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(54) **COMPOUND HAVING INDENOACRIDAN RING STRUCTURE, AND ORGANIC ELECTROLUMINESCENT DEVICE**

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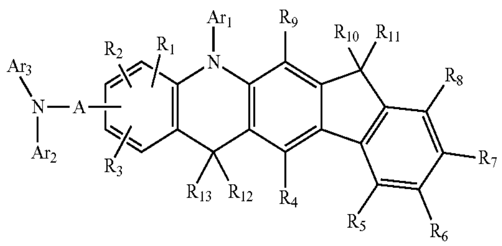
(57) **ABSTRACT**

An organic compound with excellent characteristics excelling in hole injecting and transporting performance and having an electron-blocking ability, high stability in a thin film state and excellent heat resistance is provided as a material for an organic electroluminescent device of high efficiency and high durability, and the organic electroluminescent device of high luminous efficiency and high durability is provided using this compound. The compound of a general formula (1) having an indenoacridan ring structure is used as a constituent material of at least one organic layer in the organic electroluminescent device that includes a pair of electrodes and one or more organic layers sandwiched between the pair of electrodes.

[Chemical Formula 1]



(1)

FIG. 1

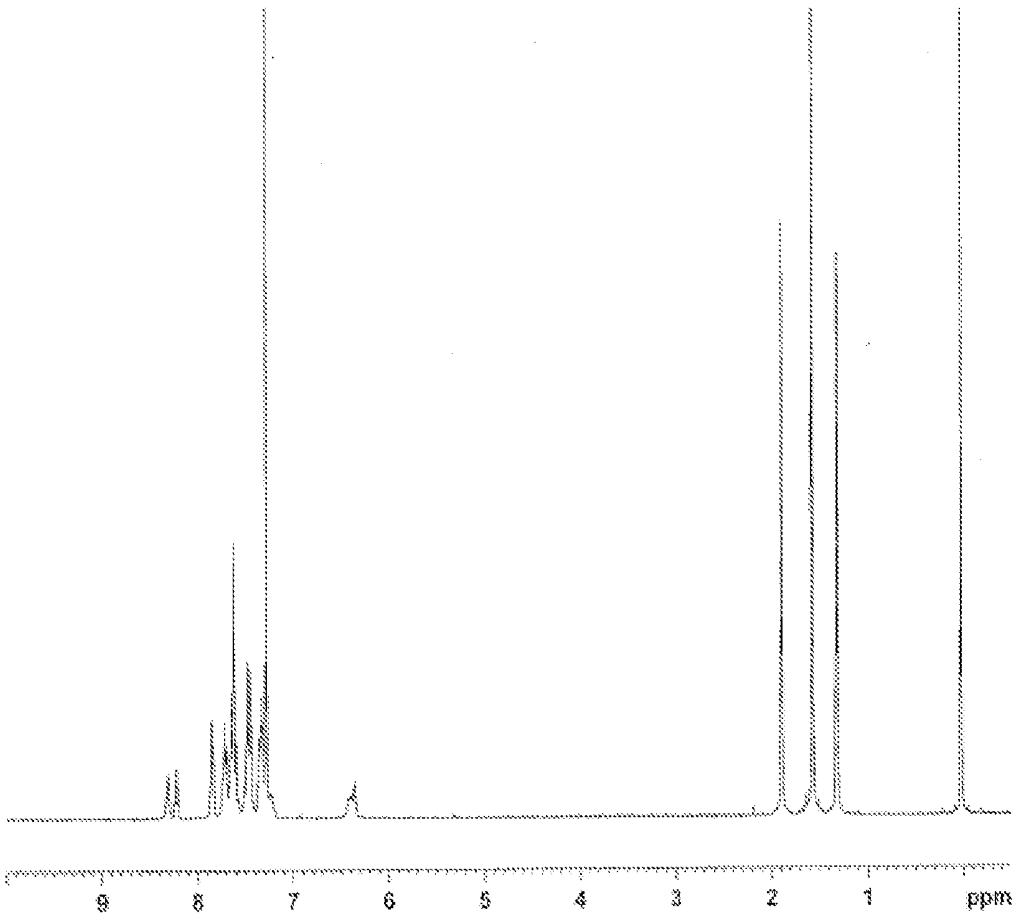


FIG. 2

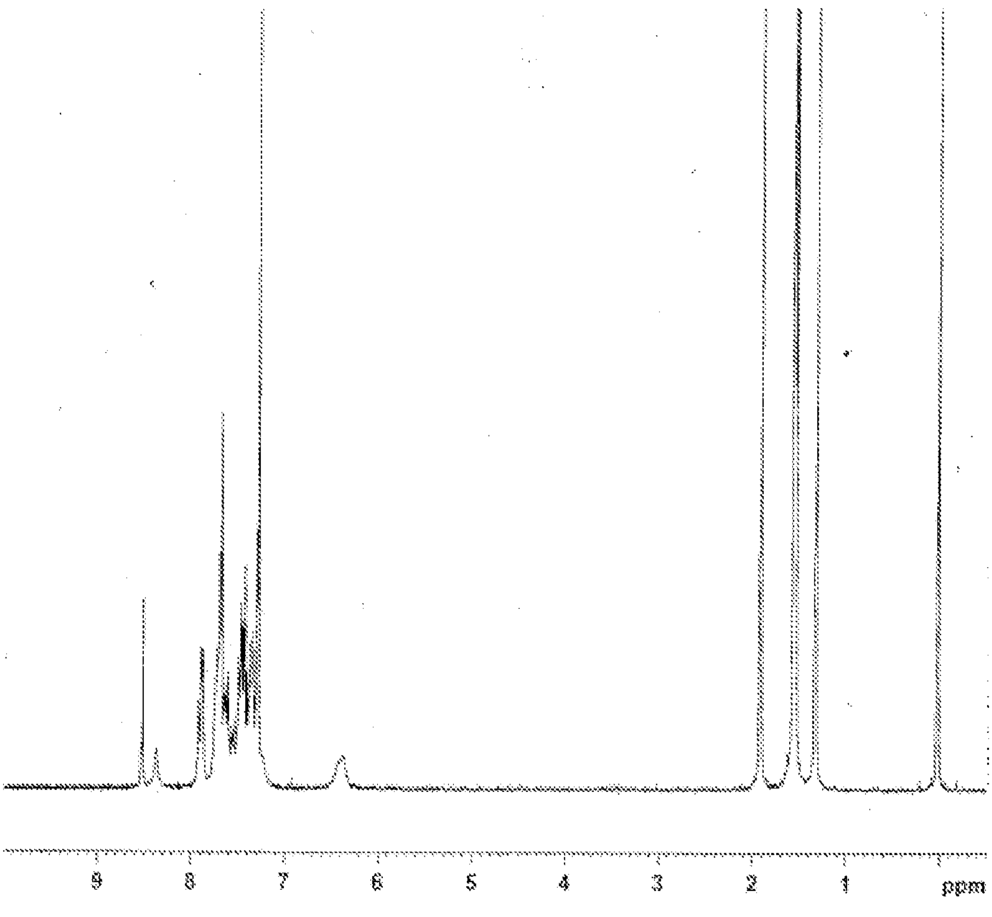


FIG.3

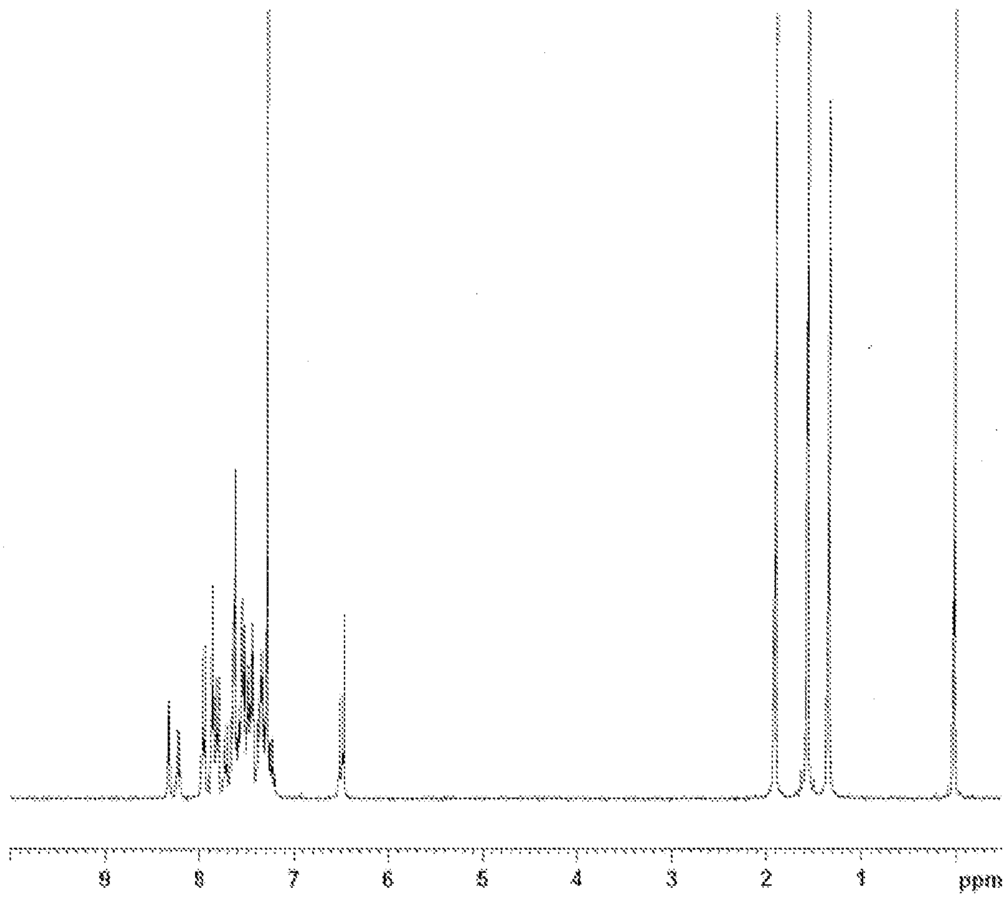


FIG.4

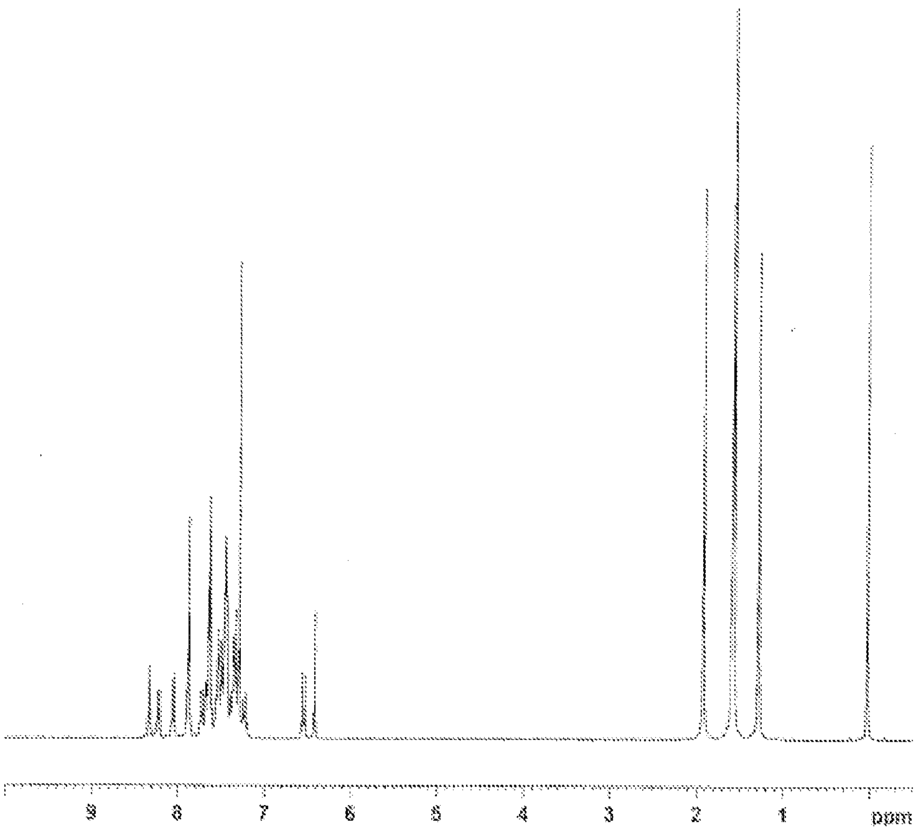
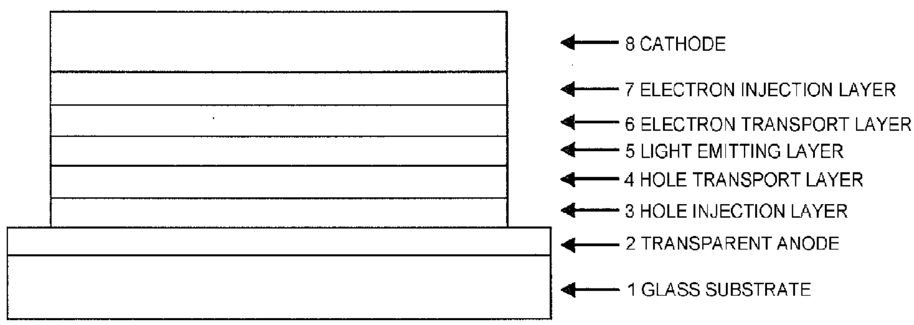

9
8
7
6
5
4
3
2
1
ppm

FIG. 5


8 CATHODE
7 ELECTRON INJECTION LAYER
6 ELECTRON TRANSPORT LAYER
5 LIGHT EMITTING LAYER
4 HOLE TRANSPORT LAYER
3 HOLE INJECTION LAYER
2 TRANSPARENT ANODE
1 GLASS SUBSTRATE

COMPOUND HAVING INDENOACRIDAN RING STRUCTURE, AND ORGANIC ELECTROLUMINESCENT DEVICE

TECHNICAL FIELD

[0001] The present invention relates to compounds suitable for an organic electroluminescent device which is a preferred self-luminous device for various display devices, and relates to the organic electroluminescent device. Specifically, this invention relates to compounds having an indenoacridan ring structure, and organic electroluminescent devices using the compounds.

BACKGROUND ART

[0002] The organic electroluminescent device is a self-luminous device and has been actively studied for their brighter, superior visibility and the ability to display clearer images in comparison with liquid crystal devices.

[0003] In 1987, C. W. Tang and colleagues at Eastman Kodak developed a laminated structure device using materials assigned with different roles, realizing practical applications of an organic electroluminescent device with organic materials. These researchers laminated an electron-transporting phosphor which is tris(8-hydroxyquinoline)aluminum (hereinafter referred to as Alq_3) and a hole-transporting aromatic amine compound, and injected both charges into a phosphor layer to cause emission in order to obtain a high luminance of 1,000 cd/m^2 or more at a voltage of 10 V or less (refer to Patent Documents 1 and 2, for example).

[0004] To date, various improvements have been made for practical applications of the organic electroluminescent device. In order to realize high efficiency and durability, various roles are further subdivided to provide an electroluminescence device that includes an anode, a hole injection layer, a hole transport layer, a light emitting layer, an electron transport layer, an electron injection layer, and a cathode successively formed on a substrate (refer to Non-Patent Document 1, for example).

[0005] Further, there have been attempts to use triplet excitons for further improvements of luminous efficiency, and the use of phosphorescent materials has been examined (refer to Non-Patent Document 2, for example).

[0006] Then, there have been developed devices that use a thermally activated delayed fluorescence (TADF). In 2011, Adachi et al. at Kyushu University, National University Corporation realized 5.3% external quantum efficiency with a device using a thermally activated delayed fluorescent material (refer to Non-Patent Document 3, for example).

[0007] The light emitting layer can be also fabricated by doping a charge-transporting compound generally called a host material, with a phosphor or a phosphorescent material. As described in the foregoing lecture preprints, the selection of organic materials in an organic electroluminescent device greatly influences various device characteristics such as efficiency and durability.

[0008] In an organic electroluminescent device, charges injected from both electrodes recombine in a light emitting layer to cause emission. What is important here is how efficiently the hole and electron charges are transferred to the light emitting layer. The probability of hole-electron recombination can be improved by improving hole injectability and electron blocking performance of blocking injected electrons from the cathode, and high luminous efficiency can be obtained by confining excitons generated in the light emitting layer. The role of a hole transport material is therefore important, and there is a need for a hole transport material that has high hole injectability, high hole mobility, high electron blocking performance, and high durability to electrons.

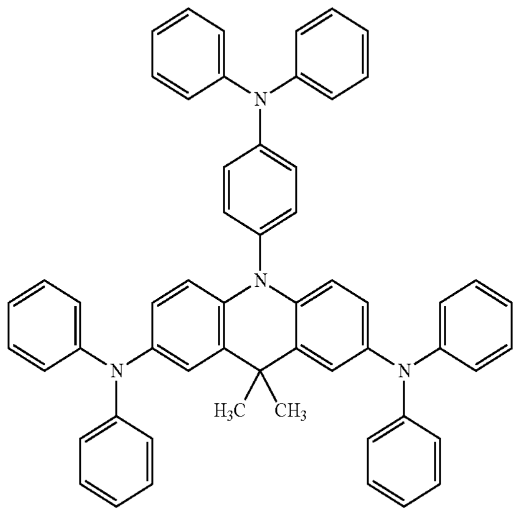
[0009] Heat resistance and amorphousness of the materials are also important with respect to a lifetime of the device. The materials with low heat resistance cause thermal decomposition even at a low temperature by heat generated during the drive of the device, which leads to the deterioration of the materials. The materials with low amorphousness cause crystallization of a thin film even in a short time and lead to the deterioration of the device. The materials in use are therefore required to have characteristics of high heat resistance and satisfactory amorphousness.

[0010] N,N'-diphenyl-N,N'-di(α-naphthyl)benzidine (hereinafter referred to as NPD) and various aromatic amine derivatives are known as the hole transport materials used for the organic electroluminescent device (refer to Patent Documents 1 and 2, for example). Although NPD has desirable hole transportability, it has a low glass transition point (Tg) of 96° C. which is an index of heat resistance and therefore causes the degradation of device characteristics by crystallization under a high-temperature condition (refer to Non-Patent Document 4, for example). The aromatic amine derivatives described in the Patent Documents 1 and 2 include a compound known to have an excellent hole mobility of 10^{-3} cm^2/Vs or higher. However, since the compound is insufficient in terms of electron blocking performance, some of the electrons pass through the light emitting layer, and improvements in luminous efficiency cannot be expected. For such a reason, a material with higher electron blocking performance, a more stable thin-film state and higher heat resistance is needed for higher efficiency.

[0011] Arylamine compounds of the following formulae having a substituted acridan structure (for example, Compounds A to C) are proposed as compounds improved in the characteristics such as heat resistance, hole injectability and electron blocking performance (refer to Patent Documents 3 to 5, for example).

[Chemical Formula 1]

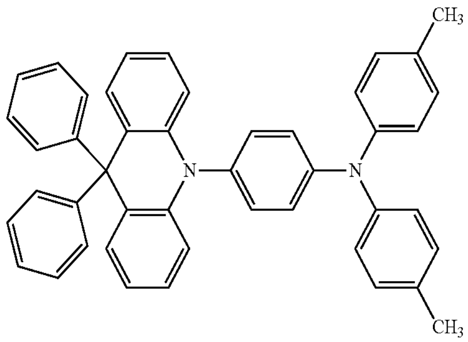
(Compound A)



-continued

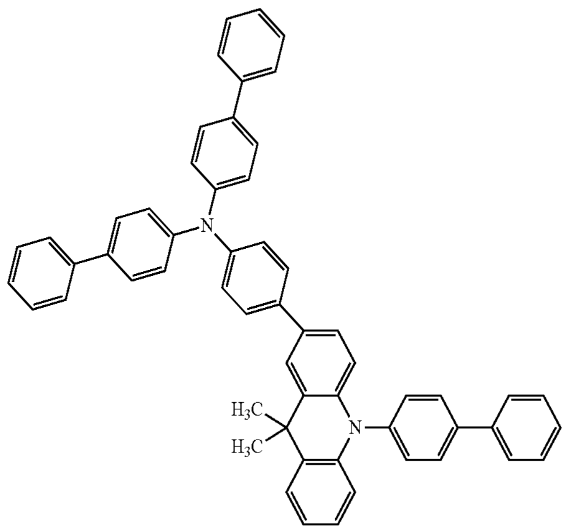
[Chemical Formula 2]

(Compound B)



[Chemical Formula 3]

(Compound C)



[0012] However, while the devices using these compounds for the hole injection layer or the hole transport layer have been improved in heat resistance, luminous efficiency and the like, the improvements are still insufficient. Further, it cannot be said to have a sufficiently low driving voltage and sufficient current efficiency, and there is a problem also in amorphousness. Further improvements of a low driving voltage and luminous efficiency while increasing amorphousness are therefore needed.

CITATION LIST

Patent Documents

[0013] Patent Document 1: JP-A-8-048656

[0014] Patent Document 2: Japanese Patent No. 3194657

[0015] Patent Document 3: WO2006/033563

[0016] Patent Document 4: WO2007/110228

[0017] Patent Document 5: WO2010/147319

Non-Patent Documents

[0018] Non-Patent Document 1: The Japan Society of Applied Physics, 9th Lecture Preprints, pp. 55 to 61 (2001)

[0019] Non-Patent Document 2: The Japan Society of Applied Physics, 9th Lecture Preprints, pp. 23 to 31 (2001)

[0020] Non-Patent Document 3: Appl. Phys. Let., 98, 083302 (2011)

[0021] Non-Patent Document 4: Organic EL Symposium, the 3rd Regular presentation Preprints, pp. 13 to 14 (2006)

[0022] Non-Patent Document 5: J. Org. Chem., 60, 7508 (1995)

[0023] Non-Patent Document 6: Synth. Commun., 11, 513 (1981)

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0024] An object of the present invention is to provide an organic compound with characteristics excelling in hole-injecting/transporting performance and having electron blocking ability, high stability in a thin-film state and excellent heat resistance, the organic compound being provided as material for an organic electroluminescent device having high luminous efficiency and high durability. This invention also provides the organic electroluminescent device of high efficiency and high durability using this compound.

[0025] Physical properties of the organic compound to be provided by the present invention include (1) good hole injection characteristics, (2) large hole mobility, (3) excellent electron blocking ability, (4) stability in the thin-film state, and (5) excellent heat resistance. Physical properties of the organic electroluminescent device to be provided by the present invention include (1) high luminous efficiency and high power efficiency, (2) low turn on voltage, and (3) low actual driving voltage.

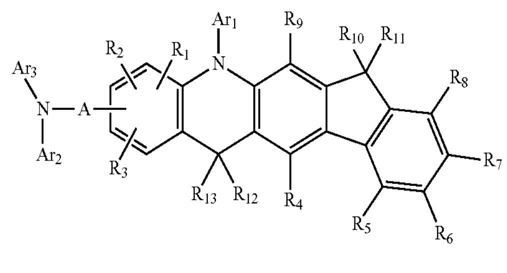
Means for Solving the Problems

[0026] In order to achieve the above objects, the present inventors designed compounds having an indenoacridan ring structure in anticipation of the high hole-injecting/transporting ability of an aromatic tertiary amine structure, the electron blocking performance of the indenoacridan ring structure, and the effect of heat resistance and thin-film stability of these partial structures. The present inventors produced various test organic electroluminescent devices using the compounds chemically synthesized to have the indenoacridan ring structure, and the present invention was completed after thorough evaluations of the device characteristics.

[0027] 1) Specifically, the present invention is a compound of the following general formula (1) having an indenoacridan ring structure.

[Chemical Formula 4]

(1)

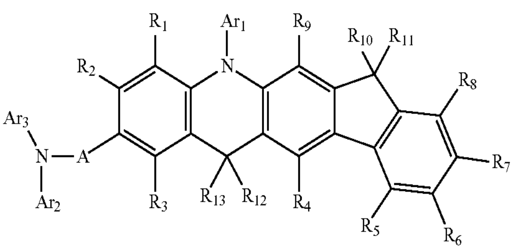


[0028] In the formula, A represents a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, a divalent group of substituted or unsubstituted condensed polycyclic aromatics, or a single bond. Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. When A is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics, A and Ar_2 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0029] 2) Further, the present invention is a compound of the following general formula (1-1) having an indenoacridan ring structure according to 1).

[Chemical Formula 5]

(1-1)



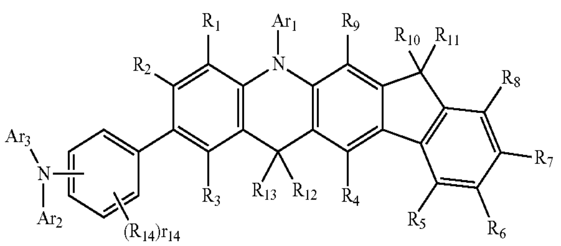
[0030] In the formula, A represents a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, a divalent group of substituted or unsubstituted condensed polycyclic aromatics, or a single bond. Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. When A is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics, A and Ar_2 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0031] 3) Further, the present invention is a compound of the general formula (1) or (1-1) having an indenoacridan ring structure according to 1) or 2) in which A is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics.

[0032] 4) Further, the present invention is a compound of the following general formula (1-2) having an indenoacridan ring structure according to 3).

[Chemical Formula 6]

(1-2)

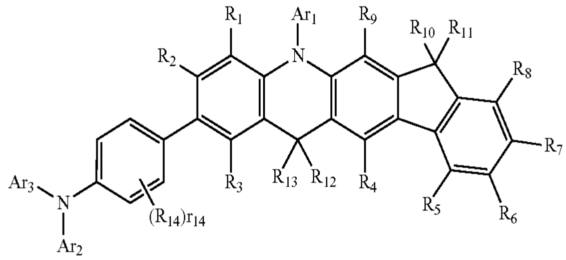


[0033] In the formula, Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{14} represents a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, substituted or unsubstituted aryloxy, or a bonding group, which may bind to each other to form a ring when a plurality of these substituents bind to the same benzene ring (when r_{14} is 2 or more). r_{14} represents 0 or an integer of 1 to 4, and the substituent R_{14} does not exist when r_{14} is 0. When R_{14} is a bonding group, r_{14} is 1, and the benzene ring binding with R_{14} and Ar_2 bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0034] 5) Further, the present invention is a compound of the following general formula (1-3) having an indenoacridan ring structure according to 3).

[Chemical Formula 7]

(1-3)

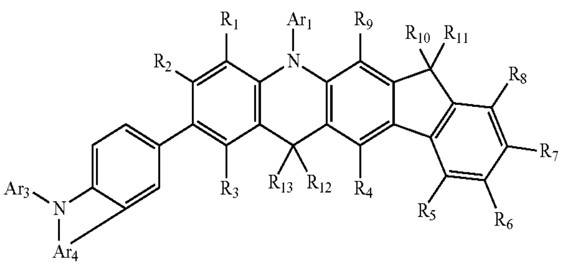


[0035] In the formula, Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{14} represents a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, substituted or unsubstituted aryloxy, or a bonding group, which may bind to each other to form a ring when a plurality of these substituents bind to the same benzene ring (when r_{14} is 2 or more). r_{14} represents 0 or an integer of 1 to 4, and the substituent R_{14} does not exist when r_{14} is 0. When R_{14} is a bonding group, r_{14} is 1, and the benzene ring binding with R_{14} and Ar_2 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0036] 6) Further, the present invention is a compound of the following general formula (1-4) having an indenoacridan ring structure according to 4).

[Chemical Formula 8]

(1-4)

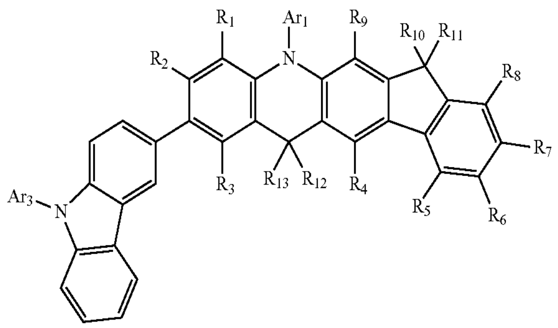


[0037] In the formula, Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_4 represents a divalent group derived from a substituted or unsubstituted aromatic hydrocarbon group, a divalent group derived from a substituted or unsubstituted aromatic heterocyclic group, or a divalent group derived from a substituted or unsubstituted condensed polycyclic aromatic group. Ar_3 and Ar_4 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0038] 7) Further, the present invention is a compound of the following general formula (1-4a) having an indenoacridan ring structure according to 4).

[Chemical Formula 9]

(1-4a)

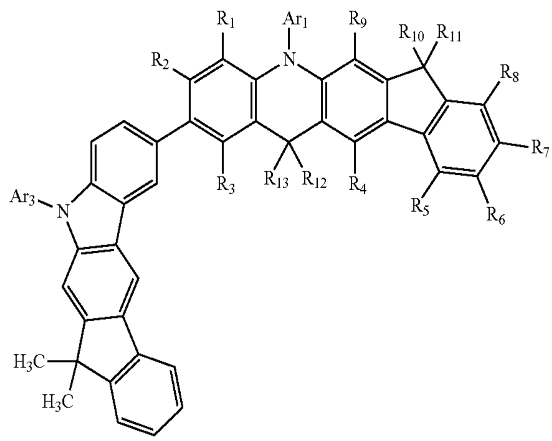


[0039] In the formula, Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0040] 8) Further, the present invention is a compound of the following general formula (1-4b) having an indenoacridan ring structure according to 4).

[Chemical Formula 10]

(1-4b)

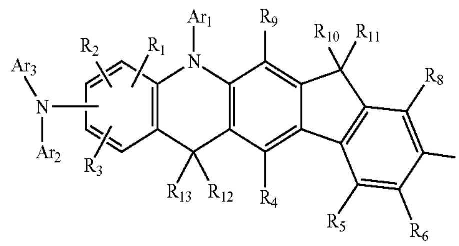


[0041] In the formula, Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0042] 9) Further, the present invention is a compound of the following general formula (1-5) having an indenoacridan ring structure according to 1).

[Chemical Formula 11]

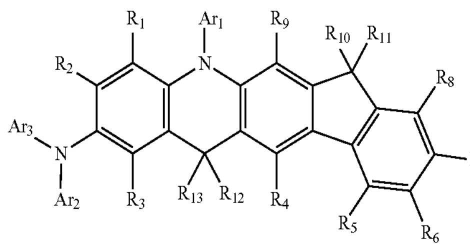
(1-5)



[0043] In the formula, Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0044] 10) Further, the present invention is a compound of the following general formula (1-6) having an indenoacridan ring structure.

[Chemical Formula 12]



(1-6)

[0045] In the formula, Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group. Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring. R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy. R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0046] 11) Further, the present invention is an organic electroluminescent device that includes a pair of electrodes, and one or more organic layers sandwiched between the pair of electrodes, wherein the compound having an indenoacridan ring structure according to 1) is used as a constituent material of at least one organic layer.

[0047] 12) Further, the present invention is an organic electroluminescent device according to 11) in which the organic layer is a hole transport layer.

[0048] 13) Further, the present invention is an organic electroluminescent device according to 11) in which the organic layer is an electron blocking layer.

[0049] 14) Further, the present invention is an organic electroluminescent device according to 11) in which the organic layer is a hole injection layer.

[0050] 15) Further, the present invention is an organic electroluminescent device according to 11) in which the organic layer is a light emitting layer.

[0051] Specific examples of the "substituted or unsubstituted aromatic hydrocarbon", "substituted or unsubstituted aromatic heterocyclic ring", or "substituted or unsubstituted condensed polycyclic aromatics" in the "divalent group of a substituted or unsubstituted aromatic hydrocarbon", "divalent group of a substituted or unsubstituted aromatic heterocyclic ring", or "divalent group of substituted or unsubstituted condensed polycyclic aromatics" represented by A in general formula (1) include benzene, biphenyl, terphenyl, tetrakisphenyl, styrene, naphthalene, anthracene, acenaphthalene, fluorene, phenanthrene, indane, pyrene, pyridine, pyrimidine, triazine, furan, pyrrole, thiophene, quinoline, isoquinoline, benzofuran, benzothiophene, indoline, carbazole, carboline, benzoxazole, benzothiazole, quinoxaline, benzimidazole, pyrazole, dibenzofuran, dibenzothiophene, naphthyridine, phenanthroline, and acridine.

[0052] The "divalent group of a substituted or unsubstituted aromatic hydrocarbon", "divalent group of a substituted or unsubstituted aromatic heterocyclic ring", or "divalent group of substituted or unsubstituted condensed polycyclic aromatics" represented by A in general formula (1) is a divalent group that result from the removal of two hydrogen atoms from the above "aromatic hydrocarbon", "aromatic heterocyclic ring", or "condensed polycyclic aromatics".

[0053] It is preferable that the "aromatic heterocyclic ring" in the "divalent group of a substituted or unsubstituted aromatic heterocyclic ring" is a sulfur-containing aromatic heterocyclic ring such as thiophene, benzothiophene, benzothiazole, or dibenzothiophene; or an oxygen-containing aromatic heterocyclic ring such as furan, benzofuran, benzoxazole, or dibenzofuran.

[0054] It is preferable that A in general formula (1) is the "divalent group of a substituted or unsubstituted aromatic hydrocarbon" or the "divalent group of substituted condensed polycyclic aromatics" particularly preferably the divalent group derived from benzene.

[0055] Specific examples of the "substituent" of the "aromatic hydrocarbon", "aromatic heterocyclic ring", or "condensed polycyclic aromatics" in the "divalent group of a substituted or unsubstituted aromatic hydrocarbon", "divalent group of a substituted or un substituted aromatic heterocyclic ring", or "divalent group of substituted or unsubstituted condensed polycyclic aromatics" represented by A in general formula (1) can be a deuterium atom; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyls of 1 to 6 carbon atoms such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, and n-hexyl; linear or branched alkyloxy of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aryloxys such as phenyloxy and tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl; arylvinyls such as styryl and naphthylvinyl; and acyls such as acetyl and benzoyl. These substituents may be further substituted with the above exemplified substituents.

[0056] Further, these substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0057] Specific examples of the "aromatic hydrocarbon group", "aromatic heterocyclic group", or "condensed polycyclic aromatic group" in the "substituted or unsubstituted aromatic hydrocarbon group", "substituted or unsubstituted aromatic heterocyclic group", or "substituted or unsubstituted condensed polycyclic aromatic group" represented by Ar_1, Ar_2, and Ar_3 in general formula (1) include phenyl, biphenylyl, terphenylyl, naphthyl, anthryl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, triphenylenyl, pyridyl, furyl, pyrrolyl, thienyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzoxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0058] It is preferable that the "aromatic heterocyclic group" in the "substituted or unsubstituted aromatic heterocyclic group" represented by Ar_1, Ar_2 and Ar_3 in general formula (1) is a sulfur-containing aromatic heterocyclic group such as thienyl, benzothienyl, benzothiazolyl, and dibenzothienyl; or an oxygen-containing aromatic heterocyclic group such as furyl, benzofuranyl, benzoxazolyl, and dibenzofuranyl.

[0059] It is preferable that Ar_2 in general formula (1) is phenyl, naphthyl, fluorenyl, thienyl, benzothienyl, and dibenzothienyl, particularly preferably phenyl and fluorenyl.

[0060] Specific examples of the "substituent" in the "substituted aromatic hydrocarbon group", "substituted aromatic heterocyclic group", or "substituted condensed polycyclic aromatic group" represented by Ar_1, Ar_2, and Ar_3 in general formula (1) include a deuterium atom, cyano, nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyl of 1 to 6 carbon atoms such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, and n-hexyl; linear or branched alkyloxy of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aryloxys such as phenyloxy and tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl; arylvinyls such as styryl and naphthylvinyl; and acyls such as acetyl and benzoyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other, or to Ar_1, Ar_2, or Ar_3 via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0061] Specific examples of the divalent group derived from a substituted or unsubstituted aromatic hydrocarbon group, divalent group derived from a substituted or unsubstituted aromatic heterocyclic group, or divalent group derived from a substituted or unsubstituted condensed polycyclic aromatic group represented by Ar_4 in general formula (1-4) may include the divalent group derived from the Ar_2 above, and specifically may be the divalent group derived from the same group exemplified as the group for Ar_2 in the general formula (1). Specific examples of the substituent that these groups may have may include the same substituent exemplified as the substituent for Ar_2 above. Further, preferable embodiments may be the same embodiments exemplified as the embodiments for Ar_2 above. The divalent group may bind to Ar_3 via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0062] Specific examples of the "linear or branched alkyl of 1 to 6 carbon atoms", "cycloalkyl of 5 to 10 carbon atoms", or "linear or branched alkenyl of 2 to 6 carbon atoms" in the "linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent", "cycloalkyl of 5 to 10 carbon atoms that may have a substituent", or "linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent" represented by R_1 to R_9 in the general formula (1) include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, n-hexyl, cyclopentyl, cyclohexyl, 1-adamantyl, 2-adamantyl, vinyl, allyl, isopropenyl, and 2-butenyl. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0063] Specific examples of the "substituent" in the "linear or branched alkyl of 1 to 6 carbon atoms that has a substituent", the "cycloalkyl of 5 to 10 carbon atoms that has a substituent", or the "linear or branched alkenyl of 2 to 6 carbon atoms that has a substituent" represented by R_1 to R_9 in the general formula (1) include a deuterium atom; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aryloxys such as phenyloxy and tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; and aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0064] Specific examples of the "linear or branched alkyloxy of 1 to 6 carbon atoms" or the "cycloalkyloxy of 5 to 10 carbon atoms" in the "linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent" or the "cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent" represented by R_1 to R_9 in the general formula (1) include methyloxy, ethyloxy, n-propyloxy, isopropyloxy, n-butyloxy, tert-butyloxy, n-pentyloxy, n-hexyloxy, cyclopentyloxy, cyclohexyloxy, cycloheptyloxy, cyclooctyloxy, 1-adamantyloxy, and 2-adamantyloxy. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0065] Specific examples of the "substituent" in the "linear or branched alkyloxy of 1 to 6 carbon atoms that has a substituent" or the "cycloalkyloxy of 5 to 10 carbon atoms that has a substituent" represented by R_1 to R_9 in the general formula (1) include a deuterium atom; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aryloxys such as phenyloxy and tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; and aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0066] Specific examples of the "aromatic hydrocarbon group", the "aromatic heterocyclic group", or the "condensed polycyclic aromatic group" in the "substituted or unsubstituted aromatic hydrocarbon group", the "substituted or unsubstituted aromatic heterocyclic group", or the "substituted or unsubstituted condensed polycyclic aromatic group" represented by R_1 to R_9 in the general formula (1) include phenyl, biphenylyl, terphenylyl, naphthyl, anthryl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, triphenylenyl, pyridyl, furyl, pyrrolyl, thienyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0067] It is preferable that the "aromatic heterocyclic group" in the "substituted or unsubstituted aromatic heterocyclic group" represented by R_1 to R_9 in general formula (1) is a sulfur-containing aromatic heterocyclic group such as thienyl, benzothienyl, benzothiazolyl, and dibenzothienyl.

[0068] Specific examples of the "substituent" in the "substituted aromatic hydrocarbon group", the "substituted aromatic heterocyclic group", or the "substituted condensed polycyclic aromatic group" represented by R_1 to R_9 in general formula (1) include a deuterium atom; trifluoromethyl; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyls of 1 to 6 carbon atoms such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, and n-hexyl; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aralkyls such as benzyl, naphthylmethyl, and phenethyl; aryloxys such as phenyloxy, tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl; arylvinyls such as styryl and naphthylvinyl; acyls such as acetyl and benzoyl; dialkylamino groups such as dimethylamino and diethylamino; disubstituted amino groups such as diphenylamino and dinaphthylamino, substituted with aromatic hydrocarbon groups or condensed polycyclic aromatic groups; diaralkylamino groups such as dibenzylamino and diphenethylamino; disubstituted amino groups such as dipyridylamino and dithienylamino, substituted with aromatic heterocyclic groups; dialkenylamino groups such as diallylamino; and disubstituted amino groups substituted with a substituent selected from alkyl, an aromatic hydrocarbon group, a condensed polycyclic aromatic group, aralkyl, an aromatic heterocyclic group, and alkenyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0069] Specific examples of the "aryloxy" in the "substituted or unsubstituted aryloxy" represented by R_1 to R_9 in general formula (1) include phenyloxy, biphenylyloxy, terphenylyloxy, naphthyloxy, anthryloxy, phenanthryloxy, fluorenyloxy, indenyloxy, pyrenyloxy, and perylenyloxy. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0070] Specific examples of the "substituent" in the "substituted aryloxy" represented by R_1 to R_9 in general formula (1) include a deuterium atom; trifluoromethyl; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyls of 1 to 6 carbon atoms such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, and n-hexyl; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aralkyls such as benzyl, naphthylmethyl, and phenethyl; aryloxys such as phenyloxy, tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl; arylvinyls such as styryl and naphthylvinyl; acyls such as acetyl and benzoyl; dialkylamino groups such as dimethylamino and diethylamino; disubstituted amino groups such as diphenylamino and dinaphthylamino, substituted with aromatic hydrocarbon groups or condensed polycyclic aromatic groups; diaralkylamino groups such as dibenzylamino and diphenethylamino; disubstituted amino groups such as dipyridylamino and dithienylamino, substituted with aromatic heterocyclic groups; dialkenylamino groups such as diallylamino; and disubstituted amino groups substituted with a substituent selected from alkyl, an aromatic hydrocarbon group, a condensed polycyclic aromatic group, aralkyl, an aromatic heterocyclic group, and alkenyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0071] Specific examples of the "linear or branched alkyl of 1 to 6 carbon atoms", "cycloalkyl of 5 to 10 carbon atoms", or "linear or branched alkenyl of 2 to 6 carbon atoms" in the "linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent", "cycloalkyl of 5 to 10 carbon atoms that may have a substituent", or "linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent" represented by R_{10} to R_{13} in the general formula (1) include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, n-hexyl, cyclopentyl, cyclohexyl, 1-adamantyl, 2-adamantyl, vinyl, allyl, isopropenyl, and 2-butenyl. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0072] Specific examples of the "substituent" in the "linear or branched alkyl of 1 to 6 carbon atoms that has a substituent", the "cycloalkyl of 5 to 10 carbon atoms that has a substituent", or the "linear or branched alkenyl of 2 to 6 carbon atoms that has a substituent" represented by R_{10} to R_{13} in the general formula (1) include a deuterium atom; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aryloxys such as phenyloxy, tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; and aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0073] Specific examples of the "linear or branched alkyloxy of 1 to 6 carbon atoms" or the "cycloalkyloxy of 5 to 10 carbon atoms" in the "linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent" or the "cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent" represented by R_{10} to R_{13} in the general formula (1) include methyloxy, ethyloxy, n-propyloxy, isopropyloxy, n-butyloxy, tert-butyloxy, n-pentyloxy, n-hexyloxy, cyclopentyloxy, cyclohexyloxy, cycloheptyloxy, cyclooctyloxy, 1-adamantyloxy, and 2-adamantyloxy. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0074] Specific examples of the "substituent" in the "linear or branched alkyloxy of 1 to 6 carbon atoms that has a substituent" or the "cycloalkyloxy of 5 to 10 carbon atoms that has a substituent" represented by R_{10} to R_{13} in the general formula (1) include a deuterium atom; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aryloxys such as phenyloxy and tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; and aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0075] Specific examples of the "aromatic hydrocarbon group", "aromatic heterocyclic group", or "condensed polycyclic aromatic group" in the "substituted or unsubstituted aromatic hydrocarbon group", "substituted or unsubstituted aromatic heterocyclic group", or "substituted or unsubstituted condensed polycyclic aromatic group" represented by R_{10} to R_{13} in general formula (1) include phenyl, biphenylyl, terphenylyl, naphthyl, anthryl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, triphenylenyl, pyridyl, furyl, pyrrolyl, thienyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzoxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0076] It is preferable that the "aromatic heterocyclic group" in the "substituted or unsubstituted aromatic heterocyclic group" represented by R_{10} to R_{13} in general formula (1) is a sulfur-containing aromatic heterocyclic group such as thienyl, benzothienyl, benzothiazolyl, and dibenzothienyl.

[0077] Specific examples of the "substituent" in the "substituted aromatic hydrocarbon group", the "substituted aromatic heterocyclic group", or the "substituted condensed polycyclic aromatic group" represented by R_{10} to R_{13} in general formula (1) include a deuterium atom; trifluoromethyl; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyls of 1 to 6 carbon atoms such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, and n-hexyl; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aralkyls such as benzyl, naphthylmethyl, and phenethyl; aryloxys such as phenyloxy, tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl; arylvinyls such as styryl and naphthylvinyl; acyls such as acetyl and benzoyl; dialkylamino groups such as dimethylamino and diethylamino; disubstituted amino groups such as diphenylamino and dinaphthylamino, substituted with aromatic hydrocarbon groups or condensed polycyclic aromatic groups; diaralkylamino groups such as dibenzylamino and diphenethylamino; disubstituted amino groups such as dipyridylamino and dithienylamino, substituted with aromatic heterocyclic groups; dialkenylamino groups such as diallylamino; and disubstituted amino groups substituted with a substituent selected from alkyl, an aromatic hydrocarbon group, a condensed polycyclic aromatic group, aralkyl, an aromatic heterocyclic group, and alkenyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0078] Specific examples of the "aryloxy" in the "substituted or unsubstituted aryloxy" represented by R_{10} to R_{13} in general formula (1) include phenyloxy, biphenylyloxy, terphenylyloxy, naphthyloxy, anthryloxy, phenanthryloxy, fluorenyloxy, indenyloxy, pyrenyloxy, and perylenyloxy. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0079] Specific examples of the "substituent" in the "substituted aryloxy" represented by R_{10} to R_{13} in general formula (1) include a deuterium atom; trifluoromethyl; cyano; nitro; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; linear or branched alkyls of 1 to 6 carbon atoms such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, n-pentyl, isopentyl, neopentyl, and n-hexyl; linear or branched alkyloxys of 1 to 6 carbon atoms such as methyloxy, ethyloxy, and propyloxy; alkenyls such as allyl; aralkyls such as benzyl, naphthylmethyl, and phenethyl; aryloxys such as phenyloxy, tolyloxy; arylalkyloxys such as benzyloxy and phenethyloxy; aromatic hydrocarbon groups or condensed polycyclic aromatic groups such as phenyl, biphenylyl, terphenylyl, naphthyl, anthracenyl, phenanthryl, fluorenyl, indenyl, pyrenyl, perylenyl, fluoranthenyl, and triphenylenyl; aromatic heterocyclic groups such as pyridyl, thienyl, furyl, pyrrolyl, quinolyl, isoquinolyl, benzofuranyl, benzothienyl, indolyl, carbazolyl, benzooxazolyl, benzothiazolyl, quinoxalyl, benzoimidazolyl, pyrazolyl, dibenzofuranyl, dibenzothienyl, and carbolinyl; arylvinyls such as styryl and naphthylvinyl; acyls such as acetyl and benzoyl; dialkylamino groups such as dimethylamino and diethylamino; disubstituted amino groups such as diphenylamino and dinaphthylamino, substituted with aromatic hydrocarbon groups or condensed polycyclic aromatic groups; diaralkylamino groups such as dibenzylamino and diphenethylamino; disubstituted amino groups such as dipyridylamino and dithienylamino, substituted with aromatic heterocyclic groups; dialkenylamino groups such as diallylamino; and disubstituted amino groups substituted with a substituent selected from alkyl, an aromatic hydrocarbon group, a condensed polycyclic aromatic group, aralkyl, an aromatic heterocyclic group, and alkenyl. These substituents may be further substituted with the exemplified substituents above. These substituents may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

[0080] It is preferable that R_{10} to R_{13} in general formula (1) are "linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent" and "substituted or unsubstituted aromatic hydrocarbon group", further preferably methyl and phenyl, and particularly preferably methyl.

[0081] Specific examples of the "linear or branched alkyl of 1 to 6 carbon atoms", "cycloalkyl of 5 to 10 carbon atoms", or "linear or branched alkenyl of 2 to 6 carbon atoms" in the "linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent", "cycloalkyl of 5 to 10 carbon atoms that may have a substituent", or "linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent" represented by R_{14} in the general formulae (1-2) and (1-3) may include the same group exemplified as the group for R_1 to R_9 in the general formula (1) above. Specific examples of the substituent that these groups may have may be the same substituent exemplified as the substituent for R_1 to R_9 above. Further, preferable embodiments may be the same embodiments exemplified as the embodiments for R_1 to R_9 above. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring when a plurality of R_{14} are present (when r_{14} is 2 or more).

[0082] Specific examples of the "linear or branched alkyloxy of 1 to 6 carbon atoms" or "cycloalkyloxy of 5 to 10 carbon atoms" in the "linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent" or "cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent" represented by R_{14} in the general formulae (1-2) and (1-3) may include the same group exemplified as the group for R_1 to R_9 in the general formula (1) above. Specific examples of the substituent that these groups may have may include the same substituent exemplified as the substituent for R_1 to R_9 above. Further, preferable embodiments may be the same embodiments exemplified as embodiments for R_1 to R_9 above. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring when a plurality of R_{14} are present (when r_{14} is 2 or more).

[0083] Specific examples of the "aromatic hydrocarbon group", "aromatic heterocyclic group", or "condensed polycyclic aromatic group" in the "substituted or unsubstituted aromatic hydrocarbon group", "substituted or unsubstituted aromatic heterocyclic group", or "substituted or unsubstituted condensed polycyclic aromatic group" represented by R_{14} in the general formulae (1-2) and (1-3) may include the same group exemplified as the group for R_1 to R_9 in the general formula (1) above. Specific examples of the substituent that these groups may have may include the same substituent exemplified as the substituent for R_1 to R_9 above. Further, preferable embodiments may be the same embodiments exemplified as the embodiments for R_1 to R_9 above. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring when a plurality of R_{14} are present (when r_{14} is 2 or more).

[0084] Specific examples of the "aryloxy" in the "substituted or unsubstituted aryloxy" represented by R_{14} in the general formulae (1-2) and (1-3) may include the same group exemplified as the group for R_1 to R_9 in the general formula (1) above. Specific examples of the substituent that these groups may have may include the same substituent exemplified as the substituent for R_1 to R_9 above. Further, preferable embodiments may be the same embodiments exemplified as embodiments for R_1 to R_9 above. These groups may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring when a plurality of R_{14} are present (when r_{14} is 2 or more).

[0085] The compounds of general formula (1) having an indenoacridan ring structure of the present invention are novel compounds and have superior electron blocking ability, superior amorphousness and a more stable thin-film state compared to conventional hole transport materials.

[0086] The compounds of general formula (1) having an indenoacridan ring structure of the present invention can be used as a constituent material of the hole injection layer and/or hole transport layer of an organic electroluminescent device (hereinafter referred to as an organic EL device). With the use of material having higher hole injectability, higher mobility, higher electron blocking performance and higher stability to electrons than conventional materials, excitons generated in a light emitting layer can be confined, and the probability of hole-electron recombination can be improved. This improves luminous efficiency, lowers driving voltage and thus improves the durability of the organic EL device.

[0087] The compounds of general formula (1) having an indenoacridan ring structure of the present invention can also be used as a constituent material of the electron blocking layer of an organic EL device. With the use of material having an excellent electron blocking ability and having superior hole transportability and higher stability in a thin-film state than conventional materials, driving voltage is lowered and current resistance is improved while maintaining high luminous efficiency. As a result, the maximum emission luminance of the organic EL device is improved.

[0088] The compounds of general formula (1) having an indenoacridan ring structure of the present invention can also be used as a constituent material of the light emitting layer of the organic EL device. The material of the present invention having superior hole transportability and a wider band gap than conventional materials is used as the host material of the light emitting layer in order to form the light emitting layer by carrying a fluorescent material or phosphorescent material called a dopant. In this way, the organic EL device with a low driving voltage and improved luminous efficiency can be achieved.

[0089] The high efficiency and high durability of the organic EL device in the present invention can be achieved because of the use of the compound having an indenoacridan ring structure, which has greater hole mobility, superior electron blocking ability and superior amorphousness than conventional hole transport materials as well as a stable thin-film state.

Effects of the Invention

[0090] The compound having an indenoacridan ring structure of the present invention is useful as the constituent material of the hole injection layer, hole transport layer, electron blocking layer, or light emitting layer of the organic EL device. The compound has an excellent electron blocking ability and satisfactory amorphousness, and excels in heat resistance as well as a stable thin-film state. The organic EL device of the present invention has high luminous efficiency and high power efficiency, and the actual driving voltage of the device can thereby be lowered. Further, turn on voltage can be lowered to improve durability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0091] FIG. **1** is a ^{1}H-NMR chart of the compound of Example 1 of the present invention (Compound 2).

[0092] FIG. **2** is a ^{1}H-NMR chart of the compound of Example 2 of the present invention (Compound 3).

[0093] FIG. **3** is a ^{1}H-NMR chart of the compound of Example 3 of the present invention (Compound 18).

[0094] FIG. **4** is a ^{1}H-NMR chart of the compound of Example 4 of the present invention (Compound 19).

[0095] FIG. **5** is a diagram illustrating the configuration of the EL devices of Examples 7 to 10 and Comparative Example 1.

MODE FOR CARRYING OUT THE INVENTION

[0096] The compounds having an indenoacridan ring structure of the present invention are novel compounds, and may be synthesized, for example, as follows. For example, after 2-(9,9-dimethylfluorene-2-yl)amino methyl benzoate is synthesized by the reaction of 2-amino methyl benzoate with 9,9-dimethyl-2-iodofluorene, 2-{2-(9,9-dimethylfluorene-2-yl)amino)phenyl}propane-2-ol is synthesized by the reaction with methylmagnesium chloride, and then, 7,7,13,13-tetramethyl-7,13-dihydro-5H-indeno[1,2-b]acridin can be synthesized by a cyclization reaction. Further, the 7,7,13,13-tetramethyl-7,13-dihydro-5H-indeno[1,2-b]acridin can be subjected to a condensation reaction such as a Buchward-Hartwig reaction with aryl halide to synthesize an indenoacridan derivative substituted with an aryl group at the 5-position. Further, the indenoacridan derivative can be brominated with N-bromosuccinimide or the like to synthesize an indenoacridan derivative brominated at the 2 position. A bromo compound having substituents at different positions can be obtained by changing reagents and conditions of bromination.

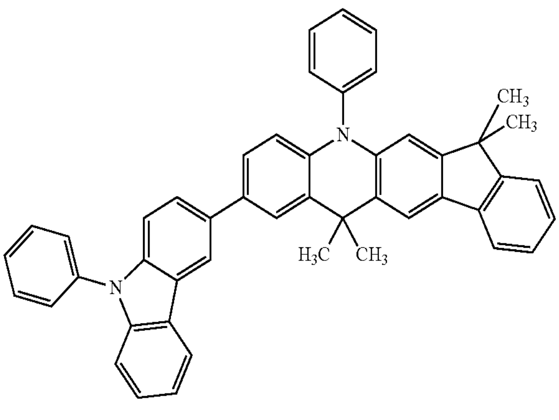
[0097] Further, the above indenoacridan derivative can be reacted with various boronic acid or borate (refer to Non-Patent Document 5, for example) in a cross-coupling reaction such as Suzuki coupling (refer to Non-Patent Document 6, for example) to synthesize the compounds having an indenoacridan ring structure of the present invention.

[0098] Also, the compounds having an indenoacridan ring structure of the present invention may be synthesized, for example, as follows. The above indenoacridan derivative substituted with an aryl group at the 5-position can be reacted with various diarylamine in a cross-coupling reaction such as Buchward-Hartwig reaction to synthesize the compounds having an indenoacridan ring structure of the present invention.

[0099] The following presents specific examples of preferred compounds among the compounds of general formula (1) having an indenoacridan ring structure. The present invention, however, is not restricted to these compounds.

[Chemical Formula 13]

(Compound 2)



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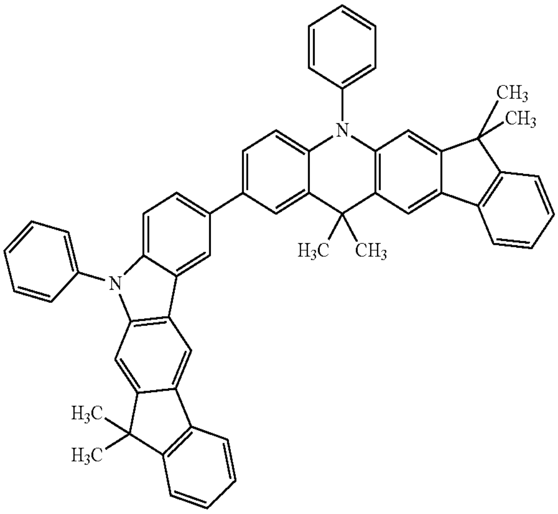
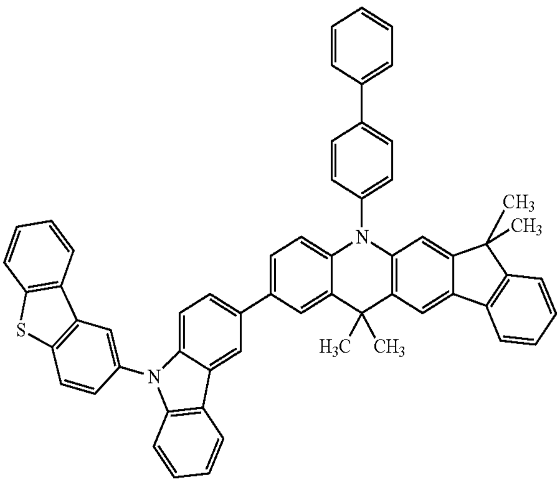
[Chemical Formula 14]

(Compound 3)



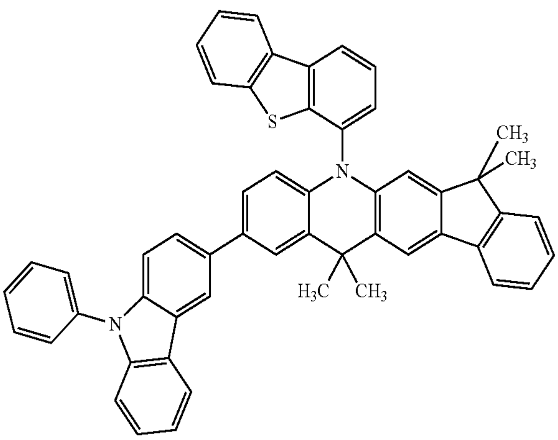
[Chemical Formula 15]

(Compound 4)



[Chemical Formula 16]

(Compound 5)



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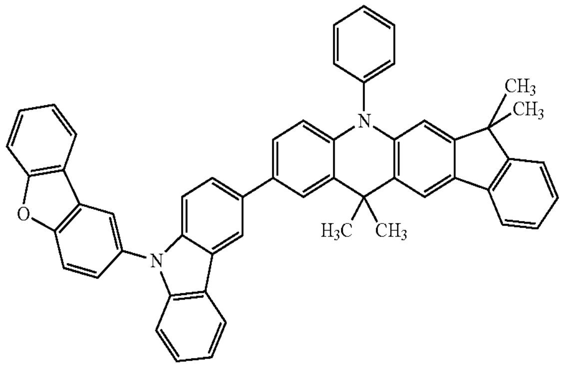
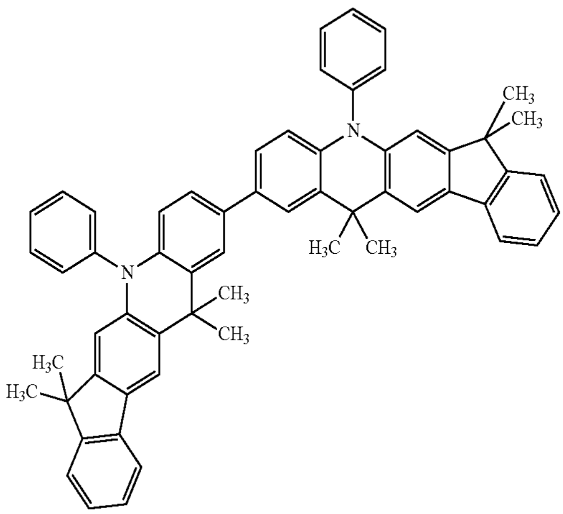
[Chemical Formula 17]

(Compound 6)



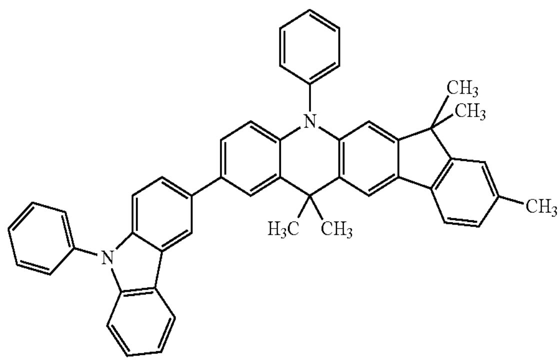
[Chemical Formula 18]

(Compound 7)



[Chemical Formula 19]

(Compound 8)



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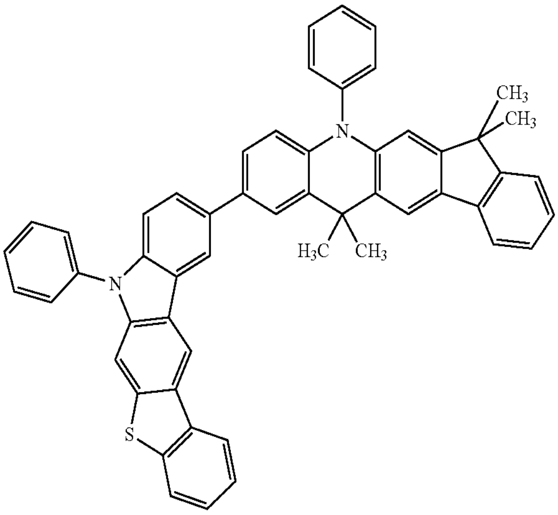
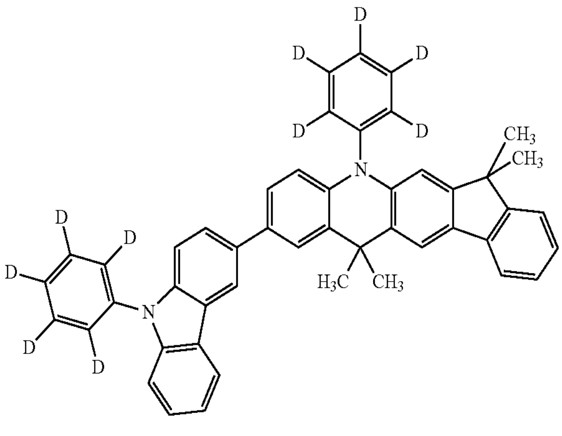
[Chemical Formula 20]

(Compound 9)



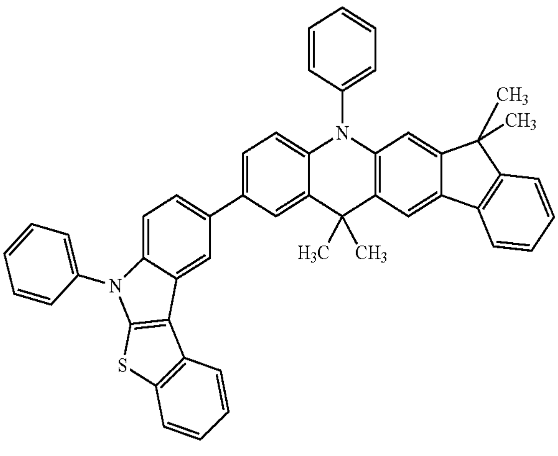
[Chemical Formula 21]

(Compound 10)



[Chemical Formula 22]

(Compound 11)



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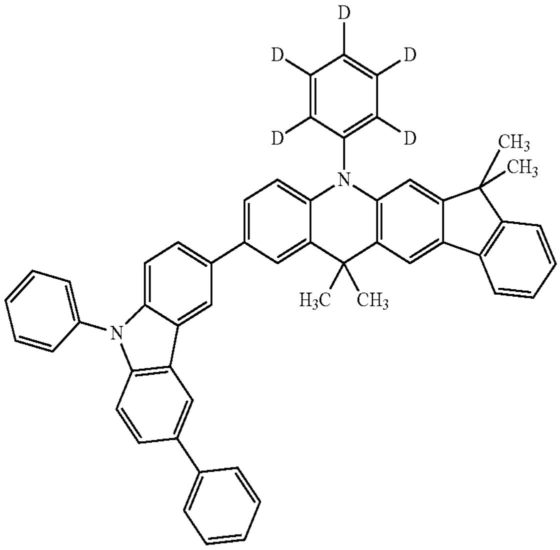
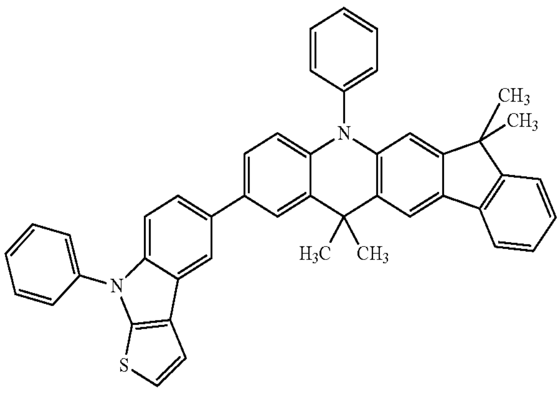
[Chemical Formula 23]

(Compound 12)



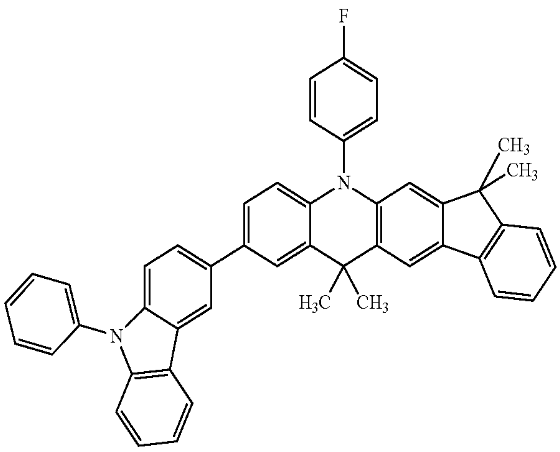
[Chemical Formula 24]

(Compound 13)



[Chemical Formula 25]

(Compound 14)



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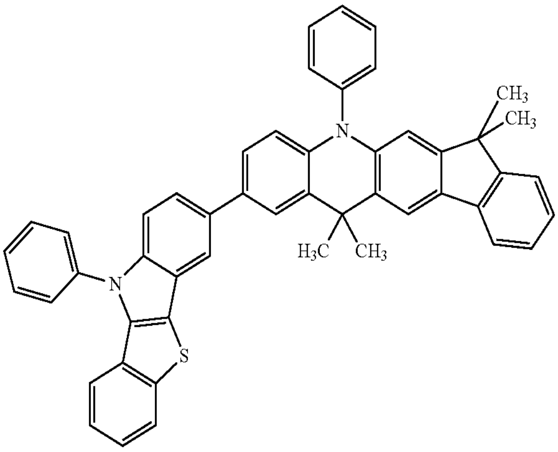
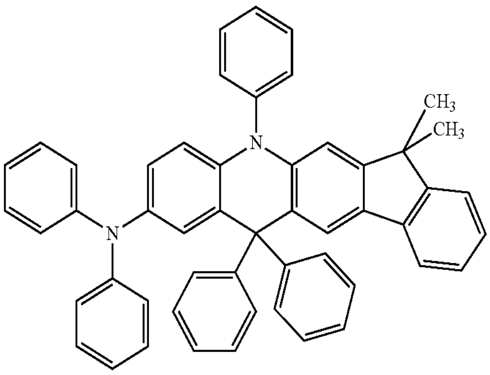
[Chemical Formula 26]

(Compound 15)



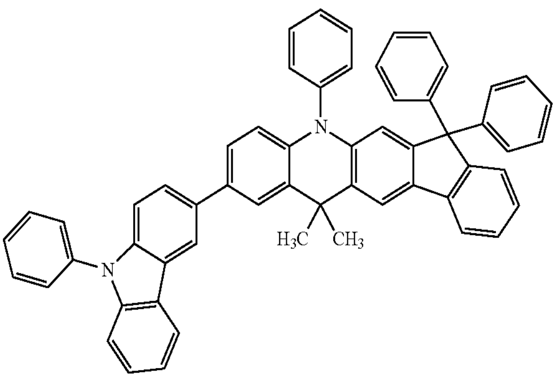
[Chemical Formula 27]

(Compound 16)



[Chemical Formula 28]

(Compound 17)



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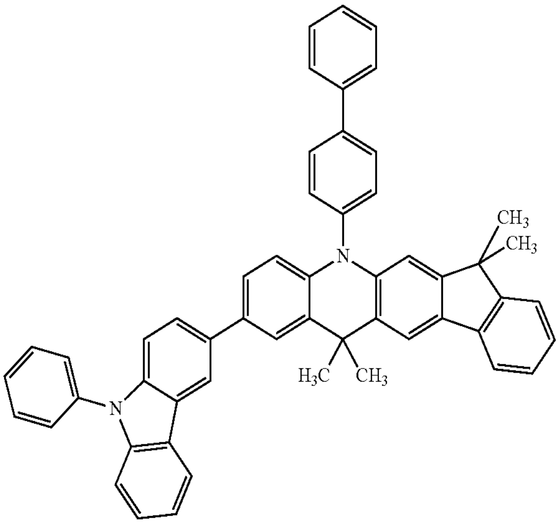
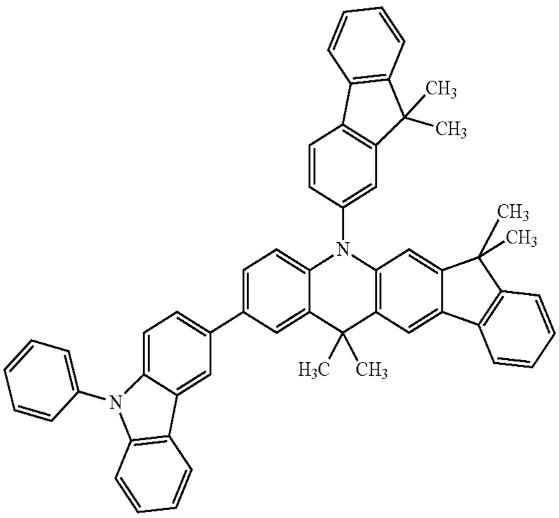
[Chemical Formula 29]

(Compound 18)



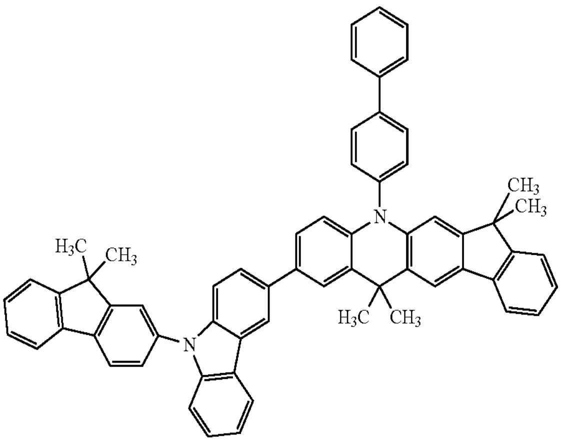
[Chemical Formula 30]

(Compound 19)



[Chemical Formula 31]

(Compound 20)



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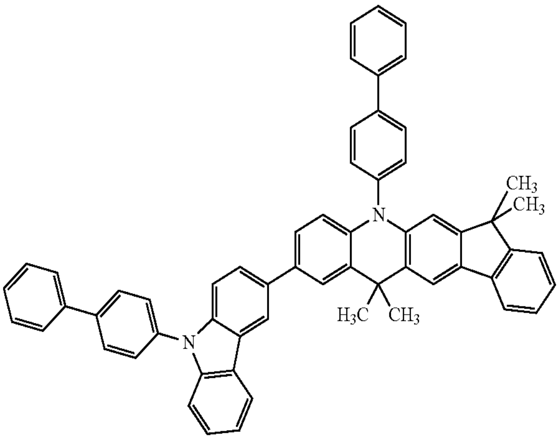
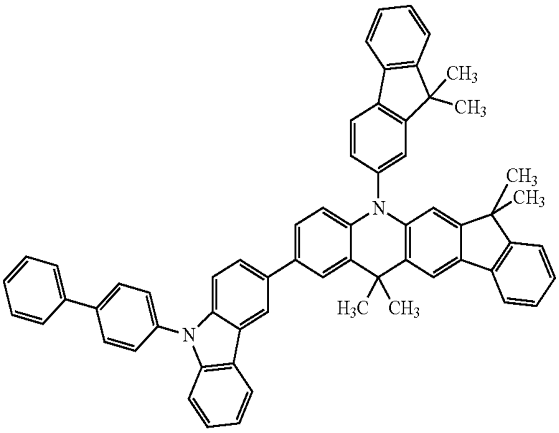
[Chemical Formula 32]

(Compound 21)



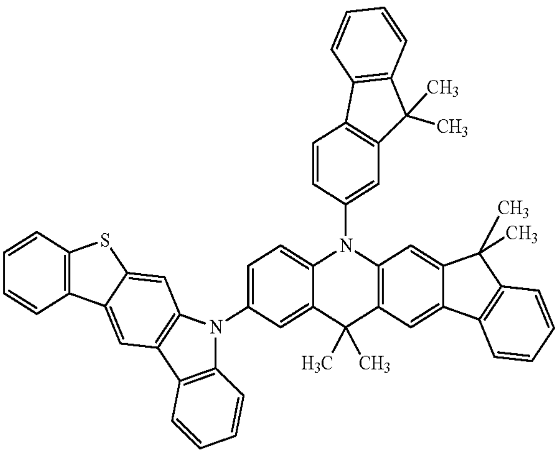
[Chemical Formula 33]

(Compound 22)



[Chemical Formula 34]

(Compound 23)



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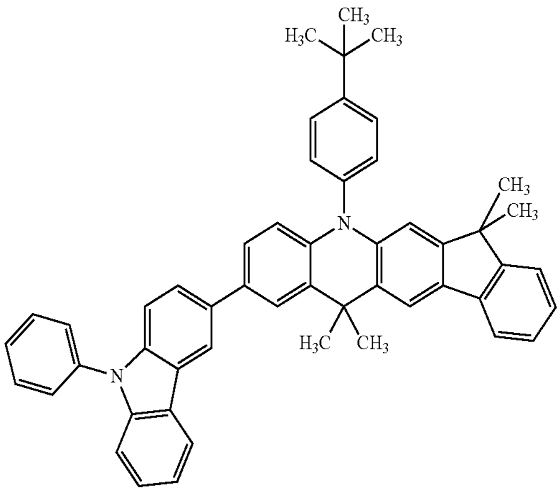
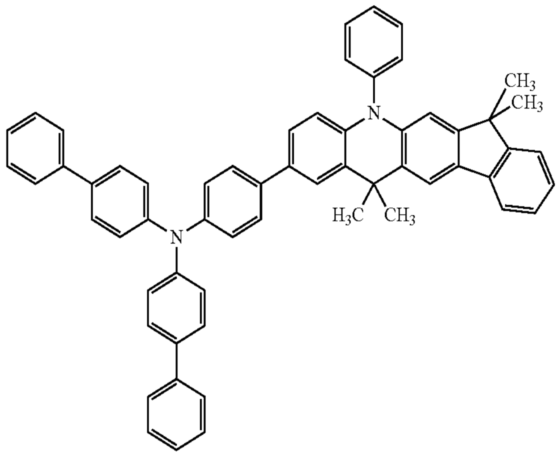
[Chemical Formula 35]

(Compound 24)



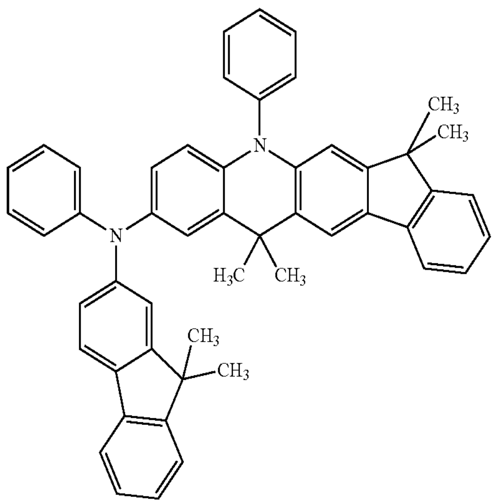
[Chemical Formula 36]

(Compound 25)



[Chemical Formula 37]

(Compound 26)



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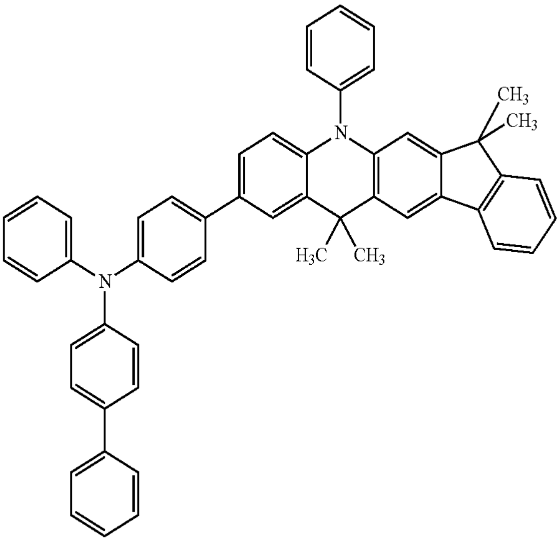
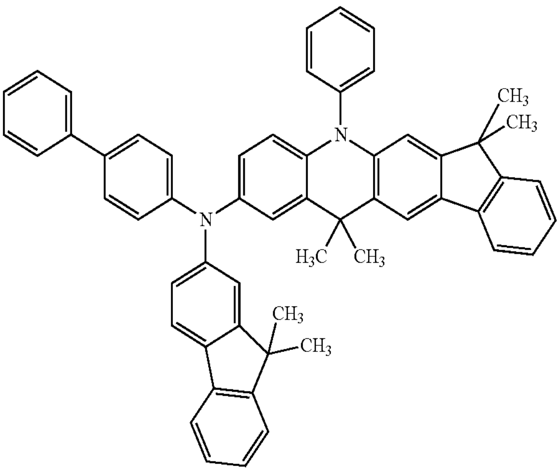
[Chemical Formula 38]

(Compound 27)



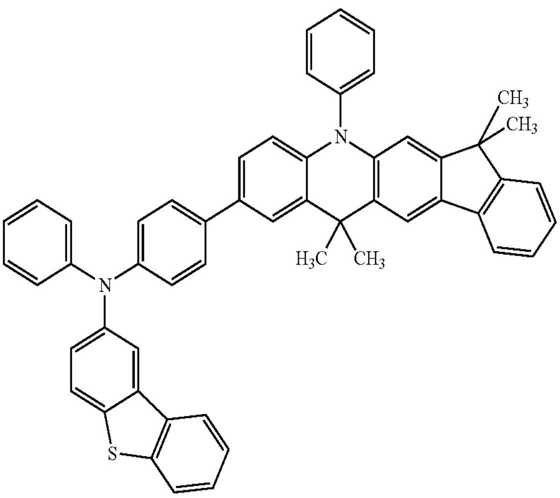
[Chemical Formula 39]

(Compound 28)



[Chemical Formula 40]

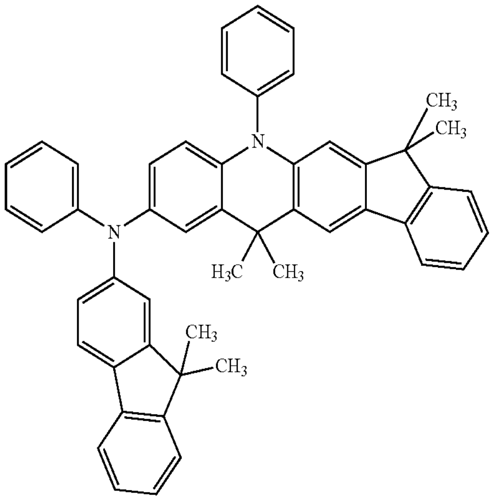
(Compound 29)



-continued

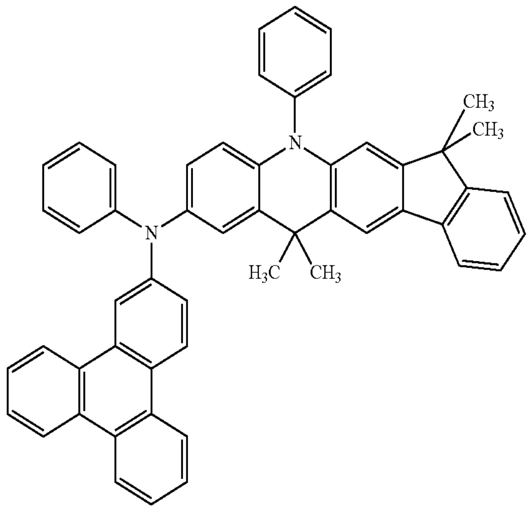
[Chemical Formula 41]

(Compound 30)



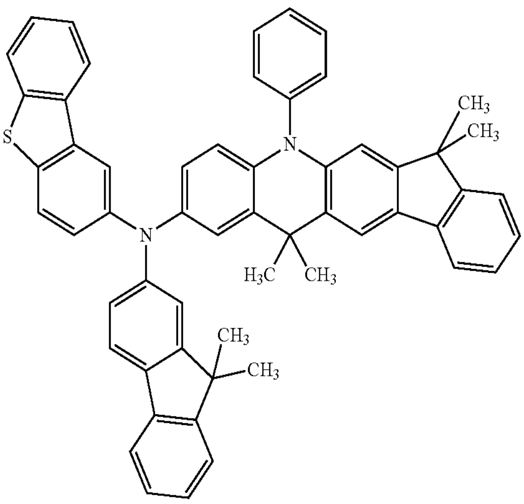
[Chemical Formula 42]

(Compound 31)



[Chemical Formula 43]

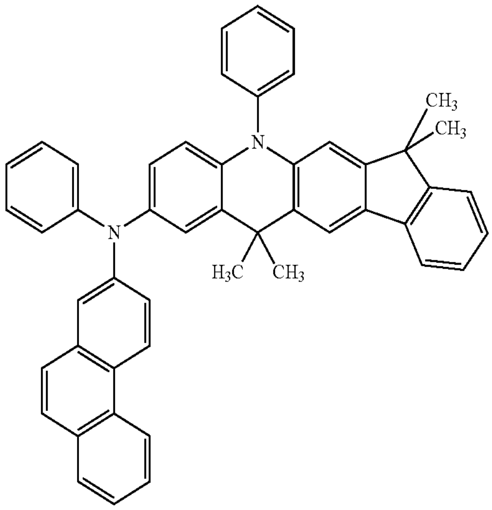
(Compound 32)



-continued

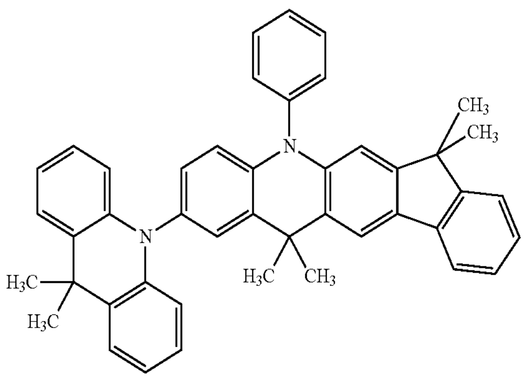
[Chemical Formula 44]

(Compound 33)



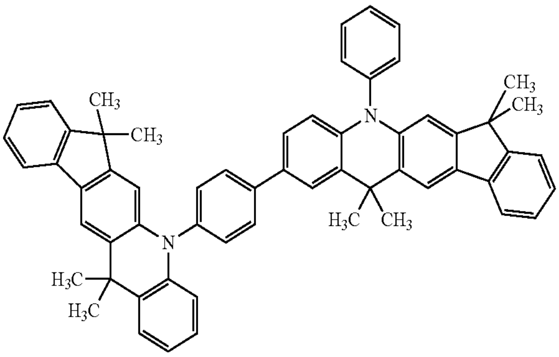
[Chemical Formula 45]

(Compound 34)



[Chemical Formula 46]

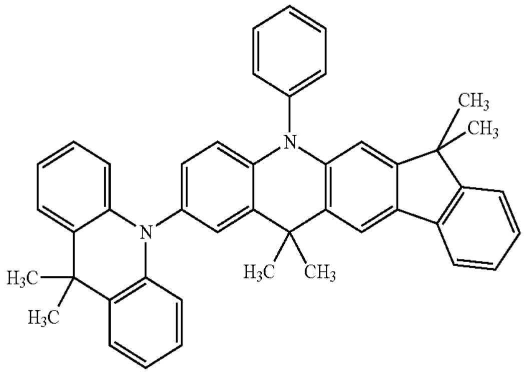
(Compound 35)



-continued

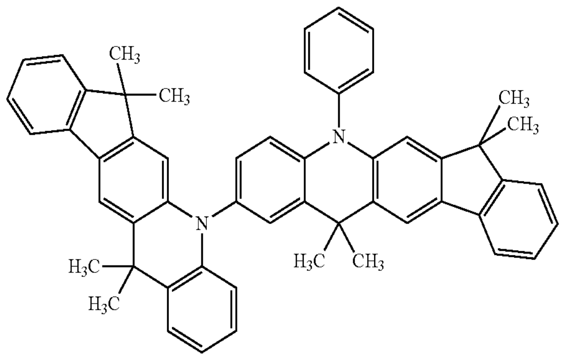
[Chemical Formula 47]

(Compound 36)



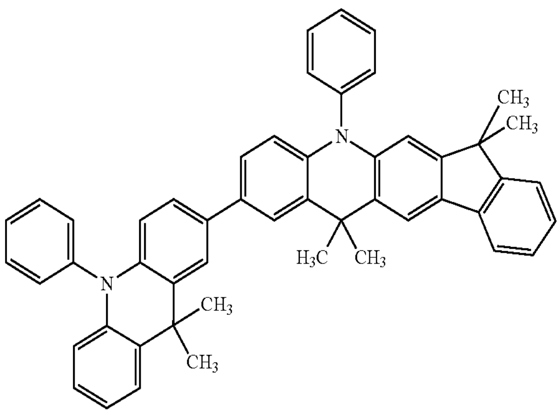
[Chemical Formula 48]

(Compound 37)



[Chemical Formula 49]

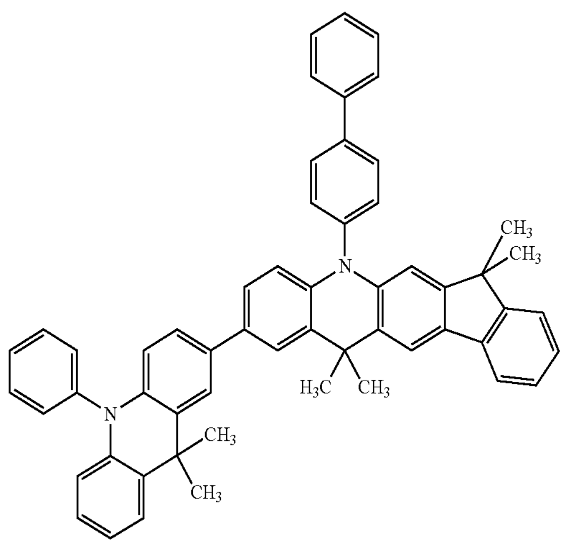
(Compound 38)



-continued

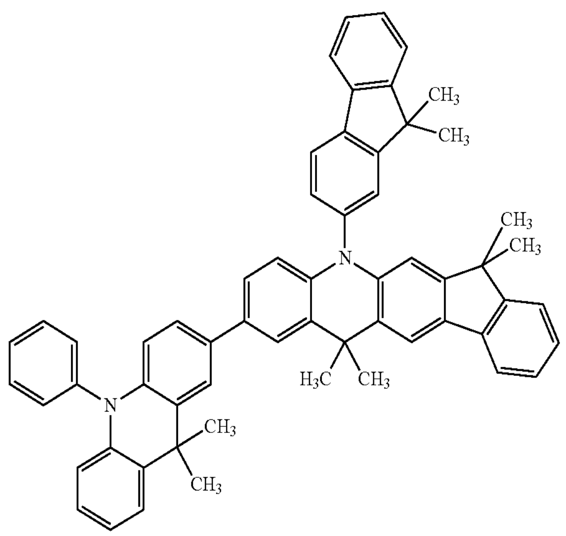
[Chemical Formula 50]

(Compound 39)



[Chemical Formula 51]

(Compound 40)



[0100] These compounds were purified by methods such as column chromatography, adsorption using, for example, silica gel, activated carbon, or activated clay, and recrystallization or crystallization using a solvent. The compounds were identified by an NMR analysis. A glass transition point (Tg) and a work function were measured as material property values. The glass transition point (Tg) can be used as an index of stability in the thin-film state, and the work function as an index of hole transportability.

[0101] The glass transition point (Tg) was measured by a high-sensitive differential scanning calorimeter (DSC3100SA produced by Bruker AXS) using powder.

[0102] For the measurement of the work function, a 100 nm-thick thin film was fabricated on an ITO substrate, and the ionization potential measurement device (PYS-202 produced by Sumitomo Heavy Industries, Ltd.) was used.

[0103] The organic EL device of the present invention may have a structure including an anode, a hole transport layer, an electlon blocking layer, a light emitting layer, an electron transport layer, and a cathode successively formed on a substrate, optionally with a hole injection layer between the anode and the hole transport layer, or with an electron injection layer between the electron transport layer and the cathode. In such multilayer structures, some of the organic layers may be omitted. For example, the device may be configured to include an anode, a hole transport layer, a light emitting layer, an electron transport layer, and a cathode successively formed on a substrate.

[0104] Electrode materials with high work functions such as ITO and gold are used as the anode of the organic EL device of the present invention. The hole injection layer of the organic EL device of the present invention may be made of material such as porphyrin compounds as represented by copper phthalocyanine, starburst-type triphenylamine derivatives, various triphenylamine tetramers, accepting heterocyclic compounds such as hexacyano azatriphenylene, and coating-type polymer materials, in addition to the compounds of general formula (1) having an indenoacridan ring structure of the present invention. These materials may be formed into a thin film by a vapor deposition method or other known methods such as a spin coating method and an inkjet method.

[0105] Examples of material used for the hole transport layer of the organic EL device of the present invention can be benzidine derivatives such as N,N'-diphenyl-N,N'-di(m-tolyl)benzidine (hereinafter referred to as TPD), N,N'-diphenyl-N,N'-di(a-naphthyl)benzidine (hereinafter referred to as NPD), and N,N,N',N'-tetrabiphenylylbenzidine; 1,1-bis[4-(di-4-tolylamino)phenyl]cyclohexane (hereinafter referred to as TAPC); and various triphenylamine trimers and tetramers, in addition to the compounds of general formula (1) having an indenoacridan ring structure of the present invention. These may be individually deposited for film forming, may be used as a single layer deposited mixed with other materials, or may be formed as a laminate of individually deposited layers, a laminate of mixedly deposited layers, or a laminate of the individually deposited layer and the mixedly deposited layer. Examples of material used for the hole injection/transport layer can be coating-type polymer materials such as poly(3,4-ethylenedioxythiophene) (hereinafter referred to as PEDOT)/poly(styrene sulfonate) (hereinafter referred to as PSS). These materials may be formed into a thin-film by a vapor deposition method or other known methods such as a spin coating method and an inkjet method.

[0106] Further, material used for the hole injection layer or the hole transport layer may be obtained by p-doping trisbromophenylamine hexachloroantimony or the like into the material commonly used for these layers, or may be, for example, polymer compounds each having a TPD structure as a part of the compound structure.

[0107] Examples of material used for the electron blocking layer of the organic EL device of the present invention can be compounds having an electron blocking effect, including, for example, carbazole derivatives such as 4,4',4"-tri(N-carbazolyl)triphenylamine (hereinafter referred to as TCTA), 9,9-bis[4-(carbazol-9-yl)phenyl]fluorene, 1,3-bis(carbazol-9-yl)benzene (hereinafter referred to as mCP), and 2,2-bis(4-carbazol-9-ylphenyl)adamantane (hereinafter referred to as Ad-Cz); and compounds having a triphenylsilyl group and a triarylamine structure, as represented by 9-[4-(carbazol-9-yl)phenyl]-9-[4-(triphenylsilyl)phenyl]-9H-fluorene, in addition to the compounds of general formula (1) having an indenoacridan ring structure of the present invention. These may be individually deposited for film forming, may be used as a single layer deposited mixed with other materials, or may be formed as a laminate of individually deposited layers, a laminate of mixedly deposited layers, or a laminate of the individually deposited layer and the mixedly deposited layer. These materials may be formed into a thin-film by using a vapor deposition method or other known methods such as a spin coating method and an inkjet method.

[0108] Examples of material used for the light emitting layer of the organic EL device of the present invention can be various metal complexes, anthracene derivatives, bis(styryl) benzene derivatives, pyrene derivatives, oxazole derivatives, and polyparaphenylene vinylene derivatives, in addition to quinolinol derivative metal complexes such as Alq3. Further, the light emitting layer may comprise a host material and a dopant material. Examples of the host material can be thiazole derivatives, benzimidazole derivatives, and polydialkyl fluorene derivatives, in addition to the above light-emitting materials and the compounds of general formula (1) having an indenoacridan ring structure of the present invention. Examples of the dopant material can be quinacridone, coumarin, rubrene, perylene, derivatives thereof, benzopyran derivatives, rhodamine derivatives, and aminostyryl derivatives. These may be individually deposited for film forming, may be used as a single layer deposited mixed with other materials, or may be formed as a laminate of individually deposited layers, a laminate of mixedly deposited layers, or a laminate of the individually deposited layer and the mixedly deposited layer.

[0109] Further, the light-emitting material may be a phosphorescent light-emitting material. Phosphorescent materials as metal complexes of metals such as iridium and platinum may be used as the phosphorescent light-emitting material. Examples of the phosphorescent materials can be green phosphorescent materials such as Ir(ppy)3, blue phosphorescent materials such as FIrpic and FIr6, and red phosphorescent materials such as Btp2Ir(acac). As the hole injecting and transporting host material, the compounds of general formula (1) having an indenoacridan ring structure of the present invention may be used in addition to carbazole derivatives such as 4,4'-di(N-carbazolyl)biphenyl (hereinafter referred to as CBP), TCTA, and mCP. Compounds such as p-bis(triphenylsilyl)benzene (hereinafter referred to as UGH2) and 2,2',2''-(1,3,5-phenylene)-tris(1-phenyl-1H-benzimidazole) (hereinafter referred to as TPBI) may be used as the electron transporting host material to produce a high-performance organic EL device.

[0110] In order to avoid concentration quenching, it is preferable to dope the host material with the phosphorescent light-emitting material by co-evaporation in a range of 1 to 30 weight percent to the whole light emitting layer.

[0111] Further, Examples of the light-emitting material may be delayed fluorescent-emitting material such as CDCB derivatives of PIC-TRZ, CC2TA, PXZ-TRZ, 4CzIPN or the like (refer to Non-Patent Document 3, for example).

[0112] These materials may be formed into a thin-film by using a vapor deposition method or other known methods such as a spin coating method and an inkjet method.

[0113] The hole blocking layer of the organic EL device of the present invention may be formed by using hole blocking compounds such as various rare earth complexes, triazole derivatives, triazine derivatives, and oxadiazole derivatives, in addition to the metal complexes of phenanthroline derivatives such as bathocuproin (hereinafter referred to as BCP), and the metal complexes of quinolinol derivatives such as aluminum(III) bis(2-methyl-8-quinolinate)-4-phenylphenolate (hereinafter referred to as BAlq). These materials may also serve as the material of the electron transport layer. These may be individually deposited for film forming, may be used as a single layer deposited mixed with other materials, or may be formed as a laminate of individually deposited layers, a laminate of mixedly deposited layers, or a laminate of the individually deposited layer and the mixedly deposited layer. These materials may be formed into a thin-film by using a vapor deposition method or other known methods such as a spin coating method and an inkjet method.

[0114] Examples of material used for the electron transport layer of the organic EL device of the present invention can be various metal complexes, triazole derivatives, triazine derivatives, oxadiazole derivatives, thiadiazole derivatives, carbodiimide derivatives, quinoxaline derivatives, phenanthroline derivatives, and silole derivatives, in addition to the metal complexes of quinolinol derivatives such as Alq3 and BAlq. These may be individually deposited for film forming, may be used as a single layer deposited mixed with other materials, or may be formed as a laminate of individually deposited layers, a laminate of mixedly deposited layers, or a laminate of the individually deposited layer and the mixedly deposited layer. These materials may be formed into a thin-film by using a vapor deposition method or other known methods such as a spin coating method and an inkjet method.

[0115] Examples of material used for the electron injection layer of the organic EL device of the present invention can be alkali metal salts such as lithium fluoride and cesium fluoride; alkaline earth metal salts such as magnesium fluoride; and metal oxides such as aluminum oxide. However, the electron injection layer may be omitted in the preferred selection of the electron transport layer and the cathode.

[0116] The cathode of the organic EL device of the present invention may be made of an electrode material with a low work function such as aluminum, or an alloy of an electrode material with an even lower work function such as a magnesium-silver alloy, a magnesium-indium alloy, or an aluminum-magnesium alloy.

[0117] The following describes an embodiment of the present invention in more detail based on Examples. The present invention, however, is not restricted to the following Examples.

Example 1

Synthesis of 7,7,13,13-tetramethyl-5-phenyl-2-(9-phenyl-9H-carbazol-3-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin (Compound 2)

[0118] 2-Amino methyl benzoate (35.4 g), 2-iodo-9,9-dimethyl-9H-fluoren (50.0 g), tert-butoxy sodium (22.51 g), and xylene (500 ml) were added to a nitrogen-substituted reaction vessel, and aerated with nitrogen gas for 1 hour. The mixture was heated after adding tris(dibenzylideneacetone)dipalladium(0) (2.9 g) and a toluene solution of tri(tert-butyl)phosphine (50% (w/v); 3.8 g), and stirred at 115° C. for 5 hours. After the mixture was allowed to cool to room temperature, water and toluene were added to perform liquid separation in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a crude product. The crude product was purified by column chromatography (support: silica gel, eluent: toluene/n-hexane) to obtain a yellow powder of 2-{(9,9-dimethyl-9H-fluoren-2-yl)amino}methyl benzoate (25.8 g; yield 48%).

[0119] The 2-{(9,9-dimethyl-9H-fluoren-2-yl)amino}methyl benzoate (31.0 g) and THF (310 ml) were added to a nitrogen-substituted reaction vessel, and a THF solution of methylmagnesium chloride(3 mol/L; 108 ml) was dropped. After the mixture was stirred at room temperature for 1 hour, an ammonium chloride aqueous solution (20%; 300 ml) was added and the mixture was extracted by adding toluene in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a light yellow oil of 2-[2-{(9,9-dimethyl-9H-fluoren-2-yl)amino}phenyl]propane-2-ol (31.0 g; yield 100%).

[0120] The 2-[2-{(9,9-dimethyl-9H-fluoren-2-yl)amino}phenyl]propane-2-ol (31.0 g) and phosphoric acid (62 ml) were added to a nitrogen-substituted reaction vessel, and stirred at room temperature for 2 hours. The mixture was stirred after adding toluene (300 ml) and water (300 ml), and the precipitate was collected by filtration in order to obtain a light yellow powder of 7,7,13,13-tetramethyl-7,13-dihydro-5H-indeno[1,2-b]acridin (26.2 g; yield 89%).

[0121] The 7,7,13,13-tetramethyl-7,13-dihydro-5H-indeno[1,2-b]acridin (26.2 g), iodobenzene (17.2 g), tert-butoxy sodium (11.6 g), and xylene (260 ml) were added to a nitrogen-substituted reaction vessel, and aerated with nitrogen gas for 1 hour. The mixture was heated after adding tris(dibenzylideneacetone)dipalladium(0) (1.5 g) and a toluene solution of tri-tert-butylphosphine(50% (w/v); 2.0 g), and stirred at 115° C. for 2 hours. After the mixture was allowed to cool to room temperature, water (300 ml) was added and the mixture was extracted by adding toluene in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a crude product. The crude product was purified by column chromatography (support: silica gel, eluent: toluene/n-hexane) to obtain a white powder of 7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin (29.6 g; yield 92%).

[0122] The 7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin (24.4 g), N,N-dimethylformamide (490 ml), and N-succinimide (24.2 g) were added to a nitrogen-substituted reaction vessel, and stirred at 15° C. for 2 hours while cooling. After the mixture was added to water, the precipitate was collected by filtration. Methanol was added to the precipitate, the mixture was stirred and filtrated to obtain a white powder of 2-bromo-7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin (28.5 g; yield 98%).

[0123] The 2-bromo-7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin (12.0 g), 9-phenyl-9H-carbazol-3-yl boronic acid (7.5 g), a 2 M potassium carbonate aqueous solution (37 ml), toluene (96 ml), and ethanol (24 ml) were added to a nitrogen-substituted reaction vessel, and aerated with nitrogen gas for 1 hour. The mixture was heated after adding tetrakis(triphenylphosphine)palladium (0.9 g), and stirred at 72° C. for 2 hours. After the mixture was allowed to cool to room temperature, the mixture was extracted by adding toluene in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a crude product. The crude product was purified by column chromatography (support: silica gel, eluent: toluene/n-hexane) to obtain a white powder of 7,7,13,13-tetramethyl-5-phenyl-2-(9-phenyl-9H-carbazole-3-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin (Compound 2; 10.2 g; yield 64%).

[0124] The structure of the product white powder was identified by NMR. The ^{1}H-NMR measurement result is shown in FIG. **1**.

[0125] ^{1}H-NMR ($CDCl_3$) detected 38 hydrogen signals, as follows. d (ppm)=8.31 (1H), 8.22 (1H), 7.80-7.90 (2H), 7.56-7.80 (9H), 7.40-7.57 (6H), 7.18-7.40 (5H), 6.42 (1H), 6.38 (1H), 1.91 (6H), 1.35 (6H).

Example 2

Synthesis of 2-(3,3-dimethyl-1-phenyl-1,3-dihydroindeno[2,1-b]carbazole-10-yl)-7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin (Compound 3)

[0126] 2-Bromo-7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin synthesized in Example 1 (8.4 g), 3,3-dimethyl-1-phenyl-10-(4,4,5,5-tetramethyl-1,3,2-dioxaborolane-2-yl)-1,3-dihydroindeno[2,1-b]carbazole (8.9 g), a 2 M potassium carbonate aqueous solution (26 ml), toluene (67 ml), and ethanol (17 ml) were added to a nitrogen-substituted reaction vessel, and aerated with nitrogen gas for 1 hour. The mixture was heated after adding tetrakis(triphenylphosphine)palladium (0.6 g), and stirred at 72° C. for 5 hours. After the mixture was allowed to cool to room temperature, the mixture was extracted by adding toluene in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a crude product. The crude product was purified by column chromatography (support: silica gel, eluent: methylene chloride/n-hexane) to obtain a white powder of 2-(3,3-dimethyl-1-phenyl-1,3-dihydroindeno[2,1-b]carbazole-10-yl)-7,7,13,13-tetramethyl-5-phenyl-7,13-dihydro-5H-indeno[1,2-b]acridin (8.6 g; yield 65%).

[0127] The structure of the product white powder was identified by NMR. The ^{1}H-NMR measurement result is shown in FIG. **1**.

[0128] ^{1}H-NMR ($CDCl_3$) detected 46 hydrogen signals, as follows. d (ppm)=8.52 (1H), 8.39 (1H), 7.82-7.96 (3H), 7.28-7.80 (20H), 7.23 (1H), 6.30-6.50 (5H), 1.91 (6H), 1.55 (6H), 1.32 (6H).

Example 3

Synthesis of 5-(biphenyl-4-yl)-7,7,13,13-tetramethyl-2-(9-phenyl-9H-carbazole-3-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin (Compound 18)

[0129] 2-Bromo-7,7,13,13-tetramethyl-5-(biphenyl-4-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin synthesized in the same manner as Example 1 (15.5 g), 9-phenyl-9H-carbazol-3-yl boronic acid (8.4 g), a 2 M potassium carbonate aqueous solution (42 ml), toluene (124 ml), and ethanol (31 ml) were added to a nitrogen-substituted reaction vessel, and aerated with nitrogen gas for 1 hour. The mixture was heated after adding tetrakis(triphenylphosphine)palladium (1.0 g), and stirred at 72° C. for 4 hours. After the mixture was allowed to cool to room temperature, the mixture was extracted by adding toluene in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a crude product. The crude product was purified by column chromatography (support: silica gel, eluent: methylene chloride/n-hexane) to obtain a white powder of 5-(biphenyl-4-yl)-7,7,13,13-tetramethyl-2-(9-phenyl-9H-carbazole-3-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin (5.6 g; yield 28%).

[0130] The structure of the product white powder was identified by NMR. The ^{1}H-NMR measurement result is shown in FIG. **1**.

[0131] ^{1}H-NMR ($CDCl_3$) detected 42 hydrogen signals, as follows. d (ppm)=8.32 (1H), 8.22 (1H), 7.97 (2H), 7.78-7.90 (4H), 7.74 (1H), 7.42-7.70 (14H), 7.28-7.41 (4H), 7.23 (1H), 6.52 (1H), 6.48 (1H), 1.91 (6H), 1.35 (6H).

Example 4

Synthesis of 5-(9,9-dimetyl-9H-fluoren-2-yl)-7,7,13,13-tetramethyl-2-(9-phenyl-9H-carbazole-3-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin (Compound 19)

[0132] 2-Bromo-7,7,13,13-tetramethyl-5-(9,9-dimetyl-9H-fluoren-2-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin synthesized in the same manner as Example 1 (12.0 g), 9-phenyl-9H-carbazol-3-yl boronic acid (6.1 g), a 2 M potassium carbonate aqueous solution (30 ml), toluene (96 ml), and ethanol (24 ml) were added to a nitrogen-substituted reaction vessel, and aerated with nitrogen gas for 1 hour. The mixture was heated after adding tetrakis(triphenylphosphine)palladium (0.7 g), and stirred at 72° C. for 4 hours. After the mixture was allowed to cool to room temperature, the mixture was extracted by adding toluene in order to collect an organic layer. The organic layer was dried over anhydrous magnesium sulfate, and concentrated under reduced pressure to obtain a crude product. The crude product was purified by column chromatography (support: silica gel, eluent: toluene/n-hexane) to obtain a white powder of 5-(9,9-dimetyl-9H-fluoren-2-yl)-7,7,13,13-tetramethyl-2-(9-phenyl-9H-carbazole-3-yl)-7,13-dihydro-5H-indeno[1,2-b]acridin (12.0 g; yield 79%).

[0133] The structure of the product white powder was identified by NMR. The ^{1}H-NMR measurement result is shown in FIG. **1**.

[0134] ^{1}H-NMR ($CDCl_3$) detected 46 hydrogen signals, as follows. d (ppm)=8.32 (1H), 8.22 (1H), 8.07 (1H), 7.84-7.91 (3H), 7.60-7.77 (6H), 7.28-7.60 (13H), 7.22 (1H), 6.55 (1H), 6.41 (1H), 1.91 (6H), 1.58 (6H), 1.30 (6H).

Example 5

[0135] The glass transition point of the compounds of the present invention were determined using a high-sensitive differential scanning calorimeter (DSC 3100SA produced by Bruker AXS).

	Glass transition point
Compound of Example 1 of the present invention	140° C.
Compound of Example 2 of the present invention	187° C.
Compound of Example 3 of the present invention	155° C.
Compound of Example 4 of the present invention	164° C.

[0136] The compounds of the present invention have glass transition points of 100° C. or higher, demonstrating that the compounds of the present invention have a stable thin-film state.

Example 6

[0137] A 100 nm-thick vapor-deposited film was fabricated on an ITO substrate using the compounds of the present invention, and a work function was measured using an ionization potential measurement device (PYS-202 produced by Sumitomo Heavy Industries, Ltd.).

	Work function
Compound of Example 1 of the present invention	5.48 eV
Compound of Example 2 of the present invention	5.50 eV
Compound of Example 3 of the present invention	5.45 eV
Compound of Example 4 of the present invention	5.41 eV

[0138] As the results show, the compounds of the present invention have desirable energy levels compared to the work function 5.54 eV of common hole transport materials such as NPD and TPD, and thus possess desirable hole transportability.

Example 7

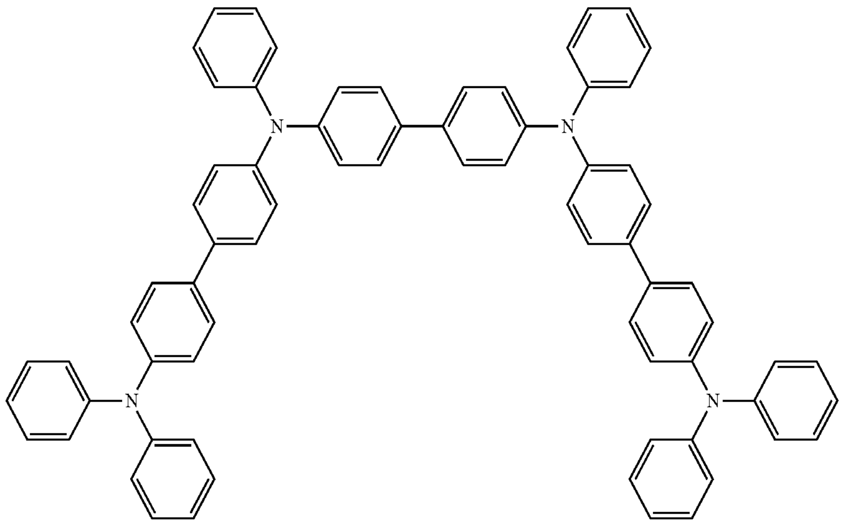
[0139] The organic EL device, as illustrated in FIG. **5**, was fabricated from a hole injection layer **3**, a hole transport layer **4**, a light emitting layer **5**, an electron transport layer **6**, an electron injection layer **7**, and a cathode (aluminum electrode) **8** successively formed by vapor deposition on a glass substrate **1** that had been provided beforehand with an ITO electrode as a transparent anode **2**.

[0140] Specifically, the glass substrate **1** having ITO (thickness 150 nm) formed thereon was washed with an organic solvent, and subjected to an oxygen plasma treatment to wash the surface. The glass substrate with the ITO electrode was then installed in a vacuum vapor deposition apparatus, and the pressure was reduced to 0.001 Pa or less. This was followed by formation of the hole injection layer **3** by forming Compound 41 of the structural formula below over the transparent anode **2** in a thickness of 20 nm. The hole transport layer **4** was then formed on the hole injection layer **3** by forming the compound of Example 1 of the present invention (Compound 2) in a thickness of 40 nm. Then, the light emitting layer **5** was formed on the hole transport layer **4** in a thickness of 30 nm by the dual vapor deposition of Compound 42 of the structural formula below and Compound 43 of the structural formula below at a deposition rate ratio of Compound 42: Compound 43=5:95. The electron transport layer **6** was then formed on the light emitting layer **5** by forming Alq3 in a thickness of 30 nm. Then, the electron injection layer **7** was formed on the electron transport layer **6** by forming lithium fluoride in a thickness of 0.5 nm. Finally, the cathode **8** was formed by vapor depositing aluminum in a thickness of 150 nm. The characteristics of the organic EL device thus fabricated were measured in an atmosphere at ordinary temperature.

[0141] Table 1 summarizes the results of the emission characteristics measurements performed by applying a DC voltage to the organic EL device fabricated with the compound of Example 1 of the present invention (Compound 2).

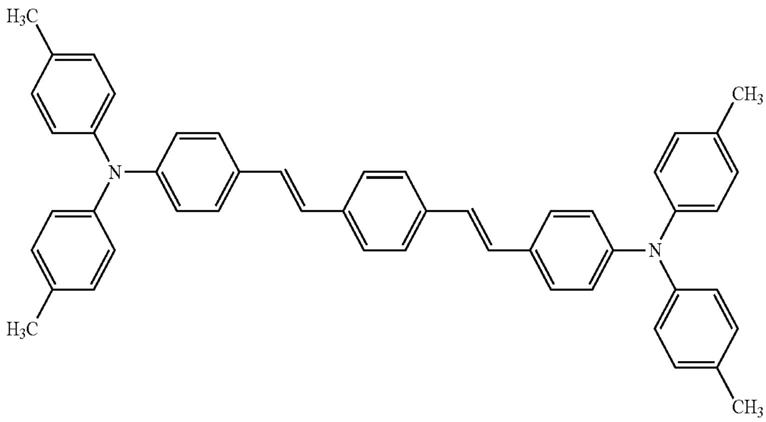
[Chemical Formula 52]

(Compound 41)



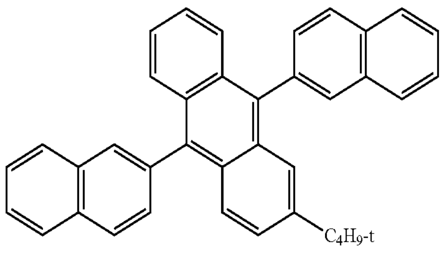
[Chemical Formula 53]

(Compound 42)



[Chemical Formula 54]

(Compound 43)



Example 8

[0142] An organic EL device was fabricated under the same conditions used in Example 7, except that the hole transport layer **4** was formed by forming the compound of Example 2 of the present invention (Compound 3) in a thickness of 40 nm, instead of using the compound of Example 1 of the present invention (Compound 2). The characteristics of the organic EL device thus fabricated were measured in an atmosphere at ordinary temperature. Table 1 summarizes the results of the emission characteristics measurements performed by applying a DC voltage to the fablicated organic EL device.

Example 9

[0143] An organic EL device was fabricated under the same conditions used in Example 7, except that the hole transport layer **4** was formed by forming the compound of Example 3 of the present invention (Compound 18) in a thickness of 40 nm, instead of using the compound of Example 1 of the present invention (Compound 2). The characteristics of the organic EL device thus fabricated were measured in an atmosphere at ordinary temperature. Table 1 summarizes the results of the emission characteristics measurements performed by applying a DC voltage to the fablicated organic EL device.

Example 10

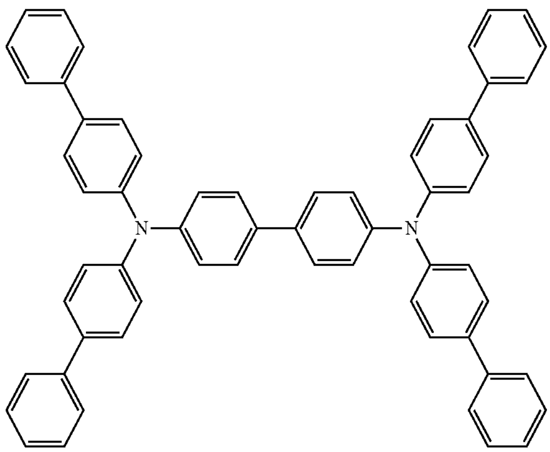
[0144] An organic EL device was fabricated under the same conditions used in Example 7, except that the hole transport layer **4** was formed by forming the compound of Example 4 of the present invention (Compound 19) in a thickness of 40 nm, instead of using the compound of Example 1 of the present invention (Compound 2). The characteristics of the organic EL device thus fabricated were measured in an atmosphere at ordinary temperature. Table 1 summarizes the results of the emission characteristics measurements performed by applying a DC voltage to the fablicated organic EL device.

Comparative Example 1

[0145] For comparison, an organic EL device was fabricated under the same conditions used in Example 7, except that the hole transport layer **4** was formed by forming Compound 44 of the structural formula below in a thickness of 40 nm, instead of using the compound of Example 1 of the present invention (Compound 2). The characteristics of the organic EL device thus fabricated were measured in an atmosphere at ordinary temperature. Table 1 summarizes the results of the emission characteristics measurements performed by applying a DC voltage to the fablicated organic EL device.

[Chemical Formula 55]

(Compound 44)



[0146] As can be seen in Table 1, the driving voltage at the current density of 10 mA/cm^2 was 4.89 V to 5.07 V for the organic EL device that uses the compounds 2, 3, 18, and 19 of Examples 1 to 4 in the present invention, which was lower than 5.17 V for the organic EL device that uses the compound 44. Further, the power efficiency was 6.09 to 6.45 lm/W for the organic EL device that uses the compounds 2, 3, 18, and 19 of Examples 1 to 4 in the present invention, and there was a great improvement in the organic EL device that uses the compound 44 as shown in its power efficiency 5.49 lm/W.

[0147] As is clear from these results, the organic EL devices using the compounds having an indenoacridan ring structure of the present invention can greatly improve power efficiency, and can achieve a lower actual driving voltage compared to the organic EL device that uses known Compound 44.

INDUSTRIAL APPLICABILITY

[0148] The compounds having an indenoacridan ring structure of the present invention have high hole transportability, excel in electron blocking ability and amorphousness, and have a stable thin-film state. The compounds are therefore excellent as the compounds for organic EL devices. The organic EL devices fabricated with the compounds can have high luminous efficiency and high power efficiency and can have a low actual driving voltage to improve durability. There are potential applications for, for example, home electric appliances and illuminations.

DESCRIPTION OF REFERENCE NUMERAL

[0149] **1** Glass substrate

[0150] **2** Transparent anode

[0151] **3** Hole injection layer

[0152] **4** Hole transport layer

[0153] **5** Light emitting layer

[0154] **6** Electron transport layer

[0155] **7** Electron injection layer

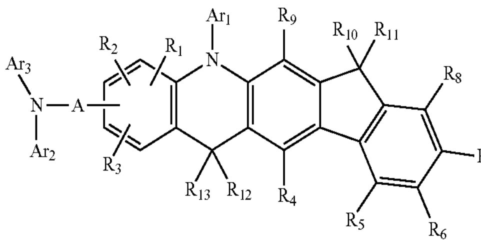
[0156] **8** Cathode

TABLE 1

	Compound	Voltage [V] (@10 mA/cm^2)	Luminance [cd/m^2] (@10 mA/cm^2)	Current efficiency [cd/A] (@10 mA/cm^2)	Power efficiency [lm/W] (@10 mA/cm^2)
Ex. 7	Compound 2	5.03	983	9.84	6.15
Ex. 8	Compound 3	5.07	1031	10.31	6.39
Ex. 9	Compound 18	4.97	962	9.62	6.09
Ex. 10	Compound 19	4.89	1002	10.03	6.45
Comp. Ex. 1	Compound 44	5.17	902	9.03	5.49

1. A compound of the following general formula (1) having an indenoacridan ring structure,

[Chemical Formula 1]

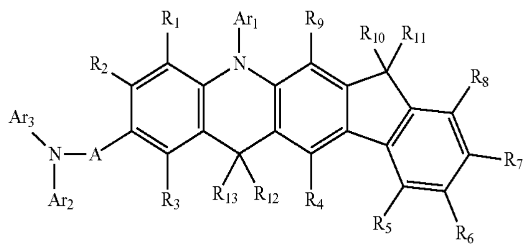


(1)

wherein A represents a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, a divalent group of substituted or unsubstituted condensed polycyclic aromatics, or a single bond; Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and when A is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics, A and Ar_2 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

2. The compound having an indenoacridan ring structure according to claim **1**, wherein the compound is represented by the following general formula (1-1),

[Chemical Formula 2]



(1-1)

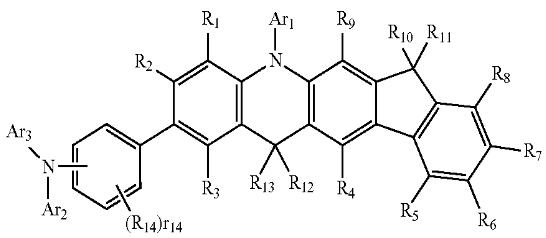
wherein A represents a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, a divalent group of substituted or unsubstituted condensed polycyclic aromatics, or a single bond; Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and when A is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, a divalent group of a substituted or unsubstituted aromatic heterocyclic ring, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics, A and Ar_2 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

3. The compound having an indenoacridan ring structure according to claim 1, wherein A in the general formulae (1) or (1-1) is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics.

4. The compound having an indenoacridan ring structure according to claim 3, wherein the compound is represented by the following general formula (1-2),

[Chemical Formula 3]

(1-2)

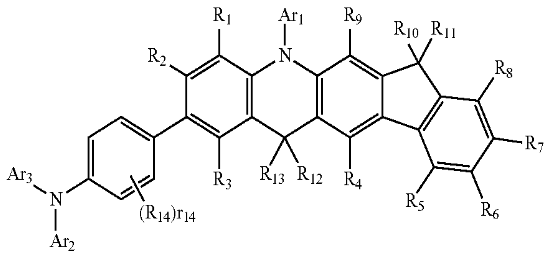


wherein Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{14} represents a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, substituted or unsubstituted aryloxy, or a bonding group, which may bind to each other to form a ring when a plurality of these substituents bind to the same benzene ring (when r_{14} is 2 or more); r_{14} represents 0 or an integer of 1 to 4, and the substituent R_{14} does not exist when r_{14} is 0; and when R_{14} is a bonding group, r_{14} is 1, and the benzene ring binding with R_{14} and Ar_2 bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

5. The compound having an indenoacridan ring structure according to claim 3, wherein the compound is represented by the following general formula (1-3),

[Chemical Formula 4]

(1-3)

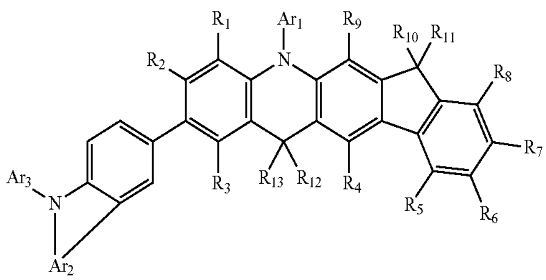


wherein Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{14} represents a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, substituted or unsubstituted aryloxy, or a bonding group, which may bind to each other to form a ring when a plurality of these substituents bind to the same benzene ring (when r_{14} is 2 or more); r_{14} represents 0 or an integer of 1 to 4, and the substituent R_{14} does not exist when r_{14} is 0; and when R_{14} is a bonding group, r_{14} is 1, and the benzene ring binding with R_{14} and Ar_2 bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

6. The compound having an indenoacridan ring structure according to claim **4**, wherein the compound is represented by the following general formula (1-4),

[Chemical Formula 5]

(1-4)

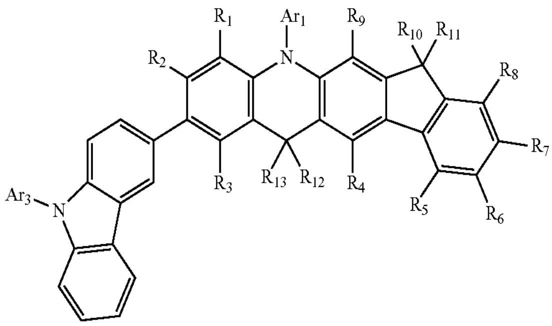


wherein, Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; Ar_4 represents a divalent group derived from a substituted or unsubstituted aromatic hydrocarbon group, a divalent group derived from a substituted or unsubstituted aromatic heterocyclic group, or a divalent group derived from a substituted or unsubstituted condensed polycyclic aromatic group; Ar_3 and Ar_4 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

7. The compound having an indenoacridan ring structure according to claim **4**, wherein the compound is represented by the following general formula (1-4a),

[Chemical Formula 6]

(1-4a)

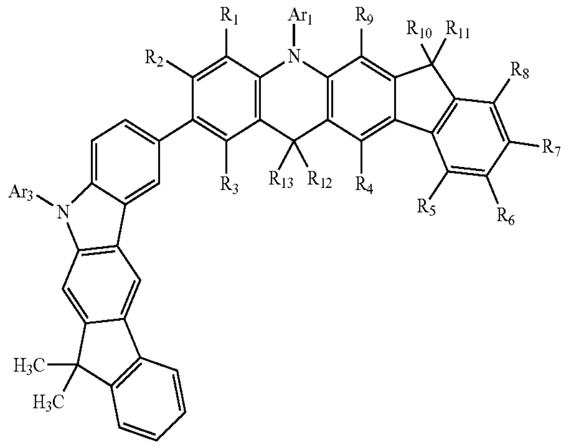


wherein Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

8. The compound having an indenoacridan ring structure according to claim **4**, wherein the compound is represented by the following general formula (1-4b),

[Chemical Formula 7]

(1-4b)

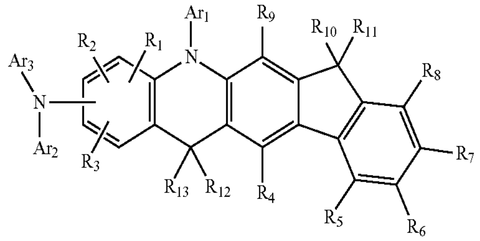


wherein Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

9. The compound having an indenoacridan ring structure according to claim **1**, wherein the compound is represented by the following general formula (1-5),

[Chemical Formula 8]

(1-5)

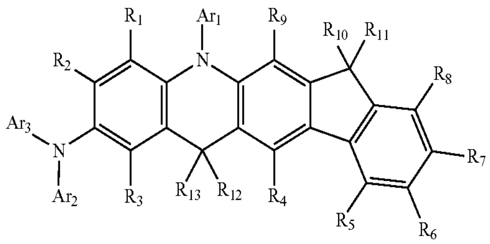


wherein Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

10. The compound having an indenoacridan ring structure according to claim **9**, wherein the compound is represented by the following general formula (1-6),

[Chemical Formula 9]

(1-6)



wherein Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

11. An organic electroluminescent device comprising a pair of electrodes, and one or more organic layers sandwiched between the pair of electrodes, wherein the compound having an indenoacridan ring structure of claim **1** is used as a constituent material of at least one of the organic layers.

12. The organic electroluminescent device according to claim **11**, wherein the organic layer is a hole transport layer.

13. The organic electroluminescent device according to claim **11**, wherein the organic layer is an electron blocking layer.

14. The organic electroluminescent device according to claim **11**, wherein the organic layer is a hole injection layer.

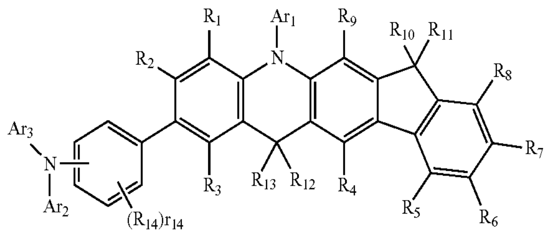
15. The organic electroluminescent device according to claim **11**, wherein the organic layer is a light emitting layer.

16. The compound having an indenoacridan ring structure according to claim **2**, wherein A in the general formulae (1) or (1-1) is a divalent group of a substituted or unsubstituted aromatic hydrocarbon, or a divalent group of substituted or unsubstituted condensed polycyclic aromatics.

17. The compound having an indenoacridan ring structure according to claim **16**, wherein the compound is represented by the following general formula (1-2),

[Chemical Formula 3]

(1-2)

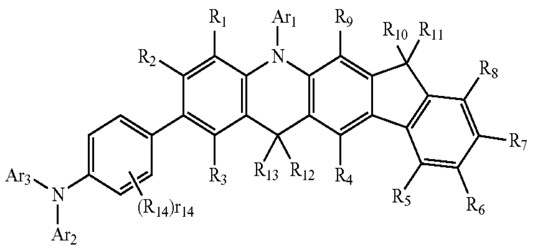


wherein Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{14} represents a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, substituted or unsubstituted aryloxy, or a bonding group, which may bind to each other to form a ring when a plurality of these substituents bind to the same benzene ring (when r_{14} is 2 or more); r_{14} represents 0 or an integer of 1 to 4, and the substituent R_{14} does not exist when r_{14} is 0; and when R_{14} is a bonding group, r_{14} is 1, and the benzene ring binding with R_{14} and Ar_2 bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

18. The compound having an indenoacridan ring structure according to claim **16**, wherein the compound is represented by the following general formula (1-3),

[Chemical Formula 4]

(1-3)

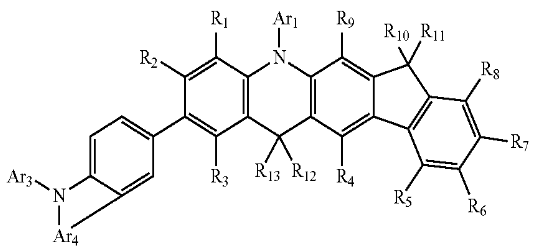


wherein Ar_1, Ar_2, and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group, where Ar_2 and Ar_3 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_{14} represents a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, substituted or unsubstituted aryloxy, or a bonding group, which may bind to each other to form a ring when a plurality of these substituents bind to the same benzene ring (when r_{14} is 2 or more); r_{14} represents 0 or an integer of 1 to 4, and the substituent R_{14} does not exist when r_{14} is 0; and when R_{14} is a bonding group, r_{14} is 1, and the benzene ring binding with R_{14} and Ar_2 bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

19. The compound having an indenoacridan ring structure according to claim **17**, wherein the compound is represented by the following general formula (1-4),

[Chemical Formula 5]

(1-4)

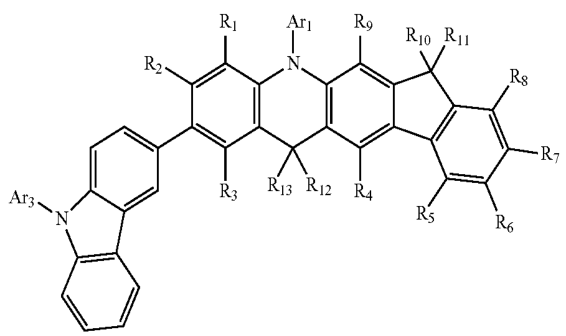


wherein, Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; Ar_4 represents a divalent group derived from a substituted or unsubstituted aromatic hydrocarbon group, a divalent group derived from a substituted or unsubstituted aromatic heterocyclic group, or a divalent group derived from a substituted or unsubstituted condensed polycyclic aromatic group; Ar_3 and Ar_4 may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

20. The compound having an indenoacridan ring structure according to claim **17**, wherein the compound is represented by the following general formula (1-4a),

[Chemical Formula 6]

(1-4a)



wherein Ar_1 and Ar_3 may be the same or different, and represent a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; R_1 to R_9 may be the same or different, and represent a hydrogen atom, a deuterium atom, a fluorine atom, a chlorine atom, cyano, nitro, linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, which may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring; and R_{10} to R_{13} may be the same or different, and represent linear or branched alkyl of 1 to 6 carbon atoms that may have a substituent, cycloalkyl of 5 to 10 carbon atoms that may have a substituent, linear or branched alkenyl of 2 to 6 carbon atoms that may have a substituent, linear or branched alkyloxy of 1 to 6 carbon atoms that may have a substituent, cycloalkyloxy of 5 to 10 carbon atoms that may have a substituent, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, a substituted or unsubstituted condensed polycyclic aromatic group, or substituted or unsubstituted aryloxy, where R_{10} and R_{11}, or R_{12} and R_{13} may bind to each other via a single bond, substituted or unsubstituted methylene, an oxygen atom, or a sulfur atom to form a ring.

* * * * *

专利名称(译)	具有茚并吖啶环结构的化合物和有机电致发光器件		
公开(公告)号	US20150249218A1	公开(公告)日	2015-09-03
申请号	US14/422256	申请日	2013-08-27
[标]申请(专利权)人(译)	保土谷化学工业株式会社		
申请(专利权)人(译)	HODOGAYA化学有限公司.		
当前申请(专利权)人(译)	HODOGAYA化学有限公司.		
[标]发明人	YOKOYAMA NORIMASA KANDA DAIZOU HAYASHI SHUICHI		
发明人	YOKOYAMA, NORIMASA KANDA, DAIZOU HAYASHI, SHUICHI		
IPC分类号	H01L51/00 C07D221/18 C07D405/14 C07D495/04 C07D401/04 C07D409/14		
CPC分类号	H01L51/0072 H01L2251/308 C07D409/14 C07D405/14 C07D495/04 C07D221/18 H01L51/0074 H01L51/0073 H01L51/0061 H01L51/0052 H01L51/006 H01L51/5056 H01L51/5096 H01L51/5088 H01L51/5012 H01L51/0054 H01L51/5072 H01L51/5092 H01L51/5221 H01L2251/301 H01L51/5206 C07D401/04 C07D401/10 C07D409/12 H01L51/0059 H01L51/0071		
优先权	2012192845 2012-09-03 JP		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种有机化合物，其具有优异的空穴注入和输送性能，并具有电子阻挡能力，薄膜状态下的高稳定性和优异的耐热性，并且作为高效率和高耐久性的有机电致发光器件的材料，使用该化合物提供了高发光效率和高耐久性的有机电致发光器件。具有茚并吖啶环结构的通式（1）的化合物用作有机电致发光器件中的至少一个有机层的构成材料，所述有机电致发光器件包括一对电极和夹在所述一对电极之间的一个或多个有机层。