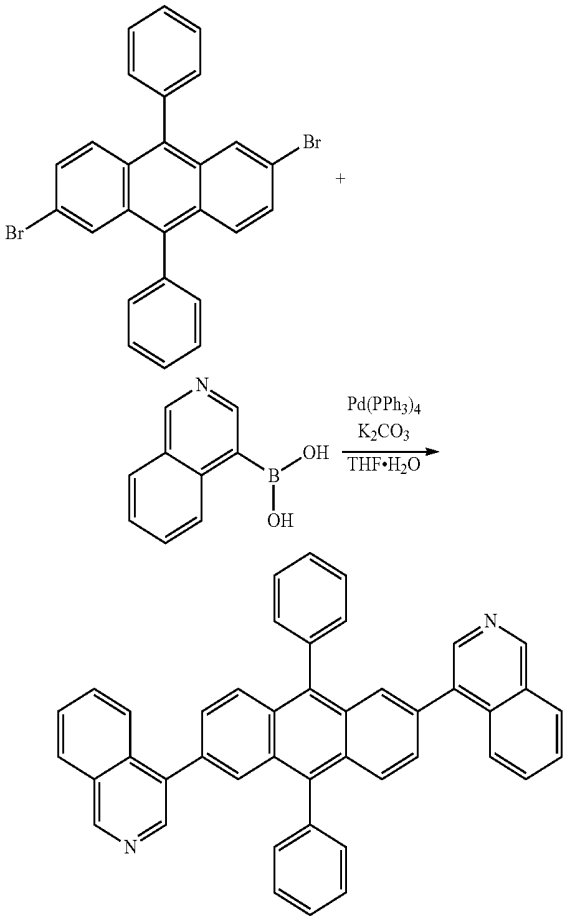
[0041] While agitating solution manufactured by dissolving 2,6-dibromoantraquinon (3 g, 8.2 mmol) in ethylether (Et20), solution manufactured by dissolving phenyllithium (2 g, 23.8 mmol) in ethylether (Et20) is slowly dropped. At this time, reaction is performed in a dry ice tub. Then, when temperature is raised to the room temperature, an intermediate is obtained. Solid obtained by filtering the intermediate is dissolved in acetic acid of 60 mL. Then, KI and NaH_2PO_2 are put into the solution obtained by dissolving the intermediate in acetic acid. Then, the solution is refluxed at 130° C. for 24 hours. When the reaction is completed, water is put and filtering is performed. Then, a generated solid material is re-crystallized using methylene chloride and methanol to obtain 2,6-dibromo-9,10-diphenylanthracene (2.7 g, 5.5 mmol, 67%).

[0042] 2) manufacturing of NC05



[0043] Pyridine boric acid (2.5 g, 20.3 mmol) and anhydrous tetrahydrofuran of 60 ml are put into the composed 2,6-dibromo-9,10-diphenylanthracene (3 g, 6.1 mmol) and the resultant solution is agitated. tetrakis(triphenylphosphine)palladium(1.4 g, 1.2 mmol), potassium carbonate (K_2CO_3, 6.3 g, 24.6 mmol), and distilled water of 60 mL are put and the resultant solution is refluxed at 100° C. for 24 hours. When reaction is completed, after removing tetrahydrofuran, a generated solid material is filtered. The solid material is re-crystallized using dichloromethane and methanol to obtain 2,6-dipyridine-9,10-diphenylanthracene, NC05) (2.0 g, 4.1 mmol, 67%).

[0044] 3) manufacturing of NC10



[0045] Quinoline boric acid (3.5 g, 20.2 mmol) and anhydrous tetrahydrofuran of 60 ml are put into the composed 2,6-dibromo-9,10-diphenylanthracene (3 g, 6.1 mmol) and the resultant solution is agitated. tetrakis(triphenylphosphine)palladium(1.4 g, 1.2 mmol), potassium carbonate (K_2CO_3, 6.3 g, 24.6 mmol), and distilled water of 60 mL are put and the resultant solution is refluxed at 100° C. for 24 hours. When reaction is completed, after removing tetrahydrofuran, a generated solid material is filtered. The solid material is re-crystallized using dichloromethane and methanol to obtain 2,6-diquinoline-9,10-diphenylanthracene, NC10) (2.0 g, 4.3 mmol, 69%).

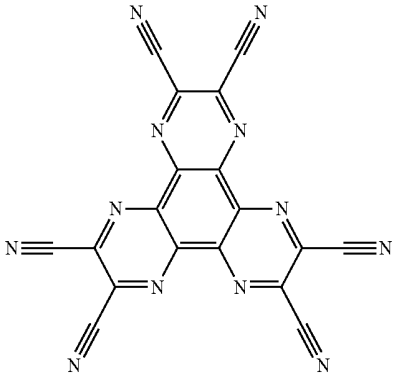
Embodiment

[0046] Hereinafter, an embodiment in which the anthracene compounds represented as NC05 and NC10 manufactured in the above-described composition examples are used as the N-type CGL to manufacture the OLED is disclosed.

Embodiment 1

[0047] After patterning ITO glass so that the emission area of the ITO glass is 2 mm×2 mm, the ITO glass is washed. After mounting a substrate in a vacuum chamber, base pressure is made to be 1×10^{-6} torr. Then, NAT-CN as a hole injection layer is deposited on ITO as an anode to a thickness

of 50 Å. Then, N,N'-diphenyl-N,N'-bis-[4-(phenyl-m-tolylamino)-phenyl-]-biphenyl-4,4'-diamine (DNTPD) of within 10% is doped on 4,4'-bis[N-(1-naphthyl)-N-phenylamino]-biphenyl (NPD) as a hole transport layer and is deposited to a thickness of 1,500 Å. Then, TCTA is continuously deposited to a thickness of 200 Å. Then, a light emitting layer where tBu-Perylene dopant is included in ADN host is formed to a thickness of 250 Å. Then, Alq3 as an electron transport layer is formed to a thickness of 250 Å. Then, Li that is an alkali metal is doped on a material represented as NC05 so that an N-type CGL is formed to a thickness of 100 Å. HAT-CN as a P-type CGL is formed to a thickness of 100 Å. Al as a cathode is formed to a thickness of about 1,000 Å so that an OLED is manufactured.



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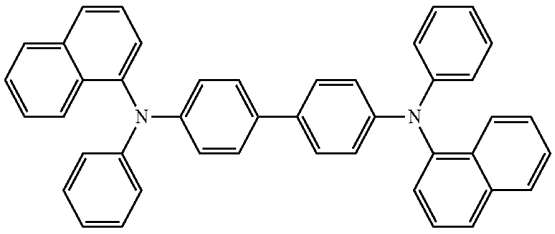

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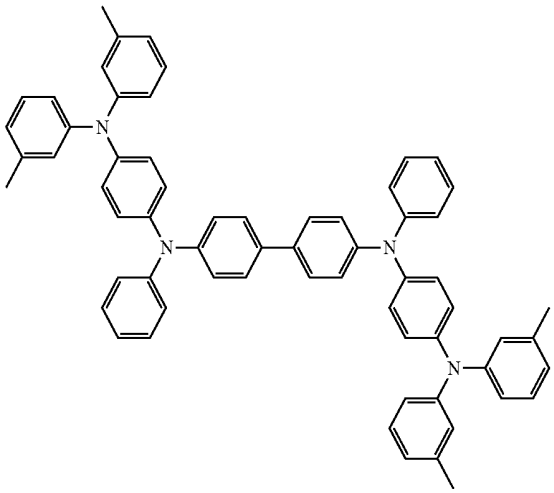

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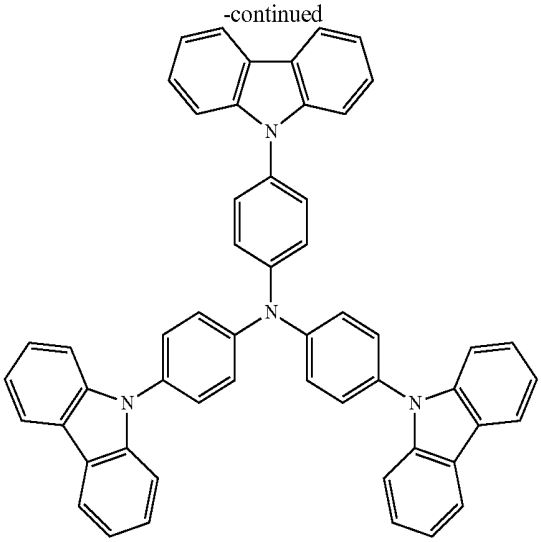

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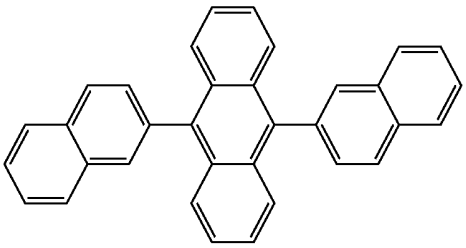

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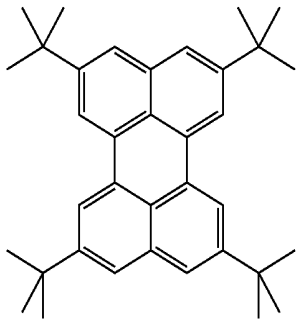
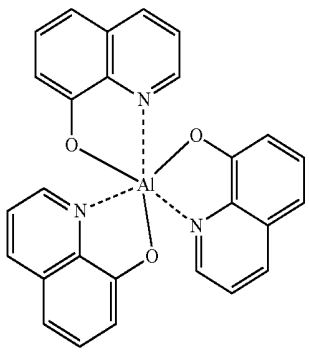


<tBu-Pyrylene>



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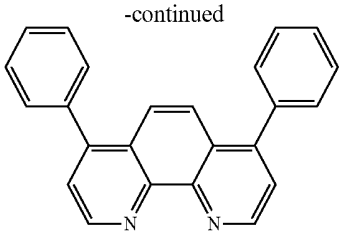


<BPhen>

Embodiment 2

[0048] Under the same condition as the above-described embodiment 1, the compound represented as NC10 is used as the material of an N-type CGL to manufacture an OLED.

COMPARATIVE EXAMPLE

[0049] Under the same condition as the above-described embodiment 1, the following Bphen material is used as the material of an N-type CGL to manufacture an OLED.

[0050] The driving voltages, the current efficiencies, the quantum efficiencies, the color coordinates, and the lives of the OLEDs manufactured in accordance with the above embodiments 1 and 2 and comparative example are measured to be illustrated in the following table 2. In addition, current densities in accordance with the driving voltages are measured to be illustrated in FIG. **2** and brightness reduction ratios in accordance with time are measured to be illustrated in FIG. **3**.

TALBE 2

	Driving voltage	Current efficiency	Quantum efficiency	Color coordinates		Life (T80,
	(V)	(cd/A)	(%)	CIE x	CIE y	hr)
Embodiment 1	5.4	7.2	8.1	0.135	0.101	110
Embodiment 2	6.2	6.5	7.3	0.134	0.102	50
Comparative example	8.3	5.6	5.8	0.134	0.111	43

[0051] As illustrated in the table 1, it is noted that the OLEDs manufactured in accordance with the embodiments 1 and 2 according to the present invention have higher color coordinates than the comparative example and that the driving voltages, the current efficiencies, and the quantum efficiencies of the OLEDs are remarkably improved. In particular, referring to FIG. **2**, the current densities in accordance with the driving voltages are improved and, referring to FIG. **3**, the lives are remarkably increased.

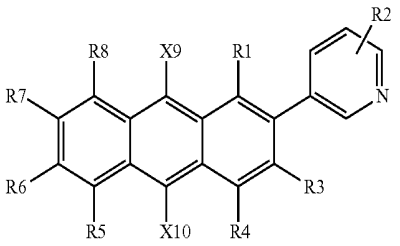
[0052] Therefore, in the anthracene compound according to the embodiment of the present invention and the OLED including the same, a driving voltage, current efficiency, quantum efficiency, color coordinates, and a life are improved in comparison with the conventional OLED.

[0053] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. An anthracene compound represented by formula 1,

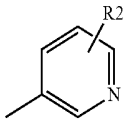
[FORMULA 1]



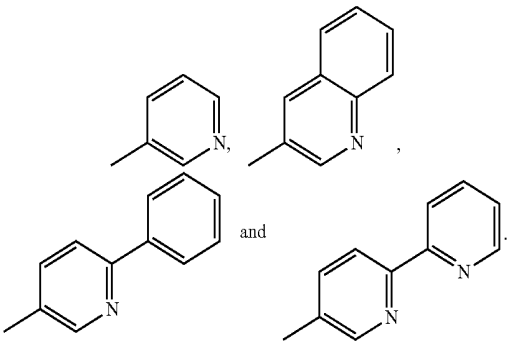
wherein each of R1 to R8 is one selected from the group consisting of a hydrogen-containing alkyl or heteroalkyl group having 1 to 20 carbon atoms, an aryl group having 5 to 20 carbon atoms, and a nitrogen, sulfur, or oxygen-containing heteroaryl group having 4 to 20 carbon atoms, and

wherein each of X9 and X10 is one selected from the group consisting of a nitrogen, sulfur, or oxygen-containing heteroaryl group having 4 to 20 carbon atoms and an aryl group having 6 to 20 carbon atoms.

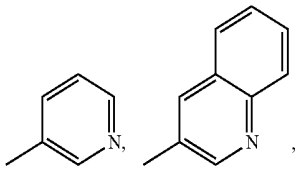
2. The anthracene compound of claim **1**, wherein



is one selected from the group consisting of



3. The anthracene compound of claim **1**, wherein R6 is one selected from the group consisting of hydrogen,



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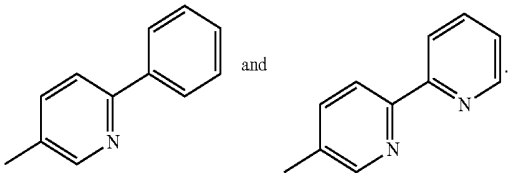

4. An organic light emitting diode (OLED), comprising:

at least two stacks formed between a first electrode and a second electrode; and

a charge generation layer (CGL) including an N-type CGL and a P-type CGL formed between the stacks,

wherein the N-type CGL is formed of the anthracene compound in accordance with anyone of claims **1** to **3**.

5. The OLED of claim **4**, wherein each of the stacks comprises a hole injection layer (HIL) and a hole transport layer (HTL) formed on one side with a light emitting layer interposed and an electron transport layer (ETL) formed on the other side.

6. The OLED of claim **5**, wherein stacks adjacent to the second electrodes among the stacks further comprise electron injection layers (EIL).

7. The OLED of claim **4**, wherein light emitting layers of the stacks emit light components of different colors.

8. The OLED of claim **4**, wherein the N-type CGL is doped with an alkali metal.

* * * * *

专利名称(译)	蒽化合物和包括其的有机发光二极管		
公开(公告)号	US20140061601A1	公开(公告)日	2014-03-06
申请号	US13/726754	申请日	2012-12-26
[标]申请(专利权)人(译)	乐金显示有限公司		
申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
[标]发明人	KIM HYOSEOK SEO JEONGDAE JEON EUNJU KIM SHINHAN		
发明人	KIM, HYOSEOK SEO, JEONGDAE JEON, EUNJU KIM, SHINHAN		
IPC分类号	H01L51/00		
CPC分类号	H01L51/0067 H01L51/0072 C07D401/04 C07D401/10 H01L51/0052 H01L51/0055 H01L51/0059 H01L51/0081 H01L51/5068 H01L51/5088 H01L51/5092 H01L51/5278 H01L2251/308		
优先权	1020120097356 2012-09-03 KR		
其他公开文献	US9276220		
外部链接	Espacenet USPTO		

摘要(译)

公开了一种蒽化合物和包含其的有机发光二极管。有机发光二极管包括：至少两个堆叠，形成在第一电极和第二电极之间;以及电荷产生层（CGL），包括N型CGL和形成在堆叠之间的P型CGL，其中N型CGL由蒽化合物形成。