Abstract:
The present disclosure relates to an organic electroluminescent compound, and a multi-component host material and an organic electroluminescent device comprising the same. By using the organic electroluminescent compound according to the present disclosure, an organic electroluminescent device can have a remarkably improved lifespan, along with low driving voltage and good current and power efficiencies.
Description

Title of Invention: ORGANIC ELECTROLUMINESCENT COMPOUND, AND MULTI-COMPONENT HOST MATERIAL AND ORGANIC ELECTROLUMINESCENT DEVICE COMPRISING THE SAME

Technical Field

The present disclosure relates to an organic electroluminescent compound, and a multi-component host material and an organic electroluminescent device comprising the same.

Background Art

An electroluminescent (EL) device is a self-light-emitting device which has advantages in that it provides a wider viewing angle, a greater contrast ratio, and a faster response time. An organic EL device was first developed by Eastman Kodak, by using small aromatic diamine molecules and aluminum complexes as materials to form a light-emitting layer [Appl. Phys. Lett. 51, 913, 1987].

The most important factor determining luminous efficiency in the organic EL device is light-emitting materials. Until now, fluorescent materials have been widely used as light-emitting materials. However, in view of electroluminescent mechanisms, since phosphorescent materials theoretically enhance luminous efficiency by four (4) times compared to fluorescent materials, phosphorescent light-emitting materials are widely being researched. Iridium(III) complexes have been widely known as phosphorescent materials, including bis(2-(2'-benzothenyl)-pyridinato-N,C3’)iridium(acetylacetonate) ((acac)Ir(btp)2), tris(2-phenylpyridine)iridium (Ir(ppy)3) and bis(4,6-difluorophenylpyrindinato-N,C2)picolinate iridium (Firpic) as red-, green- and blue-emitting materials, respectively.

At present, 4,4’-N,N’-dicarbazol-biphenyl (CBP) is the most widely known host material for phosphorescent materials. Recently, Pioneer (Japan) et al., developed a high performance organic EL device using bathocuproine (BCP) and aluminum(III) bis(2-methyl-8-quinolinate)(4-phenylphenolate) (BAIq) etc., as host materials, which were known as hole blocking materials.

Although conventional materials provide good light-emitting characteristics, they have the following disadvantages: (1) Due to their low glass transition temperature and poor thermal stability, their degradation may occur during a high-temperature deposition process in a vacuum. (2) The power efficiency of the organic EL device is given by [(π/voltage) x current efficiency], and the power efficiency is inversely pro-
portional to the voltage. Although the organic EL device comprising phosphorescent host materials provides higher current efficiency (cd/A) than one comprising fluorescent materials, a significantly high driving voltage is necessary. Thus, there is no merit in terms of power efficiency (lm/W). (3) Furthermore, the operational lifespan of the organic EL device is short, and luminous efficiency is still required to be improved.

Korean Patent Appln. Laying-Open No. 10-2010-0105501 discloses a compound for an organic electroluminescent device, in which one of nitrogen atoms of bis-carbazole is substituted, via phenylene, with quinoxaline. However, it does not disclose a compound in which one of the nitrogen atoms of bis-carbazole is substituted, directly or via a linker, with naphthyridine or a compound in which one of nitrogen atoms of bis-carbazole is substituted, directly or via a heteroarylene, with quinoxaline.

**Disclosure of Invention**

**Technical Problem**

The objective of the present disclosure is to provide an organic electroluminescent compound, which can provide an organic electroluminescent device showing long lifespan, low driving voltage, and good current and power efficiencies, and a multi-component host material and an organic electroluminescent device comprising the same.

**Solution to Problem**

The present inventors found that the above objective can be achieved by an organic electroluminescent compound represented by the following formula 1.

![Chemical Structure](image)

wherein L_i represents a single bond, a substituted or unsubstituted (3- to 30-membered) heteroarylene, or a substituted or unsubstituted (C6-C30) arylene;

X_1 represents -NR_1-, -CR_2R_3-, -O-, or -S-;

X_2 to X_6, each independently, represent -CR_4- or -N-;

Ar_i represents hydrogen, a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (3- to 30-membered) heteroaryl;

with the proviso that when X_2 is -N-, L_i is not the substituted or unsubstituted
(C6-C30)arylene and Ar is not hydrogen;

[16] Y1 to Y4 and Y13 to Y16, each independently, represent -N- or -CR5;

[17] Y5 to Y12, each independently, represent \( \frac{1}{6\text{-}} \), -N-, or -CR6;

[18] R1 to R3, each independently, represent hydrogen, deuterium, a halogen, a substituted or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (3- to 30-membered)heteroaryl, a substituted or unsubstituted (C3-C30)cycloalkyl, or a substituted or unsubstituted (3- to 7-membered)heterocycloalkyl;

[19] R4 to R6, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C3-C30)cycloalkenyl, a substituted or unsubstituted (3- to 7-membered)heterocycloalkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (3- to 30-membered)heteroaryl, or a substituted or unsubstituted di(C6-C30)arylamino; or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (3- to 30-membered), mono- or polycyclic, alicyclic or aromatic ring whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;

[20] the heteroaryl(ene) and the heterocycloalkyl, each independently, contain at least one hetero atom selected from B, N, O, S, P(=0), Si and P; and

[21] a and b, each independently represent 0 or 1.

**Advantageous Effects of Invention**

[23] An organic electroluminescent compound and a multi-component host material of the present disclosure can provide an organic electroluminescent device having low driving voltage, good current and power efficiencies, and remarkably improved lifespan.

**Mode for the Invention**

[25] Hereinafter, the present disclosure will be described in detail. However, the following description is intended to explain the invention, and is not meant in any way to restrict the scope of the invention.

[26] The present disclosure provides the organic electroluminescent compound of formula 1 above, an organic electroluminescent material comprising the same, and an organic electroluminescent device comprising the compound.

[27] The details of the organic electroluminescent compound of formula 1 are as follows.

[28] Herein, "alkyl" includes methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, etc. "Alkenyl" includes vinyl, 1-propenyl, 2-propenyl, 1-butenyl, 2-butenyl,
3-butenyl, 2-methylbut-2-enyl, etc. "Alkynyl" includes ethynyl, 1-propynyl, 2-propynyl, 1-butynyl, 2-butynyl, 3-butynyl, 1-methylpent-2-ynyl, etc. "Cycloalkyl" includes cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, etc. "(3- to 7-membered)heterocycloalkyl" indicates a cycloalkyl having 3 to 7 ring backbone atoms including at least one hetero atom selected from B, N, O, S, P(=O), Si, and P, preferably O, S, and N, and includes tetrahydrofuran, pyrrolidine, thiolan, tetrahydropyran, etc. Furthermore, "aryl(ene)" indicates a monocyclic or fused ring derived from an aromatic hydrocarbon; may be a spiro compound in which two rings are connected via one atom; and includes phenyl, biphenyl, terphenyl, naphthyl, biphenyl, phenynaphthyl, naphthylphenyl, fluorenyl, phenylfluorenyl, benzofluorenyl, dibenzofluorenyl, phenanthrenyl, phenylphenanthrenyl, anthracenyl, indenyl, triphenylenyl, pyrenyl, tetracenyl, perylenyl, chrysencyl, naphthacenyl, fluoranthynyl, spirotetrafluorenyl, etc. "(3- to 30-membered)heteroaryl(ene)" indicates an aryl group having 3 to 30 ring backbone atoms including at least one, preferably 1 to 4, hetero atom selected from the group consisting of B, N, O, S, P(=O), Si, and P; may be a monocyclic ring, or a fused ring condensed with at least one benzene ring; may be partially saturated; may be one formed by linking at least one heteroaryl or aryl group to a heteroaryl group via a single bond(s); and includes a monocyclic ring-type heteroaryl such as furyl, thiophenyl, pyrrolyl, imidazolyl, pyrazolyl, thiazolyl, thiazolyl, isothiazolyl, isoxazolyl, oxazolyl, oxadiazolyl, triazinyl, tetrazinyl, triazolyl, tetrazolyl, furazanyl, pyridyl, pyrazinyl, pyrimidinyl, pyridazinyl, etc., and a fused ring-type heteroaryl such as benzofuranyl, benzothiophenyl, isobenzofuranyl, dibenzofuranyl, dibenzothiophenyl, naphthofuranyl, naphthothiophenyl, benzophenothiophenyl, benzonaphthothiophenyl, benzimidazolyl, benzothiazolyl, benzoisothiazolyl, benzoisoxazolyl, benzoaxazolyl, isoindolyl, indolyl, indazolyl, benzothiadiazolyl, quinolyl, isquinolyl, cinnolinyl, quinazolinyl, quinoxalinyl, carbazolyl, phenoxazinyl, phenanthridinyl, benzodioxolyl, dihydroacridinyl, etc. Furthermore, "halogen" includes F, Cl, Br, and I.

Herein, "substituted" in the expression, "substituted or unsubstituted," means that a hydrogen atom in a certain functional group is replaced with another atom or group, i.e., a substituent. The substituents of the substituted alkyl, the substituted cycloalkyl, the substituted cycloalkenyl, the substituted heterocycloalkyl, the substituted aryl(ene), the substituted heteroaryl(ene), the substituted diarylamino, the substituted alkoxy, and the substituted mono- or polycyclic, alicyclic or aromatic ring in Li, Ar1, R1 to R6, R21 to R37, R31 to R33, R100 to R300, R111 to R127, L4, and M, each independently, are at least one selected from the group consisting of deuterium, a halogen, a cyano, a carboxy, a nitro, a hydroxy, a (C1-C30)alkyl, a halo(C1-C30)alkyl, a (C2-C30)alkenyl, a (C2-C30)alkynyl, a (C1-C30)alkoxy, a (C1-C30)alkythio, a (C3-C30)cycloalkyl, a
(C3-C30)cycloalkenyl, a (3- to 7-membered) heterocycloalkyl, a (C6-C30)aryloxy, a (C6-C30)arylthio, a (3- to 30-membered)heteroaryl unsubstituted or substituted with a (C6-C30)aryl, a (C6-C30)aryl unsubstituted or substituted with a (3- to 30-membered)heteroaryl, a tri(Cl-C30)alkylsilyl, a tri(C6-C30)arylsilyl, a di(Cl-C30)alkyl(C6-C30)arylsilyl, a (C1-C30)alkyl(di(C6-C30)arylsilyl, an amino, a mono- or di-(Cl-C30)alkylamino, a mono- or di-(C6-C30)arylamino, a (Cl-C30)alkyl(C6-C30)arylamino, a (Cl-C30)alkylcarbonyl, a (Cl-C30)alkoxy carbonyl, a (C6-C30)arylcarbonyl, a di(C6-C30)arylcarnbonyl, a di(Cl-C30)alkylboronyl, a (Cl-C30)alkyl(C6-C30)arylsilyl, a (Cl-C30)alkyl(C6-C30)aryl and a (Cl-C30)alkyl(C6-C30)aryl; and preferably, each independently, are at least one selected from the group consisting of a cyano, a halogen, a (Cl-C10)alkyl, a (C3-C12)cycloalkyl, a (C5-C18)aryl, a (5- to 18-membered)heteroaryl, a di(C6-C12)arylamino, and a (Cl-C10)alkyl(C5-C18)aryl.

[30] Li represents a single bond, a substituted or unsubstituted (3- to 30-membered)heteroarylene, or a substituted or unsubstituted (C6-C30)arylene. Preferably, Li may represent a single bond, a substituted or unsubstituted (5- to 21-membered)heteroarylene, or a substituted or unsubstituted (C6-C21)arylene. Specifically, Li may represent a single bond.

[31] X i represents -NR 1-, -CR 2R 3-, -O-, or -S-. Specifically, X i may represent -NR 1-.

[32] X 2 to X 6, each independently, represent -CR 4-, or -N-. Preferably, all of X 2 to X 6 may represent -CR 4-; or one of X 2 to X 6 may represent -N-, and the remainders of X 2 to X 6 may represent -CR 4-. When X 2 represents -N-, Li is not a substituted or unsubstituted (C6-C30)arylene, and Ar 1 is not hydrogen. Specifically, when X 2 represents -N-, Li may represent a single bond.

[33] Ar 1 represents hydrogen, a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (3- to 30-membered)heteroaryl. Ar 1 may represent, preferably hydrogen, or a substituted or unsubstituted (C6-C21)aryl; and more preferably hydrogen, or a (C6-C18)aryl unsubstituted or substituted with a (Cl-C10)alkyl, a cyano, a (C6-C13)aryl or a (5- to 13-membered)heteroaryl. Specifically, Ar 1 may represent hydrogen, a substituted or unsubstituted phenyl, a substituted or unsubstituted naphthyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted anthracenyl, a substituted or unsubstituted phenanthrenyl, a substituted or unsubstituted phenyl-naphthyl, or a substituted or unsubstituted naphthylphenyl. More specifically, Ar 1 may represent hydrogen; or a phenyl, biphenyl, naphthyl, terphenyl, anthracenyl, phenanthrenyl, phenyl-naphthyl, or naphthylphenyl unsubstituted or substituted with a (Cl-C4)alkyl, a cyano, or a pyridyl. Preferably, when Ar 1 represents hydrogen, at least one of X 2 to X 6 may represent -CR 4- wherein R 4 represents a substituted or unsubstituted (C6-C30)aryl, or a substituted or
unsubstituted (3- to 30-membered) heteroaryl. More preferably, when \( A \) represents
hydrogen, at least one of \( X_2 \) to \( X_6 \) may represent \(-CR_4^5\) wherein \( R_4 \) represents a sub-
stituted or unsubstituted (C6-C21)aryl, or a substituted or unsubstituted (5- to
21-membered)heteroaryl; and even more preferably, one of \( X_2 \) to \( X_6 \) may represent
\(-CR_4^5\) wherein \( R_4 \) represents a substituted or unsubstituted (C6-C18)aryl.

\[ Y_1 \) to \( Y_4 \) and \( Y_{13} \) to \( Y_{16} \) each independently, represent \(-N^\bullet \) or \(-CR_5^6\); and preferably
\(-CR_5^6\). Specifically, \( Y_1 \) to \( Y_4 \) may represent \(-CH_\text{-}; or one of \( Y_1 \) to \( Y_4 \) may represent \(-CR
5\) (wherein \( R_5 \) is not hydrogen), the remainders of \( Y_1 \) to \( Y_4 \) may represent \(-CH_\text{-}; or two
of \( Y_1 \) to \( Y_4 \) may represent \(-CH_\text{-}, the remainders of \( Y_1 \) to \( Y_4 \) may represent \(-CR_5^6\)
(wherein \( R_5 \) is not hydrogen). Specifically, \( Y_{13} \) to \( Y_{16} \) may represent \(-CH_\text{-}; or one of \( Y
_{13} \) to \( Y_{16} \) may represent \(-CR_5^6\) (wherein \( R_5 \) is not hydrogen), the remainders of \( Y_{13} \) to \( Y
_{16} \) may represent \(-CH_\text{-}; or two of \( Y_{13} \) to \( Y_{16} \) may represent \(-CH_\text{-}, the remainders of \( Y_{13} \)
to \( Y_{16} \) may represent \(-CR_5^6\) (wherein \( R_5 \) is not hydrogen).

\[ Y_5 \) to \( Y_{12} \), each independently, represent \(-\text{C}^\bullet\), \(-N^\bullet\), or \(-CR_6^7\). Preferably, \( Y_5 \) to \( Y_{12} \),
each independently, represent \(-\text{C}^\bullet\) or \(-CR_6^7\). Specifically, one of \( Y_5 \) to \( Y_8 \) may
represent \(-\text{C}^\bullet\), the remainders of \( Y_5 \) to \( Y_8 \) may represent \(-CH_\text{-}. Specifically, one of \( Y_9 
to \( Y_{12} \) may represent \(-\text{C}^\bullet\), the remainders of \( Y_9 \) to \( Y_{12} \) may represent \(-CH_\text{-}; or one of
\( Y_9 \) to \( Y_{12} \) may represent \(-\text{C}^\bullet\), the two of \( Y_9 \) to \( Y_{12} \) may represent \(-CR_6^7\) (wherein \( R_6 \) is
not hydrogen), the remainder may represent \(-CH_\text{-}.

\[ R_i \) to \( R_3 \), each independently, represent hydrogen, deuterium, a halogen, a substituted
or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted (C6-C30)aryl, a sub-
stituted or unsubstituted (3- to 30-membered) heteroaryl, a substituted or unsubstituted
(C3-C30)cycloalkyl, or a substituted or unsubstituted (3- to 7-membered)heterocycloalkyl. \( R_i \) to \( R_3 \), each independently, may represent preferably
a substituted or unsubstituted (Cl-C20)alkyl, a substituted or unsubstituted
(C6-C21)aryl, a substituted or unsubstituted (5- to 21-membered) heteroaryl, a sub-
stituted or unsubstituted (C5-C21)cycloalkyl, or a substituted or unsubstituted (5- to
7-membered)heterocycloalkyl; more preferably a substituted or unsubstituted
(Cl-C1O)alkyl, or a substituted or unsubstituted (C6-C18)aryl; and even more
preferably, an unsubstituted (Cl-C1O)alkyl or an unsubstituted (C6-C18)aryl.
Preferably, \( R_2 \) and \( R_3 \) are the same. Specifically, \( R_i \) may represent phenyl, biphenyl, or
naphthyl; \( R_2 \) may represent a (Cl-C4)alkyl or phenyl; and \( R_3 \) may represent a
(C1-C4)alkyl or phenyl.

\[ R_4 \) to \( R_6 \), each independently, represent hydrogen, deuterium, a halogen, a cyano, a
substituted or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted
(C3-C30)cycloalkyl, a substituted or unsubstituted (C3-C30)cycloalkeny1, a substituted or unsubstituted (3- to 7-membered) heterocycloalkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (3- to 30-membered) heteroaryl, or a substituted or unsubstituted di(C6-C30)arylamino; or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (3- to 30-membered), mono- or polycyclic, alicyclic or aromatic ring whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur. R_4 to R_6, each independently, represent preferably, hydrogen, a halogen, a cyano, a substituted or unsubstituted (C6-C21)aryl, a substituted or unsubstituted (C5-C21)cycloalkyl, a substituted or unsubstituted (C6-C21)ary1, a substituted or unsubstituted (5- to 21-membered) heteroaryl, or a substituted or unsubstituted di(C6-C21)arylamino; or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (5- to 21-membered), mono- or polycyclic aromatic ring whose carbon atom(s) may be replaced with one or two hetero atoms selected from nitrogen, oxygen, and sulfur.

More preferably, R_4 represents hydrogen, or a substituted or unsubstituted (C6-C18)aryl. Specifically, R_4 may represent hydrogen, a substituted or unsubstituted phenyl, a substituted or unsubstituted naphthyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted anthracenyl, a substituted or unsubstituted phenanthrenyl, a substituted or unsubstituted phenyl-naphthyl, or a substituted or unsubstituted naphthylphenyl. More preferably, R_5 and R_6 represent hydrogen, a cyano, a substituted or unsubstituted (Cl-C10)alkyl, a substituted or unsubstituted (C5-C18)cycloalkyl, a substituted or unsubstituted (C6-C18)aryl, or a substituted or unsubstituted di(C6-C18)arylamino; or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (5- to 18-membered), mono- or polycyclic aromatic ring whose carbon atom(s) may be replaced with a hetero atom(s) selected from nitrogen, oxygen, and sulfur. Specifically, R_5 and R_6, each independently, may represent hydrogen, a cyano, a (Cl-C4)alkyl, phenyl, cyclohexyl, or di(phenyl)amino, or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted thiophene ring, a substituted or unsubstituted benzene ring, a substituted or unsubstituted indole ring, a substituted or unsubstituted indene ring, a substituted or unsubstituted naphthalene ring, a substituted or unsubstituted benzothiophene ring, a substituted or unsubstituted benzofuran ring, or a substituted or unsubstituted benzindole ring.

According to one embodiment of the present disclosure, Li represents a single bond, a substituted or unsubstituted (5- to 21-membered) heteroarylene, or a substituted or unsubstituted (C6-C21)arylene; X_i represents -NR_1, -CR_2R_3, -O-, or -S-, all of X_2 to X_6 represent -CR_4-, or one of X_2 to X_6 represents -N-, and the remainders of X_2 to X_6
represent -CR₄⁻, wherein when X₂ is -N-, L i i s a single bond; Ari represents hydrogen, or a substituted or unsubstituted (C6-C21)aryl, wherein when Ari is hydrogen, at least one of R₄ is a substituted or unsubstituted (C6-C21)aryl or a substituted or unsubstituted (5- to 21-membered)heteroaryl; Y₁ to Y₄ and Y₁₃ to Y₁₆, each independently, represent -CR₅⁻; Y₅ to Y₁₂, each independently, represent -CR₆⁻; Rᵢ to R₃, each independently, represent a substituted or unsubstituted (C1-C20)alkyl, a substituted or unsubstituted (C6-C21)aryl, a substituted or unsubstituted (5- to 21-membered)heteroaryl, a substituted or unsubstituted (C5-C21)cycloalkyl, or a substituted or unsubstituted (5- to 7-membered)heterocycloalkyl; R₄ to R₆, each independently, represent hydrogen, a halogen, a cyano, a substituted or unsubstituted (Cl-C20)alkyl, a substituted or unsubstituted (C5-C21)cycloalkyl, a substituted or unsubstituted (C6-C21)aryl, a substituted or unsubstituted (5- to 21-membered)heteroaryl, or a substituted or unsubstituted di(C6-C21)arylamino, or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (5- to 21-membered), mono- or polycyclic, aromatic ring whose carbon atom(s) may be replaced with one or two hetero atom(s) selected from nitrogen, oxygen, and sulfur; the heterocycloalkyl and the heteroaryl(ene) and the heterocycloalkyl, each independently, contain at least one hetero atom selected from N, O and S; and a and b, each independently represent 0 or 1.

[39] According to another embodiment of the present disclosure, the compound of formula 1 may be represented by the following formula 2:

![Chemical Structure](image)

(2)

[41] wherein, X₁, Aᵣᵣ₁, Yᵢ to Yᵢ₆, R₄, L₁, a, and b are as defined in formula 1 above; c represents an integer of 1 to 4; and when c is 2 or more, each of R₄ may be the same or different. Preferably, in formula 2, Lᵢ represents a single bond; Ari represents a substituted or unsubstituted (C6-C21)aryl, or a substituted or unsubstituted (5- to 21-membered)heteroaryl, and R₄ represents hydrogen.

[42] According to another embodiment of the present disclosure, the compound of formula 1 may be represented by any one of the following formulae 3 to 5:
wherein, $X_l A_r_1$ to $Y_1$, $L_1$, $R_4$, $a$, and $b$ are as defined in formula 1; $c$ represents an integer of 1 to 5; and when $c$ is 2 or more, each of $R_4$ is the same or different. In formulae 3 to 5, preferably, when $A_r_1$ is hydrogen, at least one of $R_4$ represents a substituted or unsubstituted (C6-C21)aryl, or a substituted or unsubstituted (5- to 21-membered)heteroaryl. More preferably, $A_r_1$ represents hydrogen; one of $R_4$ represents a substituted or unsubstituted (C6-C18)aryl, and the remainders of $R_4$ represent hydrogen.

More specifically, the organic electroluminescent compound of the present disclosure includes the following, but is not limited thereto:


[59] H-73 H-74 H-75 H-76 H-77 H-78

[60] H-79 H-80 H-81 H-82 H-83 H-84

[61] H-85 H-86 H-87 H-88 H-89 H-90


The organic electroluminescent compound of formula 1 of the present disclosure can be prepared by a synthetic method known to one skilled in the art. For example, it can be prepared according to any one of the following reaction schemes 1 to 4.

[Reaction Scheme 1]

[Reaction Scheme 2]

[Reaction Scheme 3]
In addition, the present disclosure provides an organic electroluminescent material comprising the organic electroluminescent compound of formula 1, and an organic electroluminescent device comprising the material.

The material may comprise one or more compounds selected from the organic electroluminescent compound of formula 1. The material may further comprise a conventional compound(s) which has been comprised for an organic electroluminescent material.

The organic electroluminescent device of the present disclosure may comprise a first electrode, a second electrode, and at least one organic layer disposed between the first and second electrodes, wherein the organic layer may comprise at least one compound of formula 1.

One of the first and second electrodes may be an anode, and the other may be a cathode. The organic layer may comprise a light-emitting layer, and may further comprise at least one layer selected from a hole injection layer, a hole transport layer, an electron transport layer, an electron injection layer, an interlayer, a hole blocking layer, an electron buffer layer, and an electron blocking layer.

The organic electroluminescent compound of the present disclosure may be comprised in the light-emitting layer. When used in the light-emitting layer, the organic electroluminescent compound of the present disclosure may be comprised as a host material. The light-emitting layer may further comprise at least one dopant. If necessary, the light-emitting layer may comprise two or more compounds selected from the organic electroluminescent compound of formula 1 of the present disclosure; or may further comprise a second host material other than the organic electroluminescent compound of formula 1 of the present disclosure.

A phosphorescent host material known in the art may be used as the second host material. The compound selected from the group consisting of the compounds of formulae 6 to 11 below is preferable as the second host material in view of driving voltage, lifespan, and luminous efficiency.

\[ H-(\text{Cz-L}_4)_nM \] (6) \[ H-(\text{Cz})_pL_4-M \] (7)
wherein, $C_z$ represents the following structure:

$L_4$ and $L_5$, each independently, represent a single bond, a substituted or unsubstituted (C6-C30)arylene, or a substituted or unsubstituted (5- to 30-membered)heteroarylene;

$M$ represents a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (5- to 30-membered)heteroaryl, provided that when $h$ of formula 6 is 1, or $i$ of formula 7 is 1, $M$ is not

and $M$ of formulae 8 and 9 are not

(wherin $X_2$ to $X_6$ and $A_1$ are as defined in formula 1, and * represents a bonding site.);

$Z_1$ and $Z_2$, each independently, represent -O-, -S-, -N($R_3$i)-, or -C($R_3$2)($R_3$3)-, provided that $Z_1$ and $Z_2$ do not simultaneously exist;

$X'$ represents -O- or -S-;

ring $A$ represents

ring $B$ represents

$D$ and $E$, each independently, represent -O-, -S-, -N($R_3$4)-, or -C($R_3$5)($R_3$6)-;

$A_{r2}$ represents a substituted or unsubstituted (3- to 30-membered)heteroaryl, or a sub-
(wherein \(X_2\) to \(X_6\) and \(A_{rt}\) are as defined in formula 1, and \(*\) represents a bonding site.);

\[ R_1, R_2; \text{each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (5- to 30-membered)heteroaryl, or } R_{28}R_{29}R_{30}; \text{ or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), monocyclic or polycyclic, alicyclic or aromatic ring whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur; provided that when } h \text{ of formula 6 or } i \text{ of formula 7 is 1, } R_{26} \text{ or } R_{27} \text{ does not form the ring containing } Z_1, Z_2, D, \text{ or } E \text{ of formulae 8, 9, and 11, } R_{22} \text{ of formula 10 does not form the indole ring connected to } R_1 \text{ of formulae 8 and 9 and the indole ring connected to } R_{23} \text{ of formula 11; }

\[ R_{28} \text{ to } R_{30}; \text{ each independently, represent a substituted or unsubstituted (Cl-C30)alkyl, or a substituted or unsubstituted (C6-C30)aryl; }

\[ R_{1} \text{ to } R_{36}; \text{ each independently, represent hydrogen, a substituted or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (5- to 30-membered)heteroaryl; } R_{32} \text{ and } R_{33} \text{ may be the same or different; } R_{35} \text{ and } R_{36} \text{ may be the same or different; }

\[ \text{the heteroaryl(ene) contains one or more hetero atoms selected from B, N, O, S, P(=0), Si, and P; }

\[ h \text{ and } i, \text{ each independently, represent an integer of 1 to 3; } j, k, l \text{ and } p, \text{ each independently, represent an integer of 0 to 4; } r, s \text{ and } t, \text{ each independently, represent an integer of 1 to 4; and when } h, i, j, k, l, p, r, s, \text{ or } t \text{ is an integer of 2 or more, each of } (Cz-L_{1}^4), \text{ each of } (Cz), \text{ each of } R_{21}, \text{ each of } R_{22}, \text{ each of } R_{23}, \text{ each of } R_{24}, \text{ each of } R_{25}, \text{ each of } R_{26}, \text{ or each of } R_{27}; \text{ may be the same or different. }

\[ \text{Preferably, in formulae 6 to 10, } M \text{ may represent a substituted or unsubstituted nitrogen-containing (6- to 20-membered)heteroaryl. Preferably, the substituent of } M \text{ may be a (Cl-C20)alkyl; a (C6-C24)aryl unsubstituted or substituted with a (Cl-CIO)alkyl, a tri(C6-C13)arylsilyl, or a (6- to 13-membered)heteroaryl; a (6- to 20-membered)heteroaryl unsubstituted or substituted with a (Cl-CIO)alkyl, a tri(C6-C13)arylsilyl, or a (C6-C24)aryl; or a tri(C6-C20)arylsilyl. Specifically, } M \text{ may represent a substituted or unsubstituted pyridyl, a substituted or unsubstituted pyrimidinyl, a substituted or unsubstituted triazinyl, a substituted or unsubstituted pyrazinyl, a substituted or unsubstituted quinazolinyl, or a substituted or unsubstituted }
phenanthrolinyl.

At least one of $R_{26}$ and $R_{27}$ of formulae 6 and 7, or at least one of $R_{21}$ and $R_{22}$ of formulae 8 to 10 may be a substituted or unsubstituted carbazolyl, a substituted or unsubstituted benzocarbazolyl, a substituted or unsubstituted dibenzothiophenyl, a substituted or unsubstituted naphthobenzothiophenyl, a substituted or unsubstituted dibenzofuranyl, a substituted or unsubstituted naphthobenzofuranyl, a (C6-C18)aryl substituted with a substituted or unsubstituted carbazolyl, a (C6-C18)aryl substituted with a substituted or unsubstituted benzocarbazolyl, a (C6-C18)aryl substituted with a substituted or unsubstituted dibenzothiophenyl, a (C6-C18)aryl substituted with a substituted or unsubstituted naphthobenzothiophenyl, a (C6-C18)aryl substituted with a substituted or unsubstituted dibenzofuranyl, or a (C6-C18)aryl substituted with a substituted or unsubstituted naphthobenzofuranyl. When M is aryl, at least one of $R_{26}$ and $R_{27}$, or at least one of $R_{21}$ and $R_{22}$ may represent a substituted or unsubstituted nitrogen-containing (6- to 20-membered)heteroaryl; or may have, as a substituent, a substituted or unsubstituted nitrogen-containing (6- to 20-membered)heteroaryl. Specifically, the substituted or unsubstituted nitrogen-containing heteroaryl may represent a substituted or unsubstituted pyridyl, a substituted or unsubstituted pyrimidinyl, a substituted or unsubstituted triazinyl, a substituted or unsubstituted pyrazinyl, a substituted or unsubstituted quinazolinyl, or a substituted or unsubstituted phenanthrolinyl.

D and E, each independently, may be preferably selected from -O-, -S-, and -N(R$_{34}$)-, provided that both X and Y are not -N(R$_{34}$)-, simultaneously. According to one embodiment of the present disclosure, X and Y, each independently, may be selected from -O- and -S-. According to another embodiment of the present disclosure, X and Y, each independently, may be selected from -O- and -S-; and at least one of X and Y may be -S-. R$_{34}$ may represent preferably, a substituted or unsubstituted (C6-C30)aryl, and specifically, a substituted or unsubstituted phenyl, a substituted or unsubstituted naphthyl, or a substituted or unsubstituted biphenyl.

Ar$_2$ may represent preferably, a substituted or unsubstituted (6- to 20-membered)heteroaryl, or a substituted or unsubstituted (C6-C20)aryl; and more preferably a substituted or unsubstituted nitrogen-containing (6- to 20-membered)heteroaryl. Specifically, Ar$_2$ may represent a substituted or unsubstituted triazinyl, a substituted or unsubstituted pyrimidinyl, a substituted or unsubstituted pyridyl, a substituted or unsubstituted pyrazinyl, a substituted or unsubstituted quinazolinyl, or a substituted or unsubstituted phenanthrolinyl.

Specifically, the preferable example of the second host material includes the following, but is not limited thereto:
[118]  

![Chemical structures](attachment:image.png)

[119]  

![Chemical structures](attachment:image.png)

[120]  [Wherein, TPS represents triphenylsilyl.]

[121]  The dopant is preferably at least one phosphorescent dopant. The phosphorescent dopant material for the organic electroluminescent device of the present disclosure is not limited, but may be preferably selected from metallated complex compounds of iridium (Ir), osmium (Os), copper (Cu) or platinum (Pt), more preferably selected from ortho-metallated complex compounds of iridium (Ir), osmium (Os), copper (Cu) or platinum (Pt), and even more preferably ortho-metallated iridium complex compounds.

[122]  The dopant to be comprised in the organic electroluminescent device of the present disclosure may be selected from the group consisting of compounds represented by the following formulae 12 to 14.

[123]  

![Chemical structures](attachment:image.png)

[124]  

![Chemical structures](attachment:image.png)

[125]  wherein L is selected from the following structures:
[126]

[127] \( R_{10} \) represents hydrogen, a substituted or unsubstituted (Cl-C30)alkyl, or a substituted or unsubstituted (C3-C30)cycloalkyl; \( R_{10i} \) to \( R_{109} \) and \( R_{111} \) to \( R_{123} \), each independently, represent hydrogen, deuterium, a halogen, a (Cl-C30)alkyl unsubstituted or substituted with a halogen, a substituted or unsubstituted (C3-C30)cycloalkyl, a cyano, a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (Cl-C30)alkoxy; \( R_{1j/6} \) to \( R_{109} \) may be linked to an adjacent substituent(s) to form a substituted or unsubstituted fused ring, for example, a substituted or unsubstituted fluorene, a substituted or unsubstituted dibenzothiophene, or a substituted or unsubstituted dibenzofuran; \( R_{120} \) to \( R_{123} \) may be linked to an adjacent substituent(s) to form a substituted or unsubstituted fused ring, for example, a substituted or unsubstituted quinoline; \( R_{124} \) to \( R_{127} \), each independently, represent hydrogen, deuterium, a halogen, a substituted or unsubstituted (Cl-C30)alkyl, or a substituted or unsubstituted (C6-C30)aryl; when any one of \( R_{124} \) to \( R_{127} \) is aryl, it may be linked to an adjacent substituent(s) to form a substituted or unsubstituted fused ring, for example, a substituted or unsubstituted fluorene, a substituted or unsubstituted dibenzothiophene, or a substituted or unsubstituted dibenzofuran; \( R_{201} \) to \( R_{211} \), each independently, represent hydrogen, deuterium, a halogen, a (Cl-C30)alkyl unsubstituted or substituted with a halogen, a substituted or unsubstituted (C3-C30)cycloalkyl, or a substituted or unsubstituted (C6-C30)aryl, \( R_{204} \) to \( R_{211} \), may be linked to an adjacent substituent(s) to form a substituted or unsubstituted fused ring, for example, a substituted or unsubstituted fluorene, a substituted or unsubstituted dibenzothiophene, or a substituted or unsubstituted dibenzofuran; \( f \) and \( g \), each independently, represent an integer of 1 to 3; when \( f \) or \( g \) is an integer of 2 or more, each of \( R_{100} \) may be the same or different; and \( n \) represents an integer of 1 to 3.

[128] Specifically, the dopant material includes the following:

[129]
According to another aspect of the present disclosure, a material for preparing a
organic electroluminescent device is provided. The material may be a material for preparing a light-emitting layer or an electron transport layer of an organic electroluminescent device. When the compound of the present disclosure is comprised in the material for preparing a light-emitting layer of an organic electroluminescent device, the compound of the present disclosure may be comprised as a host material. When the compound of the present disclosure is comprised as a host material, the material may comprise two or more compounds selected from the organic electroluminescent compound of formula 1 of the present disclosure; or may comprise, in addition to an organic electroluminescent compound of formula 1 of the present disclosure (a first host material), a second host material, for example, a material selected from the compound represented by formulae 6 to 11. The weight ratio between the first host material and the second host material is in the range of 1:99 to 99:1, and preferably 30:70 to 70:30 in view of driving voltage, lifespan, and luminous efficiency. When the compound of the present disclosure is comprised in the material for preparing an electron transport layer of an organic electroluminescent device, the compound of the present disclosure may be comprised as an electron transport material. The material may be a composition or a mixture. The material may further comprise a conventional compound(s) which has been comprised for an organic electroluminescent material.

According to another aspect of the present disclosure, an organic electroluminescent device comprising a first electrode, a second electrode, and at least one organic layer disposed between the first and second electrodes, wherein the organic layer comprises the material of the present disclosure for preparing an organic electroluminescent device, is provided.

According to another aspect of the present disclosure, an organic electroluminescent device comprising an anode, a cathode, and an organic layer disposed between the anode and cathode, wherein the organic layer comprises one or more light-emitting layers; at least one light-emitting layer comprises one or more dopant compounds and two or more host compounds; and at least one of the two or more host compounds is represented by formula 1 is provided.

According to one embodiment of the present disclosure, in the organic electroluminescent device, a first host compound of the two or more host compounds may be selected from the compound represented by formulae 2 and 5.

According to another embodiment of the present disclosure, in the organic electroluminescent device, at least two of the two or more host compounds, each independently, may be selected from the compound represented by formula 1.

According to another embodiment of the present disclosure, in the organic electroluminescent device, a first host compound of the two or more host compounds may be represented by formula 1, and a second host compound may be selected from the
compound represented by formulae 6 to 11.

According to another embodiment of the present disclosure, in the organic electroluminescent device, the one or more dopant compounds may be selected from the compound represented by formulae 12 to 14.

The organic electroluminescent device of the present disclosure comprises the compound of formula 1 in the organic layer. The organic electroluminescent device of the present disclosure may further comprise at least one compound selected from the group consisting of arylamine-based compounds and styrylarylamine-based compounds.

In the organic electroluminescent device of the present disclosure, the organic layer may further comprise, in addition to the compound of formula 1, at least one metal selected from the group consisting of metals of Group 1, metals of Group 2, transition metals of the 4th period, transition metals of the 5th period, lanthanides and organic metals of the d-transition elements of the Periodic Table, or at least one complex compound comprising the metal.

In addition, the organic electroluminescent device of the present disclosure may emit white light by further comprising at least one light-emitting layer, which comprises a blue electroluminescent compound, a red electroluminescent compound or a green electroluminescent compound known in the field, besides the compound of the present disclosure. If necessary, it may further comprise an orange light-emitting layer or a yellow light-emitting layer.

In the organic electroluminescent device of the present disclosure, preferably, at least one layer (hereinafter, "a surface layer") may be placed on an inner surface(s) of one or both electrode(s), selected from a chalcogenide layer, a metal halide layer and a metal oxide layer. Specifically, a chalcogenide (includes oxides) layer of silicon or aluminum is preferably placed on an anode surface of an electroluminescent medium layer, and a metal halide layer or a metal oxide layer is preferably placed on a cathode surface of an electroluminescent medium layer. Such a surface layer provides operation stability for the organic electroluminescent device. Preferably, the chalcogenide includes SiO$_x$ (1<X<2), AlO$_x$(1≤X<1.5), SiON, SiAlON, etc.; the metal halide includes LiF, MgF$_2$, CaF$_2$, a rare earth metal fluoride, etc.; and the metal oxide includes Cs$_2$O , Li$_2$O , MgO, SrO, BaO, CaO, etc.

In the organic electroluminescent device of the present disclosure, a mixed region of an electron transport compound and a reductive dopant, or a mixed region of a hole transport compound and an oxidative dopant may be placed on at least one surface of a pair of electrodes. In this case, the electron transport compound is reduced to an anion, and thus it becomes easier to inject and transport electrons from the mixed region to an electroluminescent medium. Furthermore, the hole transport compound is oxidized to a
cation, and thus it becomes easier to inject and transport holes from the mixed region to the electroluminescent medium. Preferably, the oxidative dopant includes various Lewis acids and acceptor compounds, and the reductive dopant includes alkali metals, alkali metal compounds, alkaline earth metals, rare-earth metals, and mixtures thereof. A reductive dopant layer may be employed as a charge generating layer to prepare an electroluminescent device having two or more light-emitting layers and emitting white light.

In order to form each layer of the organic electroluminescent device of the present disclosure, dry film-forming methods such as vacuum evaporation, sputtering, plasma and ion plating methods, or wet film-forming methods such as inkjet printing, nozzle printing, slot coating, spin coating, dip coating, and flow coating methods can be used.

When using a wet film-forming method, a thin film can be formed by dissolving or diffusing materials forming each layer into any suitable solvent such as ethanol, chloroform, tetrahydrofuran, dioxane, etc. The solvent can be any solvent where the materials forming each layer can be dissolved or diffused, and where there are no problems in film-formation capability.

In the organic electroluminescent device of the present disclosure, two or more host compounds for a light-emitting layer may be co-evaporated or mixture-evaporated. Herein, a co-evaporation indicates a process for two or more materials to be deposited as a mixture, by introducing each of the two or more materials into respective crucible cells, and applying electric current to the cells for each of the materials to be evaporated. Herein, a mixture-evaporation indicates a process for two or more materials to be deposited as a mixture, by mixing the two or more materials in one crucible cell before the deposition, and applying electric current to the cell for the mixture to be evaporated.

By using the organic electroluminescent device of the present disclosure, a display system or a lighting system can be produced.

Hereinafter, the organic electroluminescent compound of the present disclosure, the preparation method of the compound, and the luminescent properties of the device will be explained in detail with reference to the following examples.

[Example 1]
Preparation of compound 1-2

After adding compound 1-1 (20 g, 100.5 mmol), compound 2-1 (19 g, 150 mmol), palladium(O) tetrakis(triphenylphosphine) [Pd(PPh₃)₄] (5.7 g, 5.0 mmol), and Na₂C₀₃ (31 g, 300 mmol) to toluene (500 mL), ethanol (250 mL), and purified water 250 mL, the mixture was stirred at 120°C for 15 hours. After the completion of the reaction, the mixture was standed to remove the water layer, and the organic layer was then concentrated. The mixture was purified by column chromatography to obtain compound 1-2 (20 g, 83%).

Preparation of compound H-1

After dissolving compound 1-2 (20 g, 83 mmol), compound 1-3 (50 g, 99 mmol), and NaH (4 g, 166 mmol) into dimethylformamide (DMF), the mixture was then stirred for 15 hours. After the completion of the reaction, the solid was filtered, and purified by column chromatography to obtain compound H-1 (50 g, 82%).

Example 2

Preparation of compound 1-4

After dissolving compound 1-3 (30 g, 73.44 mmol) in dimethylformamide (370 mL), sodium hydride (4.4 g, 110.16 mmol) was slowly added to the mixture, and the mixture was then stirred for 30 minutes. Compound 1-1 (17.5 g, 88.13 mmol) was added to the mixture, and the mixture was then stirred for 4 hours. After slowly adding the mixture to distilled water (500 mL), the mixture was stirred for 30 minutes. The obtained solid was purified by column chromatography and recrystallization to obtain compound 1-4 (30 g, 71%).

Preparation of compound H-5

After introducing compound 1-4 (10 g, 17.51 mmol), compound 2-2 (4.2 g, 21.01 mmol)...
mmol), palladium(O) tetrakis(triphenylphosphine) \([\text{Pd}(\text{PPh}_3)_4]\) (0.6g, 0.53 mmol), sodium carbonate (4.6g, 43.78 mmol), toluene (90mL), and ethanol (22mL) into a reaction vessel, distilled water (22mL) was added to the mixture. The mixture was stirred at 120°C for 4 hours. After the completion of the reaction, the mixture was washed with distilled water, and extracted with ethyl acetate. The obtained organic layer was dried with magnesium sulfate, and the solvent was removed therefrom by a rotary evaporator. The products were purified by column chromatography to obtain compound H-5 (5.5g, 46%).

[Example 3]

Preparation of compound H-80

After introducing compound 1-4 (10g, 17.51 mmol), compound 2-3 (4.2g, 21.01 mmol), palladium(O) tetrakis(triphenylphosphine) \([\text{Pd}(\text{PPh}_3)_4]\) (0.6g, 0.53 mmol), sodium carbonate (4.6g, 43.78 mmol), toluene (90mL), and ethanol (22mL) into a reaction vessel, distilled water (22mL) was added to the mixture, and the mixture was then stirred at 120°C for 4 hours. After the completion of the reaction, the mixture was washed with distilled water, and extracted with ethyl acetate. The obtained organic layer was dried with magnesium sulfate, and the solvent was removed therefrom by a rotary evaporator. The products were purified by column chromatography to obtain compound H-80 (7.7g, 64%).

[Example 4]
Preparation of compound 3-1
After dissolving compound 10-bromo-7H-benzo[c]carbazole (15.5 g, 41.64 mmol), compound A (13.1 g, 45.80 mmol), Pd(PPh₃)₄ (2.4 g, 2.08 mmol), and 2M Na₂CO₃ (110 mL) in toluene (220 mL) and ethanol (110 mL), the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed therefrom with magnesium sulfate, and then the mixture was dried. The products were purified by column chromatography to obtain compound 3-1 (15.4 g, yield: 81%).

Preparation of compound H-55
After dissolving compound 1-2 (6.3 g, 26.17 mmol), and compound 3-1 (10 g, 21.81 mmol) in DMF (110 mL), NaH (0.5 g, 14.54 mmol, 60% in mineral oil) was added to the mixture. The mixture was stirred at room temperature for 12 hours, and methanol and distilled water were added thereto. The obtained solid was filtered under reduced pressure, and then purified by column chromatography to obtain compound H-55 (2.5 g, yield: 18%).
Preparation of compound 4-1

After dissolving naphthalene-2-yl boronic acid (30g, 174.35 mmol), 2-bromonitrobenzene (42g, 209.22 mmol), Pd(PPh₃)₄ (10g, 8.71 mmol), and 2M Na₂CO₃ (425mL) in toluene (850mL) and ethanol (425mL) of a flask, the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 4-1 (40g, yield: 93%).

Preparation of compound 4-2

After dissolving compound 4-1 (40g, 160.34 mmol), and PPh₃ (105.1g, 400.86 mmol) in dichlorobenzene (DCB) (1000mL), the mixture was under reflux at 150°C for 6 hours. After the completion of the reaction, the mixture was distilled, and was triturated with methanol. As a result, compound 4-2 (24g, yield: 50%) was obtained.

Preparation of compound 4-3

After dissolving compound 1-2 (24g, 110.46 mmol) in DMF (570mL), N-bromosuccinimide (NBS) (17g, 99.42 mmol) was added thereto at 0°C. The mixture was stirred for 5 hours, and distilled water was then added thereto. The obtained solid was filtered under reduced pressure, added to methanol, stirred, and then filtered under reduced pressure. After the solid was added to ethyl acetate and methanol, the mixture was stirred, and filtered under reduced pressure to obtain compound 4-3 (23g, yield:
Preparation of compound 4-4

After dissolving compound 4-3 (23.4g, 79.01 mmol), iodobenzene (18mL, 158.02 mmol), Cul (7.5g, 39.50 mmol), ethylene diamine (EDA) (2.6mL, 39.50 mmol), and Cs₂CO₃ (77g, 237.03 mmol) in toluene (400mL), the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 4-4 (21.5g, yield: 74%).

Preparation of compound 4-5

After dissolving compound 4-4 (21.5g, 57.75 mmol), (9H-carbazol-3-yl)boronic acid (15g, 69.31 mmol), Pd(PPh₃)₄ (3.4g, 2.88 mmol) and 2M Na₂CO₃ (150mL) in toluene (300mL) and ethanol (150mL), the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 4-5 (4.2g, yield: 17%).

Preparation of compound H-88

After introducing compound 1-2 (2.6g, 10.99 mmol), compound 4-5 (4.2g, 9.16 mmol), K₂CO₃ (1.2g, 9.16 mmol), 4-dimethylaminopyridine(DMAP) (0.6g, 4.58 mmol), and dimethylacetamide (DMA) (50mL) in a reaction vessel, the mixture was stirred under reflux for 4 hours. The mixture was cooled to room temperature, and distilled water was then added thereto. The mixture was extracted with methylene chloride (MC), dried with magnesium sulfate, distilled under reduced pressure, and purified by column chromatography to obtain compound H-88 (1.7 g, 28%).
Preparation of compound 5-1

After dissolving 2-bromo-carbazole (30g, 121.90 mmol), phenylboronic acid (18g, 146.28 mmol), Pd(PPh₃)₄ (7g, 6.09 mmol), and 2M Na₂CO₃ (250mL) in toluene (500mL) and ethanol (250mL) in a flask, the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed therefrom with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 5-1 (15g, yield: 52%).

Preparation of compound 5-2

After dissolving compound 5-1 (14.4g, 59.19 mmol) in DMF (200mL) in a flask, NBS (11g, 59.19 mmol) was added thereto at 0°C. The mixture was stirred for 12 hours, and distilled water was then added thereto. The obtained solid was filtered under reduced pressure, added to methanol, stirred, and then filtered under reduced pressure. The solid was added to ethyl acetate and methanol. The mixture was stirred and filtered under reduced pressure. As a result, compound 5-2 (15.8g, yield: 83%) was obtained.

Preparation of compound 5-3

After dissolving compound 5-2 (15.8g, 49.04 mmol), compound A (15.5g, 53.94 mmol), Pd(PPh₃)₄ (3g, 2.452 mmol), and 2M Na₂CO₃ (150mL) in toluene (300mL) and ethanol (150mL) in a flask, the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 5-3 (4g, yield: 17%).

Preparation of compound H-7
After dissolving compound 5-3 (4 g, 8.254 mmol), compound B (2.4 g, 9.905 mmol), K₂CO₃ (1.15 g, 8.254 mmol), and DMAP (0.5 g, 4.127 mmol) in DMF (40 mL) in a flask, the mixture was under reflux at 220°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound H-7 (2.8 g, yield: 50%).

[Example 7]

Preparation of compound 6-3

After dissolving compound 6-1 (25.4 g, 68.22 mmol), compound 6-2 (20 g, 68.22 mmol), Pd(PPh₃)₄ (4 g, 3.41 mmol), and 2M K₂CO₃ (100 mL) in toluene (340 mL) and ethanol (100 mL) in a flask, the mixture was under reflux at 120°C for 3 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 6-3 (8 g, yield: 25%).

Preparation of compound H-3

After dissolving compound 6-3 (11 g, 23.99 mmol), compound 6-4 (9 g, 35.98 mmol), and NaH (60% in mineral oil) (2.8 g, 71.97 mmol) in DMF (230 mL) in a flask, the mixture was stirred at room temperature for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound H-3 (4 g, yield: 25%).

<table>
<thead>
<tr>
<th>H-3</th>
<th>MW</th>
<th>UV</th>
<th>PL</th>
<th>Melting point</th>
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<td></td>
<td>662.78</td>
<td>296 nm</td>
<td>517 nm</td>
<td>234 °C</td>
</tr>
</tbody>
</table>

[Example 8]
Preparation of compound 7-1

After dissolving 7H-benzo[c]carbazole (50g, 230.12 mmol), and N-bromosuccinimide (41g, 230.12 mmol) in DMF (500mL) in a flask, the mixture was stirred at room temperature for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 7-1 (50g, yield: 73%).

Preparation of compound 7-2

After dissolving 10-bromo-7H-benzo[c]carbazole (compound 7-1) (15g, 61.00 mmol), iodobenzene(14ml, 123.00mmol), Cul (6.0g, 30.00 mmol), EDA (4ml, 61.00 mmol), and K$_3$PO$_4$ (40g, 183.00 mmol) in toluene (500mL) in a flask, the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 7-2 (13g, yield: 73%).

Preparation of compound 7-4

After dissolving compound 10-bromo-7-phenyl-7H-benzo[c]carbazole (compound 7-2) (10g, 34.10 mmol), and compound 7-3 (10g, 40.92 mmol) in toluene (100 mL), ethanol (50 mL), and H$_2$O (50 mL), the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 7-4 (9g, yield: 57%).

Preparation of compound 7-7

After dissolving compound 2,3-dichloroquinoxaline (compound 7-5) (28g, 140.67 mmol), and compound 7-6 (24g, 140.67 mmol) in toluene 100 mL, ethanol 50 mL, H$_2$O 50 mL, the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was
removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound 7-7 (30 g, yield: 73%).

[243] Preparation of compound H-4

[244] After introducing compound 10-(9H-carbazol-3-yl)-7-phenyl-7H-benzo[c]carbazole (compound 7-4) (9.1 g, 19.80 mmol), compound 7-7 (9 g, 29.7 mmol), K$_2$CO$_3$ (5.5 g, 39.6 mmol), DMAP (1.2 g, 9.9 mmol), and DMF (100 mL) in a reaction vessel, the mixture was stirred under reflux for 1 hour, cooled to room temperature, and distilled water was then added thereto. The mixture was extracted with methylene chloride, dried with magnesium sulfate, distilled under reduced pressure, and purified by column chromatography to obtain compound H-4 (5 g, yield: 35%).

[245]

<table>
<thead>
<tr>
<th></th>
<th>MW</th>
<th>UV</th>
<th>PL</th>
<th>Melting point</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-4</td>
<td>712.84</td>
<td>334nm</td>
<td>516nm</td>
<td>298.0 °C</td>
</tr>
</tbody>
</table>

[246] [Example 9]

[247]

[248] Preparation of compound 91-1

[249] After dissolving 9-phenyl-9H,9'H-3,3'-bicarbazole (33.8 g, 82.7 mmol), 2,4-dichloroquinoline (17.2 g, 86.9 mmol), Cul (31.5 g, 165.4 mmol), and trans-1,2-diaminocyclohexane (6 mL, 49.63 mmol) in o-DCB 550 mL in a flask, the mixture was stirred under reflux at 200°C for 6 hours. After the completion of the reaction, the mixture was extracted with methylene chloride, dried with MgSO$_4$, subjected to column chromatography, and methanol was then added to the separated material. The obtained solid was filtered under reduced pressure to obtain compound 91-1 (32.5 g, yield: 69%).

[250] Preparation of compound H-91

[251] After dissolving compound 91-1 [9-(4-chloroquinolin-2-yl)-9'-phenyl-9H,9'H-3,3'-bicarbazole] (32 g, 56.13 mmol), phenylboronic acid (13.7 g, 112.3 mmol), Pd(PPh$_3$)$_4$ (6.5 g, 5.7 mmol), and K$_2$CO$_3$ (19.4 g, 140.33 mmol) in toluene (560 mL), ethanol (35 mL), and H$_2$O (70 mL), the mixture was under reflux at 120°C for 12 hours. After the completion of the reaction, the mixture was extracted with methylene chloride, dried with MgSO$_4$, subjected to
column chromatography, and hexane was then added to the separated material. The obtained solid was filtered under reduced pressure to obtain compound **H-91** (23g, yield: 67%).

---

**Example 10**

Preparation of compound **97-1**

After dissolving compound 9-phenyl-9H,9′H-3,3′-bicarbazole (20.5g, 50.24 mmol), and compound A (12g, 60.29 mmol) in DMF (50mL) in a flask, NaH (2.6g, 62.31 mmol, 60% in mineral oil) was added thereto. The mixture was stirred at room temperature for 12 hours, and methanol and distilled water were added thereto. The produced solid was filtered under reduced pressure, and purified by column chromatography to obtain compound **97-1** (10g, yield: 35%).

Preparation of compound **H-97**

After dissolving compound **97-1** (10g, 17.51 mmol), compound **2-2** (4.5g, 22.76 mmol), Pd₂dba₃ (0.96g, 1.05 mmol), S-phos (0.6g, 1.40 mmol), and K₃P0₄ (12g, 52.53 mmol) in toluene (200mL) in a flask, the mixture was under reflux at 120°C for 5 hours. After the completion of the reaction, the mixture was extracted with ethyl acetate, the remaining moisture was removed from the obtained organic layer with magnesium sulfate, and then the organic layer was dried. The products were purified by column chromatography to obtain compound **H-97** (3g, yield: 25%).

**rDevice Example 11 OLED using the compound of the present disclosure**

OLED was produced using the compound of the present disclosure as follows. A transparent electrode indium tin oxide (ITO) thin film (15 Ω/sq) on a glass substrate for an organic light-emitting diode (OLED) (Geomatec) was subjected to an ultrasonic washing with trichloroethylene, acetone, ethanol, and distilled water sequentially, and was then stored in isopropanol. The ITO substrate was then mounted on a substrate holder of a vacuum vapor depositing apparatus. N₁,N₁′-(1,1′-biphenyl)-4,4′-diyl)bis(N₁-(naphthalene-1-yl)-N₄,N₄′-diphenylbenzene-1,4-diamine) was introduced into a cell of said vacuum vapor depositing apparatus, and then the pressure in the chamber of said apparatus was controlled to 10⁻⁴ torr. Thereafter, an electric current was applied to
cell to evaporate the above introduced material, thereby forming a hole injection layer having a thickness of 60 nm on the ITO substrate. N,N'-di(4-biphenyl)-N,N'-di(4-biphenyl)-4,4'-diaminobiphenyl was then introduced into another cell of said vacuum vapor depositing apparatus, and evaporated by applying electric current to the cell, thereby forming a hole transport layer having a thickness of 20 nm on the hole injection layer. Thereafter compound H-1 was introduced into one cell of the vacuum vapor depositing apparatus as a host, and compound D-88 was introduced into another cell as a dopant. The two materials were evaporated at different rates so that the dopant was deposited in a doping amount of 4 wt% based on the total amount of the host and dopant to form a light-emitting layer having a thickness of 30 nm on the hole transport layer.

2-(4-(9,10-di(naphthalene-2-yl)anthracen-2-yl)phenyl)-1-phenyl-1H-benzo[d]imidazole was then introduced into one cell, and lithium quinolate was introduced into another cell. The two materials were evaporated at the same rate, so that they were respectively deposited in a doping amount of 50 wt% to form an electron transport layer having a thickness of 30 nm on the light-emitting layer. After depositing lithium quinolate as an electron injection layer having a thickness of 2 nm on the electron transport layer, an Al cathode having a thickness of 150 nm was then deposited by another vacuum vapor deposition apparatus on the electron injection layer. Accordingly, an OLED was produced. All the materials used for producing the OLED were those purified by vacuum sublimation at 10⁻⁶ torr. The produced OLED showed a red emission having a luminance of 1,050 cd/m² and a current density of 11.1 mA/cm² at a driving voltage of 4.1 V. The minimum time taken to be reduced to 90% of the luminance at 5,000 nit was 90 hours.

[262]

**Device Examples 2 to 8: OLED using the compound of the present disclosure**

[263]

OLED was produced in the same manner as in Device Example 1, except that a host and a dopant shown in Table 2 below were used as a light-emitting material. Driving voltage (V), current density (mA/cm²), luminance (cd/m²), color, and minimum time taken to be reduced to 90% of the luminance at 5000 nit (lifespan), of the produced OLEDs are shown in Table 2 below.

[264]

**Comparative Examples 1 and 2: OLED using conventional light-emitting materials**

[265]

OLED was produced in the same manner as in Device Example 1, except that compound T-1 or T-2 shown in Table 1 below was used as a host, and a dopant shown in Table 2 below was used. A driving voltage (V), current density (mA/cm²), luminance (cd/m²), color, and minimum time taken to be reduced to 90% of the luminance at 5000 nit (lifespan), of the produced OLEDs are shown in Table 2 below.
As shown in Table 2, organic electroluminescent devices using the organic electroluminescent compound of the present disclosure show lifespan remarkably improved up to 600% better than those using conventional compounds, while maintaining good driving voltage, and good current and power efficiencies.

Device Example 9.1 OLED in which a first host compound and a second host compound of the present disclosure were co-evaporated

OLED was produced using the compound of the present disclosure as follows. A transparent electrode indium tin oxide (ITO) thin film (10 Ω/sq) on a glass substrate for an organic light-emitting diode (OLED) (Geomatec) was subjected to an ultrasonic washing with trichloroethylene, acetone, ethanol, and distilled water sequentially, and was then stored in isopropanol. The ITO substrate was then mounted on a substrate holder of a vacuum vapor depositing apparatus. N<sub>4</sub>,N<sub>4</sub>′-diphenyl-N<sub>4</sub>,N<sub>4</sub>′-bis(9-phenyl-9H-carbazole-3-yl)-[1',1'-biphenyl]-4,4′-diamine (compound HI-1) was introduced into a cell of the vacuum vapor depositing apparatus, and then the pressure in the chamber of the apparatus was controlled to 10<sup>6</sup> torr. Thereafter, an electric
current was applied to the cell to evaporate the above introduced material, thereby forming a first hole injection layer having a thickness of 80 nm on the ITO substrate. 1,4,5,8,9, 12-hexazatriphenylene-hexacarbonitrile (compound HI-2) was introduced into another cell of the vacuum vapor depositing apparatus, and then an electric current was applied to the cell to evaporate the above introduced material, thereby forming a second hole injection layer having a thickness of 5 nm on the first hole injection layer. N-([1,l’-biphenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazole-3-yl)phenyl)-9H-fluoren-2-amine (compound HT-1) was introduced into a cell of the vacuum vapor depositing apparatus, and then an electric current was applied to the cell to evaporate the above introduced material, thereby forming a first hole transport layer having a thickness of 10 nm on the second hole injection layer. Thereafter, N,N-di([1,l’-biphenyl]-4-yl)-4’- (9H-carbazole-9-yl) - [1,l’-biphenyl]-4-amine (compound HT-3) was introduced into another cell of the vacuum vapor depositing apparatus, and then an electric current was applied to the cell to evaporate the above introduced material, thereby forming a second hole transport layer having a thickness of 60 nm on the first hole transport layer. As a host material, compound H-1 and compound H2-116 were introduced into two cells of the vacuum vapor depositing apparatus, respectively. Compound D-96 was introduced into another cell as a dopant. The two host materials were evaporated at the same rate, while the dopant was evaporated at a different rate from the host material so that the dopant was deposited in a doping amount of 3 wt% based on the total amount of the host and dopant to form a light-emitting layer having a thickness of 40 nm on the hole transport layer.

2,4-bis(9,9-dimethyl-9H-fluoren-2-yl) -6-(naphthalene-2-yl)-1,3,5-triazine (compound ET-1) was then introduced into one cell, and lithium quinolate (compound EI-1) was introduced into another cell. The two materials were evaporated at 1:1 rate to form an electron transport layer having a thickness of 30 nm on the light-emitting layer. After depositing lithium quinolate (compound EI-1) as an electron injection layer having a thickness of 2 nm on the electron transport layer, an Al cathode having a thickness of 80 nm was then deposited by another vacuum vapor deposition apparatus on the electron injection layer. The minimum time taken to be reduced to 80% of the luminance at 5,000 nit was 195 hours.

[276]

[277] Device Examples 10 to 161 PLED using a multi-component host material of the present disclosure
OLED was produced in the same manner as in Device Example 9, except that compounds shown in Table 3 below were used as a first host and a second host for preparing a light-emitting layer. The minimum time taken to be reduced to 80% of the luminance at 5000 nit of the produced OLEDs is shown in Table 3 below.

**Comparative Examples 3 to 4**

OLED was produced in the same manner as in Device Example 9, except that only a first host compound shown in Table 3 below was used as a host for a light-emitting layer. The minimum time taken to be reduced to 80% of the luminance at 5000 nit of the produced OLEDs is shown in Table 3 below.

**Table 3**

<table>
<thead>
<tr>
<th>Device Example No.</th>
<th>Host</th>
<th>Dopant</th>
<th>Minimum time taken to be reduced to 80% of the luminance at 5000nit</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>H-1 : H2-116</td>
<td>D-96</td>
<td>195 hours</td>
</tr>
<tr>
<td>10</td>
<td>H-3 : H2-94</td>
<td>D-96</td>
<td>490 hours</td>
</tr>
<tr>
<td>11</td>
<td>H-3 : H2-117</td>
<td>D-96</td>
<td>517 hours</td>
</tr>
<tr>
<td>12</td>
<td>H-3 : H2-116</td>
<td>D-96</td>
<td>378 hours</td>
</tr>
<tr>
<td>13</td>
<td>H-3 : H2-118</td>
<td>D-96</td>
<td>480 hours</td>
</tr>
<tr>
<td>14</td>
<td>H-3 : H-110</td>
<td>D-96</td>
<td>1,422 hours</td>
</tr>
<tr>
<td>15</td>
<td>H-3 : H2-119</td>
<td>D-96</td>
<td>1,080 hours</td>
</tr>
<tr>
<td>16</td>
<td>H-3 : H2-120</td>
<td>D-96</td>
<td>1,250 hours</td>
</tr>
<tr>
<td>Comparative Example 3</td>
<td>H-1</td>
<td>D-96</td>
<td>168 hours</td>
</tr>
<tr>
<td>Comparative Example 4</td>
<td>H-3</td>
<td>D-96</td>
<td>295 hours</td>
</tr>
</tbody>
</table>

As shown above, although organic electroluminescent devices using the organic electroluminescent compound of the present disclosure as a sole host show excellent lifespan, a multi-component host material comprising an organic electroluminescent compound of the present disclosure can provide an organic electroluminescent device having more improvement in lifespan.

**rPevice Examples 17-1 to 17-5, 18-1 to 18-6**

OLED in which a first compound and a second host compound according to the present disclosure were co-evaporated

OLED was produced using the compound of the present disclosure as follows. A transparent electrode indium tin oxide (ITO) thin film (10 Ω/sq) on a glass substrate for an organic light-emitting diode (OLED) (Geomatec) was subjected to an ultrasonic washing with trichloroethylene, acetone, ethanol, and distilled water sequentially, and
was then stored in isopropanol. The ITO substrate was then mounted on a substrate holder of a vacuum vapor depositing apparatus.

1,4,5,8,9, 12-hexazatriphenylene-hexacarbonitrile (compound HI-1) was introduced into a cell of the vacuum vapor depositing apparatus, and then the pressure in the chamber of the apparatus was controlled to 10⁻⁶ torr. Thereafter, an electric current was applied to the cell to evaporate the above introduced material, thereby forming a first hole injection layer having a thickness of 5 nm on the ITO substrate. N,N'-bis(naphthalene-1-yl)-N,N'-bis(phenyl)benzidine (compound HI-2) was then introduced into another cell of the vacuum vapor depositing apparatus, and evaporated by applying electric current to the cell, thereby forming a second hole injection layer having a thickness of 95 nm on the first hole injection layer. N-(1,3-biphenyl)-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluorene-2-amine (compound HT-1) was introduced into one cell of the vacuum vapor depositing apparatus, and evaporated by applying electric current to the cell, thereby forming a hole transport layer having a thickness of 20 nm on the second hole transport layer. As a host material, two compounds shown in Table 4 below were introduced into two cells of the vacuum vapor depositing apparatus, respectively. Compound D-122 was introduced into another cell as a dopant. The two host materials were evaporated at the same rate of 1:1, while the dopant was evaporated at a different rate from the host material so that the dopant was deposited in a doping amount of 12 wt% based on the total amount of the host and dopant to form a light-emitting layer having a thickness of 30 nm on the hole transport layer.

2,4,6-tris(9,9-dimethyl-9H-fluorene-2-yl)-1,3,5-triazine (compound ET-1) was then introduced into another cell, and evaporated to be deposited as an electron transport layer having a thickness of 35 nm on the light-emitting layer. After depositing lithium quinolate (compound EI-1) as an electron injection layer having a thickness of 2 nm on the electron transport layer, an Al cathode having a thickness of 80 nm was then deposited by another vacuum vapor deposition apparatus on the electron injection layer.

Comparative Device Examples 5-1 to 5-31 PLED using conventional compounds.

OLED was produced in the same manner as in Device Example 17-1, except that the
conventional compounds shown in Tables 4 and 5 below were used as a first host compound and a second host compound.

A driving voltage, luminous efficiency, CIE color coordinate, and the minimum time taken to be reduced from 100% to 95% of the luminance at 10,000 nit and a constant current, of OLEDs produced in Device Examples 17-1 to 17-5, Device Examples 18-1 to 18-6, and Comparative Device Examples 5-1 to 5-3 are shown in Table 4 below.

<table>
<thead>
<tr>
<th>Device Example No.</th>
<th>Host</th>
<th>Dopant</th>
<th>Voltage [V]</th>
<th>Current Efficiency [cd/A]</th>
<th>Color coordinate (x, y)</th>
<th>Minimum time taken to be reduced to 95% of the luminance at 10,000nit</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-1</td>
<td>H-91 : H2-110</td>
<td>D-122</td>
<td>3.7</td>
<td>74.6</td>
<td>0.430, 0.557</td>
<td>328 hours</td>
</tr>
<tr>
<td>17-2</td>
<td>H-102 : H2-110</td>
<td>D-122</td>
<td>4.0</td>
<td>70</td>
<td>0.429, 0.558</td>
<td>206 hours</td>
</tr>
<tr>
<td>17-3</td>
<td>H-103 : H2-110</td>
<td>D-122</td>
<td>3.6</td>
<td>-</td>
<td>0.429, 0.557</td>
<td>97 hours</td>
</tr>
<tr>
<td>17-4</td>
<td>H-105 : H2-110</td>
<td>D-122</td>
<td>4.0</td>
<td>74.4</td>
<td>0.429, 0.558</td>
<td>126 hours</td>
</tr>
<tr>
<td>17-5</td>
<td>H-104 : H2-110</td>
<td>D-122</td>
<td>3.6</td>
<td>-</td>
<td>0.429, 0.558</td>
<td>157 hours</td>
</tr>
<tr>
<td>18-1</td>
<td>H-91 : H2-31</td>
<td>D-122</td>
<td>3.7</td>
<td>73.6</td>
<td>0.426, 0.560</td>
<td>185 hours</td>
</tr>
<tr>
<td>18-2</td>
<td>H-91 : H2-111</td>
<td>D-122</td>
<td>3.6</td>
<td>72.2</td>
<td>0.419, 0.570</td>
<td>172 hours</td>
</tr>
<tr>
<td>18-3</td>
<td>H-91 : H2-112</td>
<td>D-122</td>
<td>3.5</td>
<td>-</td>
<td>0.420, 0.569</td>
<td>87 hours</td>
</tr>
<tr>
<td>18-4</td>
<td>H-91 : H2-113</td>
<td>D-122</td>
<td>3.9</td>
<td>-</td>
<td>0.428, 0.559</td>
<td>105 hours</td>
</tr>
<tr>
<td>18-5</td>
<td>H-91 : H2-115</td>
<td>D-122</td>
<td>3.8</td>
<td>72.9</td>
<td>0.428, 0.558</td>
<td>138 hours</td>
</tr>
<tr>
<td>18-6</td>
<td>H-91 : H2-114</td>
<td>D-122</td>
<td>3.9</td>
<td>75.1</td>
<td>0.425, 0.561</td>
<td>111 hours</td>
</tr>
<tr>
<td>Comparative Example 5-1</td>
<td>A-5 : A-1</td>
<td>D-122</td>
<td>3.8</td>
<td>73.9</td>
<td>0.429, 0.558</td>
<td>83 hours</td>
</tr>
<tr>
<td>Comparative Example 5-2</td>
<td>A-2 : A-3</td>
<td>D-122</td>
<td>3.8</td>
<td>70.8</td>
<td>0.425, 0.561</td>
<td>42 hours</td>
</tr>
<tr>
<td>Comparative Example 5-3</td>
<td>A-4 : A-5</td>
<td>D-122</td>
<td>3.7</td>
<td>72.4</td>
<td>0.428, 0.558</td>
<td>66 hours</td>
</tr>
</tbody>
</table>

[Table 4]
Compounds employed for device example 19, and comparative examples 5-1 and 5-2

A-1  A-2  A-3  A-4  A-5
Claims

[Claim 1] An organic electroluminescent compound represented by the following formula 1:

wherein $L_i$ represents a single bond, a substituted or unsubstituted (3- to 30-membered)heteroarylene, or a substituted or unsubstituted (C6-C30)arylene;

$X_i$ represents $-NR_1$, $-CR_2R_3$, $-0$-, or $-S$-;

$X_2$ to $X_6$, each independently, represent $-CR_4$- or $-N$-;

$Ari$ represents hydrogen, a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (3- to 30-membered)heteroaryl;

with the proviso that when $X_2$ is $-N$-, $L_i$ is not the substituted or unsubstituted (C6-C30)arylene and Ari is not hydrogen;

$Y_i$ to $Y_4$ and $Y_{10}$ to $Y_{16}$, each independently, represent $-N$- or $-CR_5$-;

$Y_5$ to $Y_{12}$, each independently, represent $-C_1$-, $-N$-, or $-CR_6$-;

$R_i$ to $R_3$, each independently, represent hydrogen, deuterium, a halogen, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (3- to 30-membered)heteroaryl, a substituted or unsubstituted (C3-C30)cycloalkyl, or a substituted or unsubstituted (3- to 7-membered)heterocycloalkyl;

$R_4$ to $R_6$, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C3-C30)cycloalkenyl, a substituted or unsubstituted (3- to 7-membered)heterocycloalkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (3- to 30-membered)heteroaryl, or a substituted or unsubstituted di(C6-C30)arylamino; or may be fused with an adjacent substituent(s)}
form a substituted or unsubstituted (3- to 30-membered), mono- or polycyclic, alicyclic or aromatic ring whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;

the heteroaryl(ene) and the heterocycloalkyl, each independently, contain at least one hetero atom selected from B, N, O, S, P(=0), Si and P; and

a and b, each independently represent 0 or 1.

[Claim 2]
The organic electroluminescent compound according to claim 1, wherein the substituents of the substituted alkyl, the substituted cycloalkyl, the substituted cycloalkenyl, the substituted heterocycloalkyl, the substituted aryl(ene), the substituted heteroaryl(ene), the substituted diarylamino and the substituted mono- or polycyclic, alicyclic or aromatic ring in Li, Ar, and Ri to R6, each independently, are at least one selected from the group consisting of deuterium, a halogen, a cyano, a carboxy, a nitro, a hydroxy, a (Cl-C30)alkyl, a halo(Cl-C30)alkyl, a (C2-C30)alkenyl, a (C2-C30)alkynyl, a (Cl-C30)alkoxy, a (Cl-C30)alkylthio, a (C3-C30)cycloalkenyl, a (3- to 7-membered) heterocycloalkyl, a (C6-C30)aryloxy, a (C6-C30)arylthio, a (3- to 30-membered) heteroaryl unsubstituted or substituted with a (C6-C30)aryl, a (C6-C30)arylamino, a (3- to 30-membered) heteroaryl, a tri(Cl-C30)alkylsilyl, a tri(C6-C30)arylsilyl, a di(C1-C30)alkyl(C6-C30)arylsilyl, a (Cl-C30)alkyldi(C6-C30)arylsilyl, an amino, a mono- or di-(Cl-C30)alkylamino, a mono- or di-(C6-C30)arylamino, a (Cl-C30)alkyl(C6-C30)arylamino, a (Cl-C30)alkylcarbonyl, a (Cl-C30)alkoxy carbonyl, a (C6-C30)arylcarbonyl, a di(C6-C30)arylboryl, a di(Cl-C30)alkylboronyl, a (Cl-C30)alkyl(C6-C30)arylboryl, a (C6-C30)aryl(Cl-C30)alkyl, and a (Cl-C30)alkyl(C6-C30)aryl.

[Claim 3]
The organic electroluminescent compound according to claim 1, wherein

Li represents a single bond, a substituted or unsubstituted (5- to 21-membered) heteroarylene, or a substituted or unsubstituted (C6-C21)arylene;

Xi represents -NR1-, -CR2R3-, -O-, or -S-;

all of X2 to X6 represent -CR4-, or one of X2 to X6 represents -N-, and
the remainders of $X_2$ to $X_6$ represent $-\text{CR}_4^a$, wherein when $X_2$ is $-\text{N}-$, $L$ is a single bond;

$\text{Ari}$ represents hydrogen, or a substituted or unsubstituted (C6-C21)aryl, wherein when $\text{Ari}$ is hydrogen, at least one of $R_4$ is a substituted or unsubstituted (C6-C21)aryl or a substituted or unsubstituted (5- to 21-membered)heteroaryl;

$Y_i$ to $Y_4$ and $Y_{i1}$ to $Y_{i6}$, each independently, represent $-\text{CR}_5^a$;

$Y_5$ to $Y_{12}$, each independently, represent $\frac{\text{C}}{\text{C}}_2^b$ or $-\text{CR}_6^a$;

$R_i$ to $R_3$, each independently, represent a substituted or unsubstituted (C1-C20)alkyl, a substituted or unsubstituted (C6-C21)aryl, a substituted or unsubstituted (5- to 21-membered)heteroaryl, a substituted or unsubstituted (C5-C21)cycloalkyl, or a substituted or unsubstituted (5- to 7-membered)heterocycloalkyl;

$R_4$ to $R_6$, each independently, represent hydrogen, a halogen, a cyano, a substituted or unsubstituted (C1-C20)alkyl, a substituted or unsubstituted (C5-C21)cycloalkyl, a substituted or unsubstituted (C6-C21)aryl, a substituted or unsubstituted (5- to 21-membered)heteroaryl, or a substituted or unsubstituted di(C6-C21)aryl amino; or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (5- to 21-membered), mono- or polycyclic, aromatic ring whose carbon atom(s) may be replaced with one or two hetero atom(s) selected from nitrogen, oxygen, and sulfur; the heteroaryl(ene) and the heterocycloalkyl, each independently, contain at least one hetero atom selected from N, O and S; and $a$ and $b$, each independently represent 0 or 1.

[Claim 4]
The organic electroluminescent compound according to claim 3, wherein $\text{Ari}$ represents hydrogen, a substituted or unsubstituted phenyl, a substituted or unsubstituted naphthyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted anthracenyl, a substituted or unsubstituted phenanthrenyl, a substituted or unsubstituted phenyl napthyl, or a substituted or unsubstituted naphthyl phenyl.

[Claim 5]
The organic electroluminescent compound according to claim 1, wherein the compound is represented by any one of the following formulae 2 to 4:
wherein \(X_1, \text{Ar}_1, Y_1 \text{to } Y_6, R_4, L_1, a, \) and \(b\) are as defined in claim 1; \(c\) represents an integer of 1 to 4; and when \(c\) is an integer of 2 or more, each of \(R_4\) is the same or different.

[Claim 6] The organic electroluminescent compound according to claim 1, wherein the compound is selected from the group consisting of:
[Claim 7] An organic electroluminescent device comprising the compound according to claim 1.

[Claim 8] An organic electroluminescent device comprising an anode, a cathode, and an organic layer disposed between the anode and cathode, wherein
the organic layer comprises one or more light-emitting layers; at least one light-emitting layer comprises one or more dopant compounds and two or more host compounds; and at least one of the two or more host compounds is the organic electroluminescent compound represented by formula 1 according to claim 1.

[Claim 9] The organic electroluminescent device according to claim 8, wherein a first host compound of the two or more host compounds is selected from the organic electroluminescent compound represented by the following formulae 2 and 5.

\[
\text{H-(Cz-L)}_h \cdot \text{M} \quad (6) \quad \text{H-(Cz)rL}_4 \cdot \text{M} \quad (7)
\]

wherein, \(X_1, A r_1, Y_i, Y_6, R_4\), \(L_i, a,\) and \(b\) are as defined in claim 1; \(c\) represents an integer of 1 to 5; and where \(c\) is 2 or more, each of \(R_4\) may be the same or different.

[Claim 10] The organic electroluminescent device according to claim 8, wherein at least two of the two or more host compounds, each independently, are selected from the organic electroluminescent compound represented by formula 1.

[Claim 11] The organic electroluminescent device according to claim 8, wherein a first host compound of the two or more host compounds is the organic electroluminescent compound represented by formula 1, and a second host compound is selected from the compound represented by the following formulae 6 to 11.
wherein $C_z$ represents the following structure:

\[
\text{\begin{figure}
\includegraphics{structure1.png}
\end{figure}}
\]

$L_4$ and $L_5$, each independently, represent a single bond, a substituted or unsubstituted (C6-C30)arylene, or a substituted or unsubstituted (5- to 30-membered)heteroarylene;

$M$ represents a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (5- to 30-membered)heteroaryl, provided that where $h$ of formula 6 is 1, or $i$ of formulae 7 is 1, $M$ is not , and $M$ of formulae 8 and 9 are not

\[
\text{\begin{figure}
\includegraphics{structure2.png}
\end{figure}}
\]

(wherin $X_2$ to $X_6$, and $Ar_2$ are as defined in formula 1, and * represents a bonding site.);

$Z_1$ and $Z_2$, each independently, represent -O-, -S-, -N($R_3$)-, or -C($R_3$)($R_6$)-, provided that $Z_1$ and $Z_2$ do not simultaneously exist;

$X'$ represents -O- or -S-;

ring A represents \( \begin{array}{c}
\text{D}
\end{array}\)

ring B represents \( \begin{array}{c}
\text{E}
\end{array}\)

$D$ and $E$, each independently, represent -O-, -S-, -N($R_3$)-, or -C($R_3$)($R_36$)-;

$Ar_2$ represents a substituted or unsubstituted (3- to
30-membered)heteroaryl, or a substituted or unsubstituted (C6-C30)aryl, provided that Ar₂ is not (wherein X₂ to X₆ and Ar₁ are as defined in formula 1, and * represents a bonding site.); R₂ to R₂₇, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C30)aryl, a substituted or unsubstituted (5- to 30-membered)heteroaryl, or R₃₈R₃₉R₄₀Si--; or may be fused with an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), monocyclic or polycyclic, alicyclic or aromatic ring whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur; provided that where h of formula 6 or i of formula 7 is 1, R₂₆ or R₂₇ does not form the ring containing Z₁, Z₂, D, or E of formulae 8, 9, and 11, R₂₂ of formula 10 does not form the indole ring connected to R₂₁ of formulae 8 and 9 and the indole ring connected to R₂₃ of formula 11; R₂₈ to R₃₀, each independently, represent a substituted or unsubstituted (Cl-C30)alkyl, or a substituted or unsubstituted (C6-C30)aryl; R₃₁ to R₃₆, each independently, represent hydrogen, a substituted or unsubstituted (Cl-C30)alkyl, a substituted or unsubstituted (C6-C30)aryl, or a substituted or unsubstituted (5- to 30-membered)heteroaryl; R₃₂ and R₃₃ may be the same or different; R₃₅ and R₃₆ may be the same or different; the heteroaryl(ene) contains one or more hetero atoms selected from B, N, O, S, P(=O), Si, and P; h and i, each independently, represent an integer of 1 to 3; j, k, l and p, each independently, represent an integer of 0 to 4; r, s, and t, each independently, represent an integer of 1 to 4; and where h, i, j, k, l, p, r, s, or t is an integer of 2 or more, each of (C₃-L₄), each of (C₃), each of R₂₃, each of R₂₂, each of R₂₁, each of R₂₄, each of R₂₅, each of R₂₆, or each of R₂₇ may be the same or different.

[Claim 12]
The organic electroluminescent device according to claim 11, wherein the compound represented by formulae 6 to 11 is selected from the group consisting of:
**A. CLASSIFICATION OF SUBJECT MATTER**

H01L 51/00 (2006.01) H01L 27/32 (2006.01) C07D 209/82 (2006.01) C07D 401/02 (2006.01) C07D 401/04 (2006.01) C07D 401/14 (2006.01) C07D 403/02 (2006.01) C07D 403/04 (2006.01) C07D 403/14 (2006.01) C07D 405/10 (2006.01) C07D 409/14 (2006.01) C09K 11/06 (2006.01)

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

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

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

Inventor and Applicant search:

Patentscope & Google: LEE, Mi-Ja; LEE, Kyung-Joo; LEE, Su-Hyun; ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.

STN Registry and CAplus: Substructure search based on compounds of formula (1)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**Date of the actual completion of the international search**

27 April 2015

**Date of mailing of the international search report**

27 April 2015

**Name and mailing address of the ISA/AU**

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustralia.gov.au

**Authorised officer**

Pina Potenza
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. 0399359614

Form PCT/ISA/210 (fifth sheet) (July 2009)
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<td>WO 2011/019156 A1 (ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.) 17 February 2011&lt;br&gt;Abstract: Chemical Formula 1, Claim 1 for generic definition; Claim 5 compounds 26-27 on page 29, compounds 60-62 on page 30; Claims 6 and 7</td>
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<td>WO 2012/121561 A1 (ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.) 13 September 2012&lt;br&gt;Abstract: Paragraphs [45]-[61]; Claim 1 for generic definition; Claim 5 compounds C-1, C-10, C-24, C-25, C-26, C-66, C-68 and C-72; Claim 6</td>
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<td>WO 2012/134124 A1 (ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.) 04 October 2012&lt;br&gt;see Abstract; Paragraphs [72]-[92]; Claim 1 for generic definition; Claim 5 compounds C-40, C-78, C-80, C-81 and C-83; Claim 6</td>
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<td>WO 2012/036482 A1 (ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.) 22 March 2012&lt;br&gt;Abstract: pages 12-22; compounds 47-48, page 14; compounds 69, 71, 73, page 16; compounds 139, 142-144, page 21; Claim 1 for generic definition; Claims 4 and 6-7</td>
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<td>WO 2010/07244 A2 (DOW ADVANCED DISPLAY MATERIALS, LTD.) 23 September 2010&lt;br&gt;Abstract; compounds associated with CAS Registry Numbers RN 1246309-55-6, RN 1246309-70-5, RN 1246309-70-4; Claims 1-6</td>
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This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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