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Youfu et al.

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(54) **ORGANIC TRANSISTOR, COMPOUND, ORGANIC SEMICONDUCTOR MATERIAL FOR NON-LIGHT-EMITTING ORGANIC SEMICONDUCTOR DEVICE, MATERIAL FOR ORGANIC TRANSISTOR, COATING SOLUTION FOR NON-LIGHT-EMITTING ORGANIC SEMICONDUCTOR DEVICE, ORGANIC SEMICONDUCTOR FILM FOR NON-LIGHT-EMITTING ORGANIC SEMICONDUCTOR DEVICE, AND METHOD FOR MANUFACTURING ORGANIC SEMICONDUCTOR FILM FOR NON-LIGHT-EMITTING ORGANIC SEMICONDUCTOR DEVICE**

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(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jan. 10, 2014 (JP) 2014-003664

(51) **Int. Cl.**
H01L 51/00 (2006.01)
C07D 495/04 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01L 51/0074** (2013.01); **C07D 491/22** (2013.01); **C07D 493/22** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01L 51/0074; H01L 51/0065; H01L 51/0068; H01L 51/0071; H01L 51/005;
(Continued)

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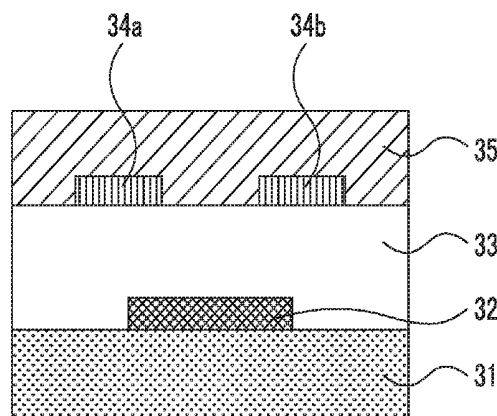
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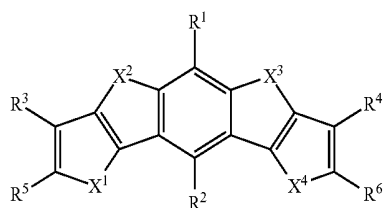
(57) **ABSTRACT**

Provided are an organic transistor having high carrier mobility that contains a compound represented by the following formula in a semiconductor active layer (each of X¹ to X⁴ represents NR¹⁰⁰, an O atom, or a S atom; NR¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group; each of R¹ to R⁶ represents a hydrogen atom or a

(Continued)



substituent; at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by -L-R; L is a divalent linking group having a specific structure; and R is an alkyl group having 5 to 19 carbon atoms); a compound; an organic semiconductor material for a non-light-emitting organic semiconductor device; a material for an organic transistor; a coating solution for a non-light-emitting organic semiconductor device; an organic semiconductor film for a non-light-emitting organic semiconductor device; and a method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device.



26 Claims, 1 Drawing Sheet

- (51) **Int. Cl.**
C07D 495/22 (2006.01)
C09D 5/24 (2006.01)
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C07D 493/22 (2006.01)
H01L 51/05 (2006.01)
- (52) **U.S. Cl.**
 CPC **C07D 495/04** (2013.01); **C07D 495/22** (2013.01); **C09D 5/24** (2013.01); **H01L 51/0065** (2013.01); **H01L 51/0068** (2013.01); **H01L 51/0071** (2013.01); **H01L 51/0005** (2013.01); **H01L 51/0545** (2013.01); **H01L 51/0558** (2013.01); **H01L 51/0566** (2013.01)
- (58) **Field of Classification Search**
 CPC H01L 51/0545; H01L 51/0558; H01L 51/0566
- See application file for complete search history.

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FIG. 1

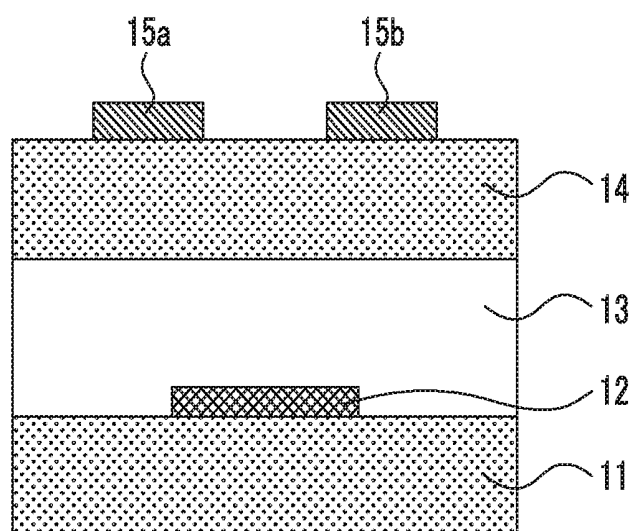
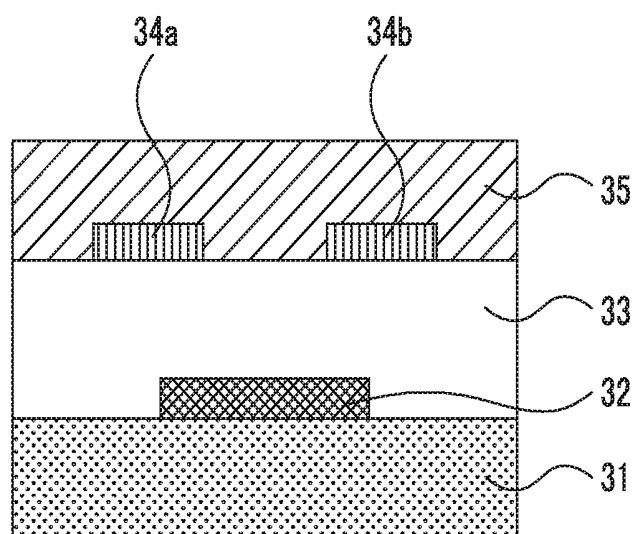


FIG. 2



1

**ORGANIC TRANSISTOR, COMPOUND,
ORGANIC SEMICONDUCTOR MATERIAL
FOR NON-LIGHT-EMITTING ORGANIC
SEMICONDUCTOR DEVICE, MATERIAL
FOR ORGANIC TRANSISTOR, COATING
SOLUTION FOR NON-LIGHT-EMITTING
ORGANIC SEMICONDUCTOR DEVICE,
ORGANIC SEMICONDUCTOR FILM FOR
NON-LIGHT-EMITTING ORGANIC
SEMICONDUCTOR DEVICE, AND METHOD
FOR MANUFACTURING ORGANIC
SEMICONDUCTOR FILM FOR NON-LIGHT
EMITTING ORGANIC SEMICONDUCTOR
DEVICE**

**CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application is a Continuation of PCT International Application No. PCT/JP2015/050004, filed on Jan. 5, 2015, which claims priority under 35 U.S.C. Section 119(a) to Japanese Patent Application No. 2014-003664 filed on Jan. 10, 2014. Each of the above applications is hereby expressly incorporated by reference, in its entirety, into the present application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an organic transistor, a compound, an organic semiconductor material for a non-light-emitting organic semiconductor device, a material for an organic transistor, a coating solution for a non-light-emitting organic semiconductor device, an organic semiconductor film for a non-light-emitting organic semiconductor device, and a method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device. Specifically, the present invention relates to a compound having a skeletal structure in which four 5-membered heterocyclic rings are condensed with a benzene ring, an organic transistor, an organic semiconductor material for a non-light-emitting organic semiconductor device, a material for an organic transistor, a coating solution for a non-light-emitting organic semiconductor device, an organic semiconductor film for a non-light-emitting organic semiconductor device, and a method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device.

2. Description of the Related Art

The devices using organic semiconductor materials are drawing great attention because they are expected to be superior in various aspects to the devices using inorganic semiconductor materials of the related art such as silicon. Examples of the devices using organic semiconductor materials include a photoelectric conversion element such as an organic solar cell or a solid-state imaging element using organic semiconductor materials as photoelectric conversion materials, an organic transistor (referred to as an organic thin-film transistor in some cases) having non-light-emitting properties (in the present specification, "non-light-emitting" refers to properties by which a luminous efficiency of equal to or less than 1 lm/W is obtained in a case where electric currents are applied to a device at a current density of 0.1 mW/cm² at room temperature in the atmosphere; non-light-emitting organic semiconductor devices mean organic semiconductor devices excluding light-emitting organic semiconductor devices such as organic electroluminescence

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elements), and the like. The devices using organic semiconductor materials are likely to make it possible to prepare large area elements at lower temperature and lower costs compared to the devices using inorganic semiconductor materials. Furthermore, the characteristics of the materials can be easily changed by varying the molecular structure thereof. Therefore, the materials show a wide variation and can realize functions or elements that cannot be obtained by inorganic semiconductor materials.

For example, JP2009-054810A discloses an organic transistor containing a compound in which two substituted or unsubstituted thienothiophene rings are condensed with a benzene ring. JP2009-054810A describes that if the aforementioned compound is used, it is possible to obtain an organic transistor which has high charge mobility and a high on/off current ratio and is excellent in preservation stability.

WO2010/000670A discloses an organic transistor containing dithieno[2,3-d:2',3'-d']benzo[1-2-d:4,5-b']dithiophene.

SUMMARY OF THE INVENTION

As a result of investigating the organic transistor using the compound described in JP2009-054810A or WO2010/000670A, the inventors of the present invention found that the compound, in which thienothiophene rings facing in different directions are condensed with a benzene ring on both sides of the benzene ring, has low carrier mobility. Furthermore, the inventors found that the compound disclosed in JP2009-054810A, in which thienothiophene rings facing in the same direction are condensed with a benzene ring on both sides of the benzene ring, has low carrier mobility.

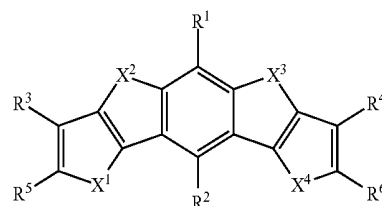
Therefore, in order to solve the above problems of the related art, the inventors of the present invention continued investigation.

An object of the present invention is to provide an organic transistor having high carrier mobility.

As a result of conducting intensive investigation to achieve the above object, the inventors of the present invention obtained knowledge that if a compound having the structure of a skeleton (hereinafter, referred to as a condensed heterocyclic skeleton), in which four 5-membered heterocyclic rings are condensed with a benzene ring, is substituted with substituents including an alkyl group having carbon atoms within a specific numerical range, carrier mobility is improved when the compound is used in a semiconductor active layer of an organic transistor. Based on the knowledge, the inventors accomplished the present invention.

The present invention as specific means for achieving the object described above is constituted as below.

[1] An organic transistor comprising a compound represented by the following Formula (1) in a semiconductor active layer:



Formula (1)

3

in Formula (1),

each of X^1 to X^4 independently represents NR^{100} , an O atom, or a S atom,

R^{100} represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group,

each of R^1 to R^6 independently represents a hydrogen atom or a substituent, and at least one of R^1 , R^2 , R^3 , R^4 , R^5 , or R^6 is a substituent represented by the following Formula (W):

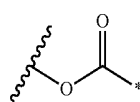
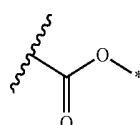
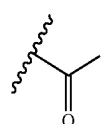
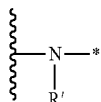
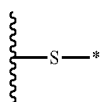
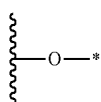
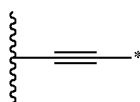
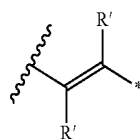
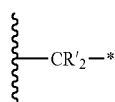
-L-R

Formula (W)

in Formula (W),

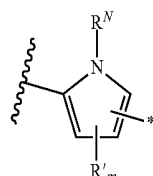
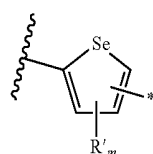
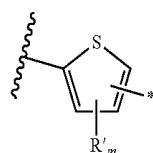
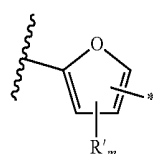
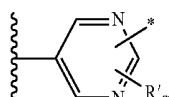
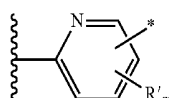
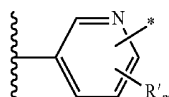
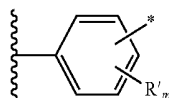
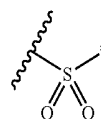
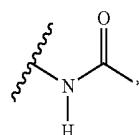
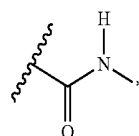
R represents an alkyl group having 5 to 19 carbon atoms, and

L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



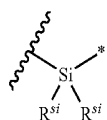
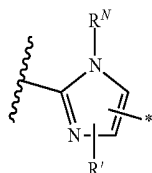
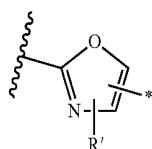
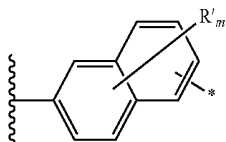
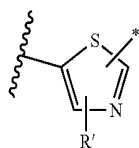
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in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

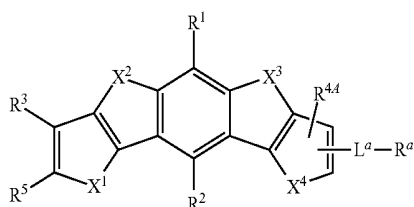
m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

[2] The organic transistor described in [1], in which the compound represented by Formula (1) is preferably a compound represented by the following Formula (2-1) or (2-2):

Formula (2-1)



in Formula (2-1), each of X¹ to X⁴ independently represents an O atom or a S atom,

each of R¹ to R³, R^{4A}, and R⁵ independently represents a hydrogen atom or a substituent and is not a group represented by -L^a-R^a,

R^a represents an alkyl group having 5 to 19 carbon atoms, and

6

L^a represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

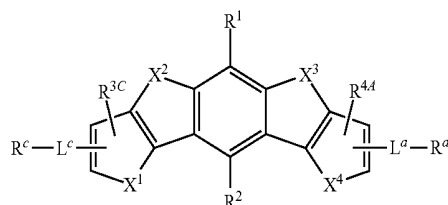
(L-22)

Formula (2-2)

10

(L-23)

15



in Formula (2-2),

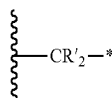
each of X¹ to X⁴ independently represents an O atom or a S atom,

each of R¹, R², R^{3C}, and R^{4B} independently represents a hydrogen atom or a substituent,

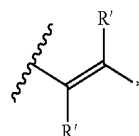
each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

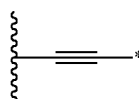
(L-1)



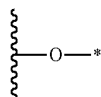
(L-2)



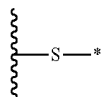
(L-3)



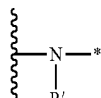
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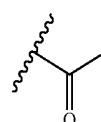
(L-5)



(L-6)

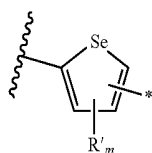
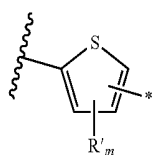
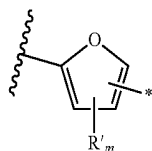
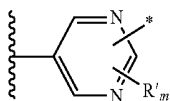
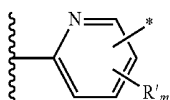
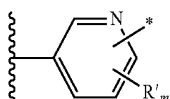
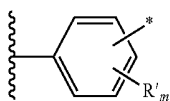
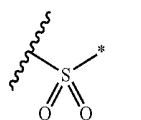
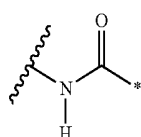
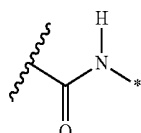
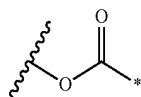
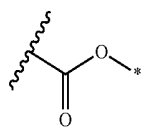


(L-7)



7

-continued



8

-continued

(L-8)

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(L-9)

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(L-10)

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(L-11)

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(L-12)

25

(L-13)

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(L-14)

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(L-15)

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(L-16)

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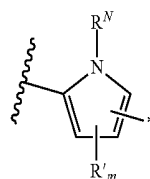
(L-17)

50

(L-18)

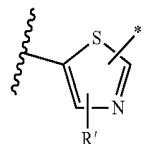
55

(L-8)



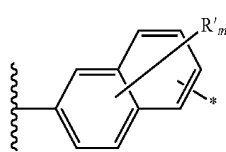
(L-20)

(L-9)



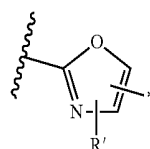
(L-21)

(L-10)



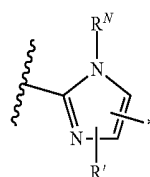
(L-22)

(L-11)



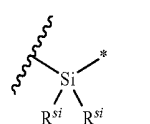
(L-23)

(L-12)



(L-24)

(L-13)



(L-25)

(L-14)

(L-15)

(L-16)

(L-17)

(L-18)

(L-19)

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

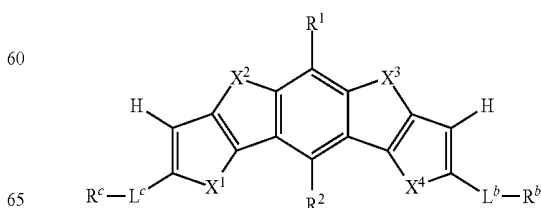
m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

[3] The organic transistor described in [1] or [2], in which the compound represented by Formula (1) is preferably a compound represented by the following Formula (2-2A):

Formula (2-2A)



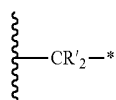
in Formula (2-2A),

each of X^1 to X^4 independently represents an O atom or a S atom,

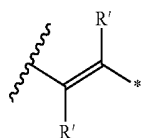
each of R^1 and R^2 independently represents a hydrogen atom or a substituent,

each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

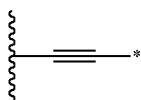
each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



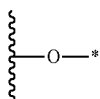
(L-1)



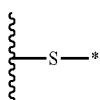
(L-2)



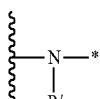
(L-3)



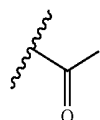
(L-4)



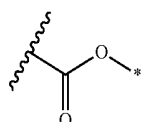
(L-5)



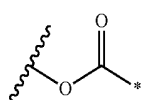
(L-6)



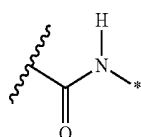
(L-7)



(L-8)

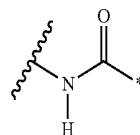


(L-9)

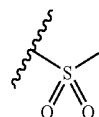


(L-10)

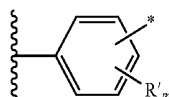
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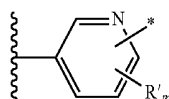
(L-11)



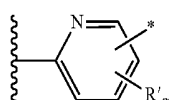
(L-12)



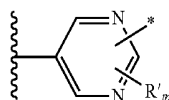
(L-13)



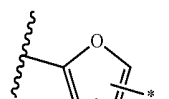
(L-14)



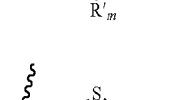
(L-15)



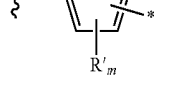
(L-16)



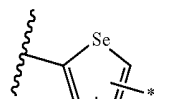
(L-17)



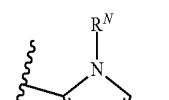
(L-18)



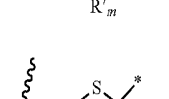
(L-19)



(L-20)



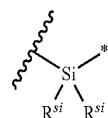
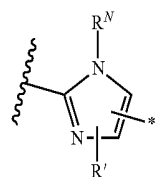
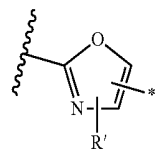
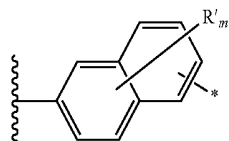
(L-21)



65

11

-continued



in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and

each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

[4] The organic transistor described in any one of [1] to [3], in which in Formula (1), (2-1), (2-2), or (2-2A), each of L, L^a, L^b, and L^c is preferably independently a divalent linking group represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24) or a divalent linking group in which two or more divalent linking groups represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24) are bonded to each other.

[5] The organic transistor described in any one of [1] to [4], in which in Formula (1), (2-1), (2-2), or (2-2A), each of L, L^a, L^b, and L^c is preferably independently a divalent linking group represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24), or a divalent linking group in which a divalent linking group represented by any one of Formulae (L-2), (L-3), and (L-13) to (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any of Formulae (L-2), (L-3), and (L-13) to (L-24) are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1).

[6] The organic transistor described in any one of [1] to [5], in which in Formula (1), (2-1), (2-2), or (2-2A), each of L, L^a, L^b, and L^c is preferably independently a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking group in which a divalent linking group, in which two or more divalent linking groups represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) are

12

bonded to each other, is bonded to a divalent linking group represented by Formula (L-1).

[7] The organic transistor described in any one of [1] to [6], in which in Formula (1), (2-1), (2-2), or (2-2A), each of R, R^a, R^b, and R^c is preferably independently an unsubstituted alkyl group.

[8] The organic transistor described in any one of [1] to [7], in which in Formula (1), (2-1), (2-2), or (2-2A), at least one of R, R^a, R^b, or R^c is preferably a branched alkyl group.

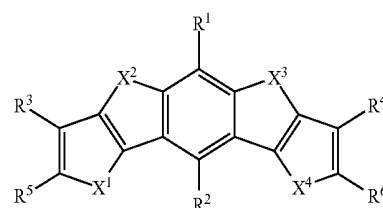
[9] A compound represented by the following Formula (1):

(L-24)

15

(L-25)

20



Formula (1)

in Formula (1),

each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom,

R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group,

each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by the following Formula (W):

-L-R

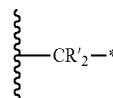
Formula (W)

in Formula (W),

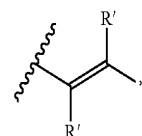
R represents an alkyl group having 5 to 19 carbon atoms, and

L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

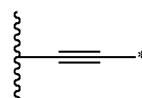
(L-1)



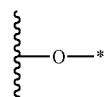
(L-2)



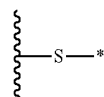
(L-3)



(L-4)

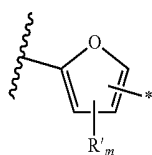
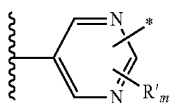
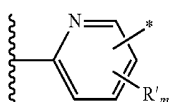
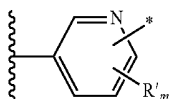
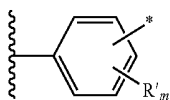
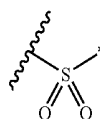
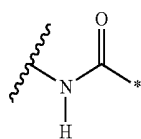
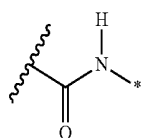
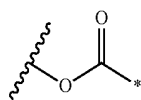
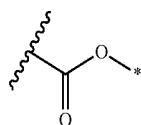
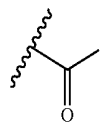
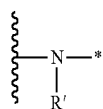


(L-5)



13

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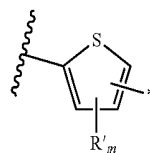


14

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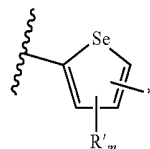
(L-6)

5



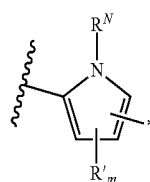
(L-7)

10



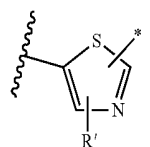
(L-8)

15



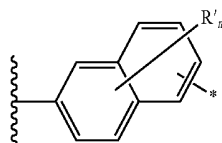
(L-9)

20



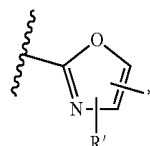
(L-10)

25



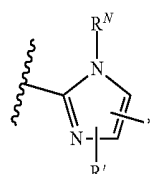
(L-11)

30



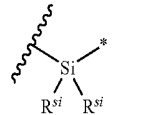
(L-12)

35



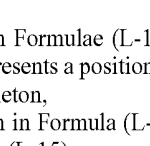
(L-13)

40



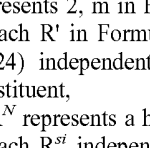
(L-14)

45



(L-15)

50



(L-16)

55

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

(L-16)

60

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

(L-17)

65

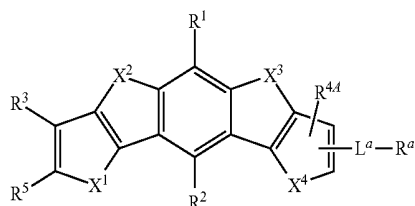
each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

[10] The compound described in [9], in which the compound represented by Formula (1) is preferably a compound represented by the following Formula (2-1) or (2-2):

15

Formula (2-1)



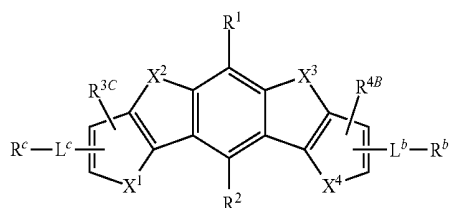
in Formula (2-1),
each of X^1 to X^4 independently represents an O atom or a S atom,

each of R^1 to R^3 , R^{4A} , and R^5 independently represents a hydrogen atom or a substituent and is not a group represented by $-L^a-R^a$,

R^a represents an alkyl group having 5 to 19 carbon atoms, and

L^a represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

Formula (2-2)

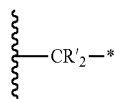


in Formula (2-2),
each of X^1 to X^4 independently represents an O atom or a S atom,

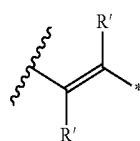
each of R^1 , R^2 , R^{3C} , and R^{4B} independently represents a hydrogen atom or a substituent,

each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

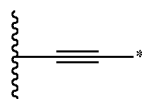
each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



(L-1)



(L-2)

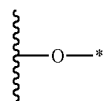


(L-3)

16

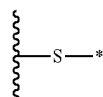
-continued

(L-4)



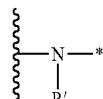
5

(L-5)



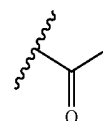
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(L-6)



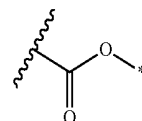
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(L-7)



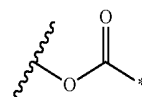
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(L-8)



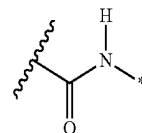
25

(L-9)



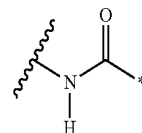
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(L-10)



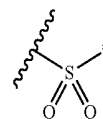
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(L-11)



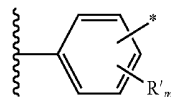
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(L-12)



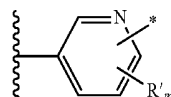
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(L-13)



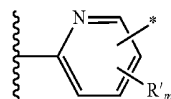
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(L-14)



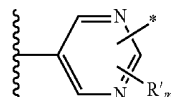
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(L-15)



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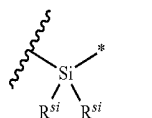
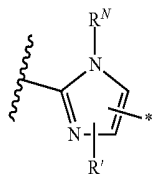
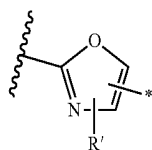
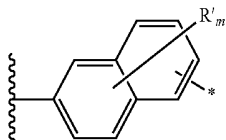
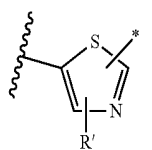
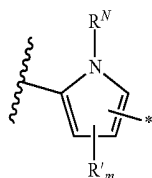
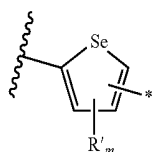
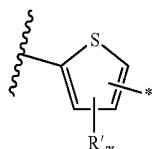
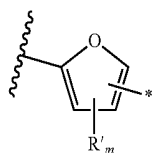
(L-16)



65

17

-continued



in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

18

(L-17) R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

[11] The compound described in [9] or [10], in which the compound represented by Formula (1) is preferably a compound represented by the following Formula (2-2A):

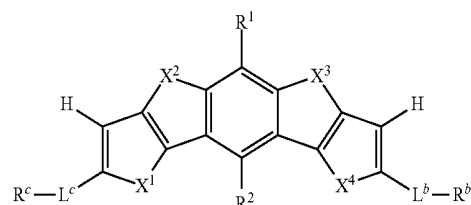
(L-18)

Formula (2-2A)

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(L-19)

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(L-20)

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in Formula (2-2A), each of X^1 to X^4 independently represents an O atom or a S atom,

each of R^1 and R^2 independently represents a hydrogen atom or a substituent,

each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

(L-21)

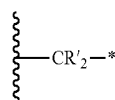
25

each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

(L-22)

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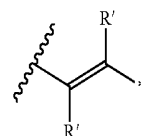
(L-1)



(L-23)

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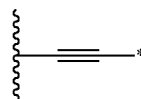
(L-2)



(L-24)

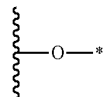
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(L-3)



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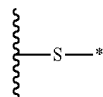
(L-4)



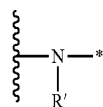
(L-25)

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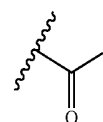
(L-5)



(L-6)

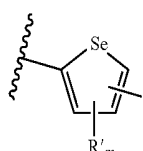
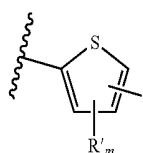
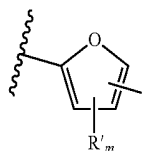
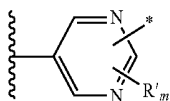
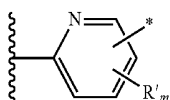
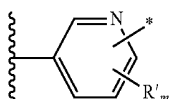
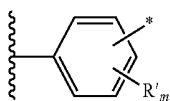
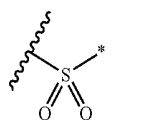
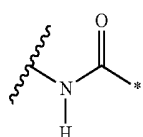
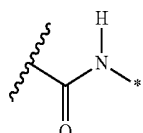
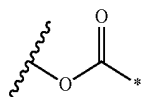
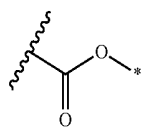


(L-7)



19

-continued



20

-continued

(L-8)

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(L-9)

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(L-10)

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(L-11)

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(L-12)

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(L-13)

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(L-14)

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(L-15)

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(L-16)

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(L-17)

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(L-18)

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(L-19)

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(L-20)

(L-21)

(L-22)

(L-23)

(L-24)

(L-25)

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

[12] The compound described in any one of [9] to [11], in which in Formula (1), (2-1), (2-2), or (2-2A), each of L, L^a, L^b, and L^c is preferably independently a divalent linking group represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24) or a divalent linking group in which two or more divalent linking groups represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24) are bonded to each other.

[13] The compound described in any one of [9] to [12], in which in Formula (1), (2-1), (2-2), or (2-2A), each of L, L^a, L^b, and L^c is preferably independently a divalent linking group represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24) or a divalent linking group in which a divalent linking group represented by any one of Formula (L-2), (L-3), and (L-13) to (L-24) or a divalent linking

group, in which two or more divalent linking groups represented by any one of Formula (L-2), (L-3), and (L-13) to (L-24) are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1).

[14] The compound described in any one of [9] to [13], in which in Formula (1), (2-1), (2-2), or (2-2A), each of L, L^a, L^b, and L^c is preferably independently a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking group in which a divalent linking group, in which two or more divalent linking groups represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1).

[15] The compound described in any one of [9] to [14], in which in Formula (1), (2-1), (2-2), or (2-2A), each of R, R^a, R^b, and R^c is preferably independently an unsubstituted alkyl group.

[16] The compound described in any one of [9] to [15], in which in Formula (1), (2-1), (2-2), or (2-2A), at least one of R, R^a, R^b, or R^c is a branched alkyl group.

[17] An organic semiconductor material for a non-light-emitting organic semiconductor device, comprising the compound described in any one of [9] to [16].

[18] A material for an organic transistor, comprising the compound described in any one of [9] to [16].

[19] A coating solution for a non-light-emitting organic semiconductor device, comprising the compound described in any one of [9] to [16].

[20] A coating solution for a non-light-emitting organic semiconductor device, comprising the compound described in any one of [9] to [16] and a polymer binder.

[21] The coating solution for a non-light-emitting organic semiconductor device described in [19] or [20], further comprising a non-halogen-based solvent.

[22] An organic semiconductor film for a non-light-emitting organic semiconductor device, comprising the compound described in any one of [9] to [16].

[23] An organic semiconductor film for a non-light-emitting organic semiconductor device, comprising the compound described in any one of [9] to [16] and a polymer binder.

[24] The organic semiconductor film for a non-light-emitting organic semiconductor device described in [22] or [23] that is preferably prepared by a solution coating method.

[25] The organic semiconductor film for a non-light-emitting organic semiconductor device described in any one of [22] to [24] that is preferably prepared by performing coating using the coating solution for a non-light-emitting organic semiconductor device described in any one of [19] to [21] by an ink jet method.

[26] A method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device, comprising forming an organic semiconductor film for a non-light-emitting organic semiconductor device by performing coating using the coating solution for a non-light-emitting organic semiconductor device described in any one of [19] to [21] by an ink jet method.

According to the present invention, it is possible to provide an organic transistor having higher carrier mobility.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing a section of an exemplary structure of an organic transistor of the present invention.

FIG. 2 is a schematic view showing a section of a structure of the organic transistor manufactured as a substrate for measuring FET characteristics in examples of the present invention.

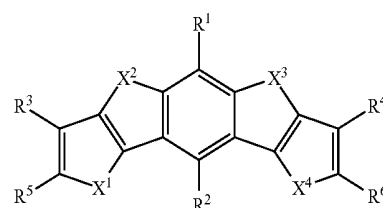
DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be specifically described. The constituents described below will be explained based on representative embodiments or specific examples, but the present invention is not limited to the embodiments. In the present specification, a range of numerical values described using "to" means a range including the numerical values listed before and after "to" as a lower limit and an upper limit respectively.

In the present invention, unless otherwise specified, a hydrogen atom used in the description of each formula represents a hydrogen atom including an isotope (deuterium atom or the like). Furthermore, an atom constituting a substituent represents an atom including an isotope thereof.

[Organic Transistor]

An organic transistor of the present invention contains a compound represented by the following Formula (1) in a semiconductor active layer.



Formula (1)

In Formula (1), each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom.

R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group.

each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by the following Formula (W):

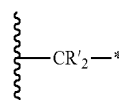


Formula (W)

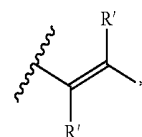
in Formula (W),

R represents an alkyl group having 5 to 19 carbon atoms, and

L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



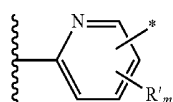
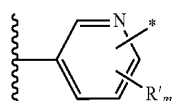
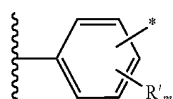
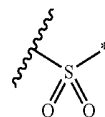
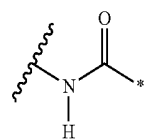
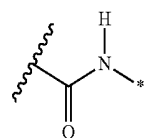
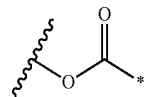
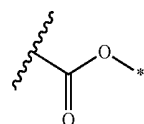
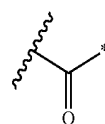
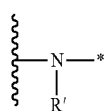
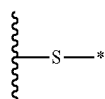
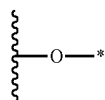
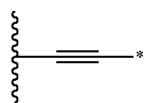
(L-1)



(L-2)

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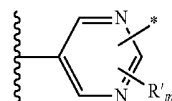
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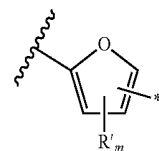
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(L-3)



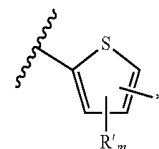
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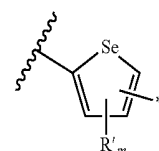
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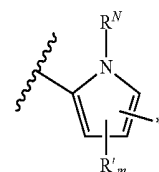
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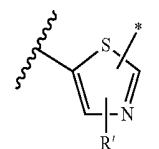
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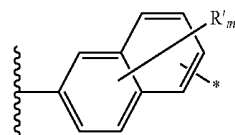
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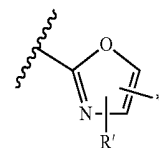
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(L-9)



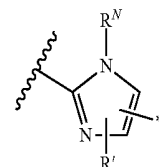
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(L-10)



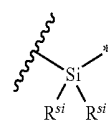
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(L-11)



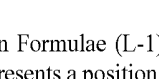
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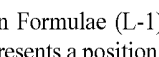
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(L-13)



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(L-14)



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(L-15)

(L-16)

(L-17)

(L-18)

(L-19)

(L-20)

(L-21)

(L-22)

(L-23)

(L-24)

(L-25)

65 in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and

each Rst independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

By being constituted as above, the organic transistor of the present invention has high carrier mobility.

JP2009-054810A and WO2010/000670A describe compounds in which two substituted or unsubstituted thienothiophene rings are condensed with a benzene ring. Among these, the compound in which thienothiophene rings facing in different directions are condensed with a benzene ring on both sides of the benzene ring has high molecular symmetry, and hence the compound has extremely low solubility. Therefore, such a compound is crystallized on a substrate at a high speed, and thus polycrystalline growth easily occurs while monocrystalline growth does not easily occur. As a result, a large number of grain boundary portions are formed between crystals, and hence high carrier mobility is not obtained. Furthermore, the compound disclosed in JP2009-054810A, in which thienothiophene rings facing in the same direction are condensed with a benzene ring on both sides of the benzene ring, has a structure in which the mother nucleus, in which the thienothiophene rings facing in the same direction are condensed with the benzene ring, is substituted with a short alkyl group or a substituent further substituted with a short alkyl group. Presumably, due to the short alkyl chain length, the compound cannot have a crystal structure resulting in high carrier mobility, and this may be a cause of low carrier mobility of the compound, although it is only a presumption not limited to any theory.

In contrast, the compound represented by Formula (1) has a gentle V-shaped skeletal structure in which thienothiophene rings facing in the same direction are condensed with a benzene ring. By additionally introducing a substituent having an appropriately long terminal alkyl chain into the compound, the crystal system of the compound becomes different from that of the compound described in JP2009-054810A, and as a result, the compound can have a crystal structure resulting in high carrier mobility.

In order to improve the solubility of the compound represented by Formula (1) in a general organic solvent, it is effective to introduce a group represented by Formula (W) into the compound. It is preferable that the compound represented by Formula (1) enables the accomplishment of both of high mobility and solubility that has been difficult so far.

It is preferable that the organic transistor of the present invention using the compound represented by Formula (1) shows only a slight threshold voltage shift after repeated driving. In order to reduce the threshold voltage shift after repeated driving, HOMO of the organic semiconductor material needs not to be too shallow or too deep. Furthermore, the chemical stability (particularly, resistance against air oxidation and stability against oxidation and reduction) of the organic semiconductor material, the heat stability of the film state, the high film density which makes it difficult for air or moisture to permeate the film, the film quality by which the film has small defectiveness such that charge accumulation does not easily occur, and the like are required. In addition, the higher the solubility of the compound represented by Formula (1) in an organic solvent at the time of film formation, the further the threshold voltage

shift after repeated driving can be reduced when the compound is used in the semiconductor active layer of the organic transistor. It is considered that because the compound represented by Formula (1) satisfies the aforementioned requirements, the organic transistor shows only a slight threshold voltage shift after repeated driving. That is, in the organic transistor showing only a slight threshold voltage shift after repeated driving, the semiconductor active layer has high chemical stability, high film density, and the like, and thus the organic transistor can effectively function as a transistor over a long period of time.

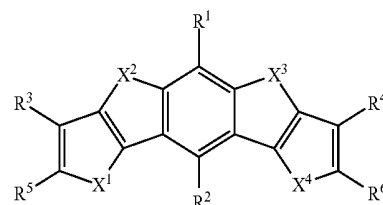
It is preferable that the compound represented by Formula (1) has a gentle V-shaped skeletal structure in which thienothiophene rings facing in the same direction are condensed with a benzene ring on both sides of the benzene ring, such that the carrier mobility variation is smaller in the compound than in the compound which consists of rod-like molecules and in which thienothiophene rings facing in different directions are condensed with a benzene ring on both sides of the benzene ring.

Furthermore, it is preferable that the compound represented by Formula (1) has a gentle V-shaped skeletal structure, in which thienothiophene rings facing in the same direction are condensed with a benzene ring on both sides of the benzene ring, and is different from the compound described in JP2009-054810A by the additional introduction of a substituent having an appropriately long terminal alkyl chain, such that the phase transition temperature thereof is increased as a result. That is, it is preferable that the compound represented by Formula (1) also improves heat resistance (of carrier mobility) when being used in an organic transistor.

Hereinafter, preferred embodiments of the compound and the organic transistor of the present invention will be described.

<Compound Represented by Formula (1)>

The compound of the present invention is represented by Formula (1). In the organic transistor of the present invention, the compound of the present invention is contained in the semiconductor active layer which will be described later. That is, the compound of the present invention can be used as a material for the organic transistor.



Formula (1)

In Formula (1),

each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom,

R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group,

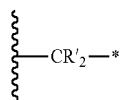
each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by the following Formula (W):

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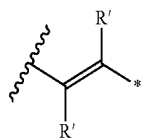
in Formula (W),

R represents an alkyl group having 5 to 19 carbon atoms,
and

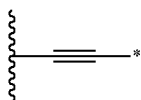
L represents a divalent linking group represented by any
of the following Formulae (L-1) to (L-25) or a divalent
linking group in which two or more divalent linking groups
represented by any of the following Formulae (L-1) to
(L-25) are bonded to each other;



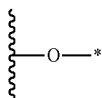
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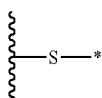
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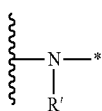
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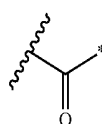
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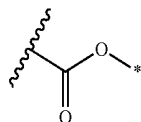
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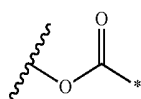
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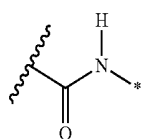
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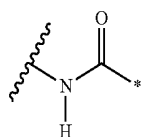
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(L-9)



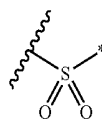
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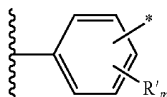
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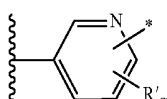
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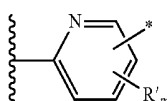
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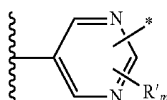
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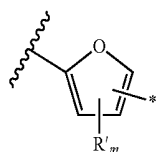
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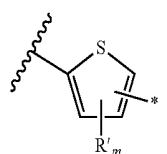
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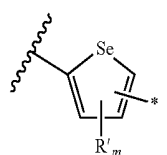
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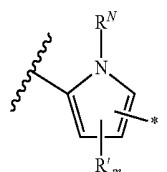
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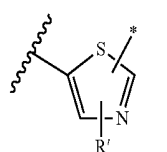
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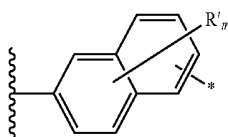
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(L-20)

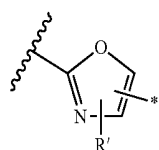


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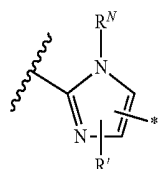


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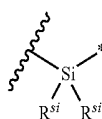
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(L-23)



(L-24)



(L-25)

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and

each R^{Si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

In Formula (1), each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom, and R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group.

From the viewpoint of the ease of synthesis, it is preferable that each of X¹ to X⁴ is independently an O atom or a S atom. In contrast, from the viewpoint of improving the carrier mobility, it is preferable that at least one of X¹, X², X³, or X⁴ is a S atom. All of X¹ to X⁴ are preferably the same linking group, and more preferably a S atom.

R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group. R¹⁰⁰ is preferably a hydrogen atom or an alkyl group, particularly preferably an alkyl group having 1 to 14 carbon atoms, and more particularly preferably an alkyl group having 1 to 4 carbon atoms.

In a case where R¹⁰⁰ represents an alkyl group, the alkyl group may be a linear, branched, or cyclic alkyl group. However, R¹⁰⁰ is preferably a linear alkyl group because then the linearity of the molecule can be improved, and hence the carrier mobility can be improved.

In Formula (1), each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ represents a group represented by Formula (W).

Examples of the substituent that each of R¹ to R⁶ in Formula (1) can independently represent include a halogen atom, an alkyl group (including an alkyl group having 1 to 40 carbon atoms such as a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, or a pentadecyl group; here, the alkyl group also includes a 2,6-dimethyloctyl group, a 2-decyltet-

radecyl group, a 2-hexyldodecyl group, a 2-ethyloctyl group, a 2-butyldecyl group, a 1-octylnonyl group, a 2-octyltetradecyl group, a 2-ethylhexyl group, a cycloalkyl group, a bicycloalkyl group, a tricycloalkyl group, and the like), an alkenyl group (including a 1-pentenyl group, a cycloalkenyl group, a bicycloalkenyl group, and the like), an alkynyl group (including a 1-pentynyl group, a trimethylsilylethynyl group, a triethylsilylethynyl group, a tri-*i*-propylsilylethynyl group, a 2-*p*-propylphenylethynyl group, and the like), an aryl group (including an aryl group having 6 to 20 carbon atoms such as a phenyl group, a naphthyl group, a *p*-pentylphenyl group, a 3,4-dipentylphenyl group, a *p*-heptoxyphenyl group, a 3,4-diheptoxyphenyl group, and the like), a hetero ring group (may be referred to as a heterocyclic group as well, including a 2-hexylfuranyl group and the like), a cyano group, a hydroxyl group, a nitro group, an acyl group (including a hexanoyl group, a benzoyl group, and the like), an alkoxy group (including a butoxy group and the like), an aryloxy group, a silyloxy group, a heterocyclic oxy group, an acyloxy group, a carbamoyloxy group, an amino group (including an anilino group), an acylamino group, an aminocarbonylamino group (including a ureide group), alkoxy- and aryloxy carbonylamino groups, alkyl- and aryl sulfonylamino groups, a mercapto group, alkyl- and arylthio groups (including a methylthio group, an octylthio group, and the like), a heterocyclic thio group, a sulfamoyl group, a sulfo group, alkyl- and aryl sulfinyl groups, alkyl- and aryl sulfonyl groups, alkyloxy- and aryloxy carbonyl groups, a carbamoyl group, aryl- and heterocyclic azo group, an imide group, a phosphino group, a phosphinyl group, a phosphinyloxy group, a phosphinylamino group, a phosphono group, a silyl group (a ditrimethylsiloxy methylbutoxy group), a hydrazino group, a ureide group, a boronic acid group (—B(OH)₂), a phosphate group (—OPO(OH)₂), a sulfate group (—OSO₃H), and other known substituents.

These substituents may further have the above substituents. In addition, in a case where the compound represented by Formula (1) is a polymer compound having a repeating structure, each of R¹ to R⁶ may have a group derived from a polymerizable group.

Among these, as the substituent that each of R¹ to R⁶ can independently represent, an alkyl group, an aryl group, an alkenyl group, an alkynyl group, a heterocyclic group, an alkoxy group, an alkylthio group, and a group represented by Formula (W) which will be described later are preferable; an alkyl group having 1 to 12 carbon atoms, an aryl group having 6 to 20 carbon atoms, an alkenyl group having 2 to 12 carbon atoms, an alkynyl group having 2 to 12 carbon atoms, an alkoxy group having 1 to 11 carbon atoms, a heterocyclic group having 5 to 12 carbon atoms, an alkylthio group having 1 to 12 carbon atoms, and a group represented by Formula (W) which will be described later are more preferable; a group having a linking group chain length, which will be described later, of equal to or less than 3.7 Å and a group represented by Formula (W) which will be described later are particularly preferable; and a group represented by Formula (W) which will be described later is more particularly preferable.

The group represented by Formula (W) will be described.

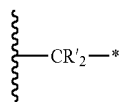
-L-R

Formula (W)

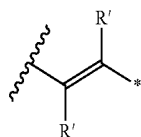
In Formula (W), R represents an alkyl group having 5 to 19 carbon atoms, and L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more

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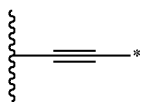
divalent linking groups represented by any of the following
Formulae (L-1) to (L-25) are bonded to each other;



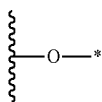
(L-1) 5



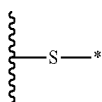
(L-2) 10



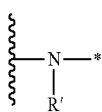
(L-3) 15



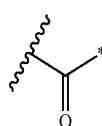
(L-4) 20



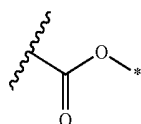
(L-5) 25



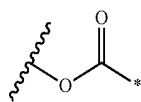
(L-6) 30



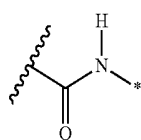
(L-7) 35



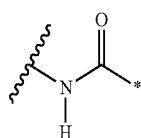
(L-8) 40



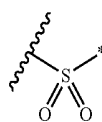
(L-9) 45



(L-10) 50



(L-11) 55

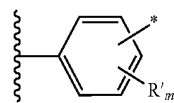


(L-12) 60

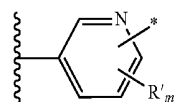
(L-12) 65

32

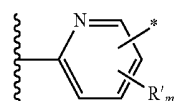
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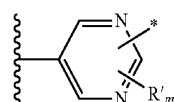
(L-13)



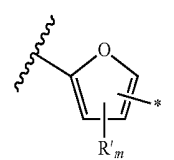
(L-14)



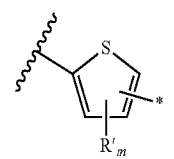
(L-15)



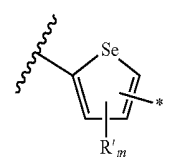
(L-16)



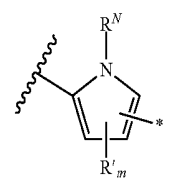
(L-17)



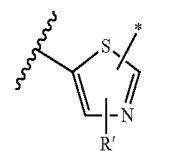
(L-18)



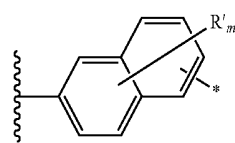
(L-19)



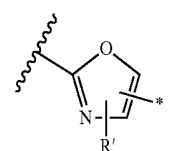
(L-20)



(L-21)



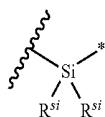
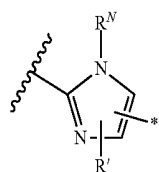
(L-22)



(L-23)

33

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in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

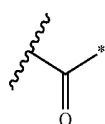
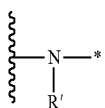
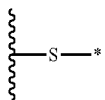
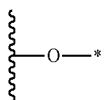
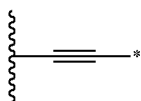
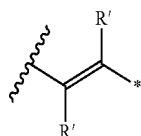
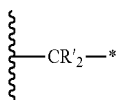
m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R^I in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and

each R^{Si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

In Formula (W), L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other.



(L-24)

5

(L-25)

10

15

20

25

30

(L-1)

35

(L-2)

40

(L-3)

45

(L-4)

50

(L-5)

55

(L-6)

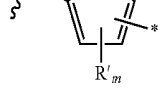
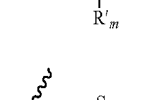
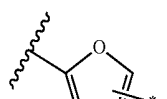
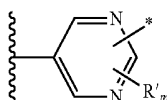
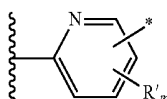
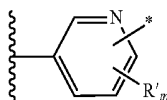
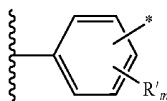
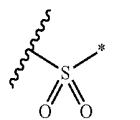
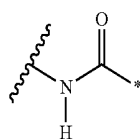
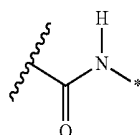
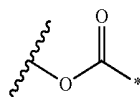
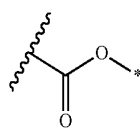
60

(L-7)

65

34

-continued



(L-8)

(L-9)

(L-10)

(L-11)

(L-12)

(L-13)

(L-14)

(L-15)

(L-16)

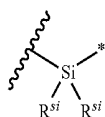
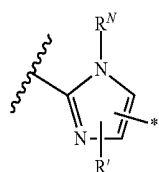
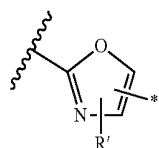
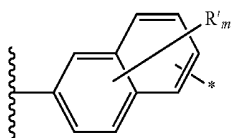
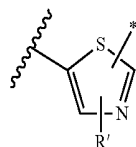
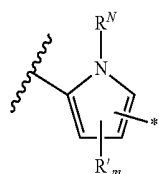
(L-17)

(L-18)

(L-19)

35

-continued



In Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton. In the present specification, in a case where L represents a divalent linking group in which two or more divalent linking groups represented by any of Formulae (L-1) to (L-25) are bonded to each other, the portion of a wavy line may represent a position of bonding to either a condensed heterocyclic skeleton or a divalent linking group represented by any of Formulae (L-1) to (L-25).

* represents a position of bonding to either the divalent linking group represented by any of Formulae (L-1) to (L-25) or R.

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, and m in Formula (L-22) represents 6.

Each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent.

R^N represents a hydrogen atom or a substituent.

Each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

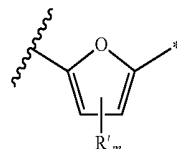
Each R' in Formulae (L-1) and (L-2) may form a condensed ring by being bonded to R adjacent to L.

Among the above, the divalent linking group represented by any of Formulae (L-17) to (L-21), (L-23), and (L-24) is more preferably a divalent linking group represented by any of the following Formulae (L-17A), (L-18A), (L-18B),

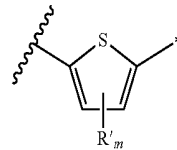
36

(L-19A) to (L-21A), (L-23A), and (L-24A), particularly preferably a divalent linking group represented by any of the following Formulae (L-17A), (L-18A), and (L-18B), and more particularly preferably a divalent linking group represented by the following Formula (L-18B).

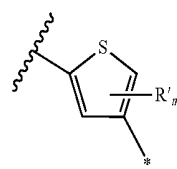
(L-21) 10 (L-17A)



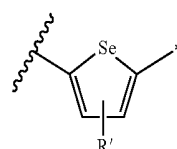
(L-22) 15 (L-18A)



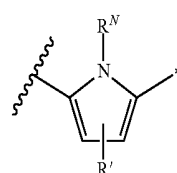
(L-23) 20 (L-18B)



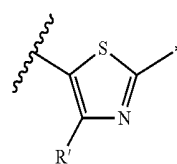
(L-24) 25 (L-19A)



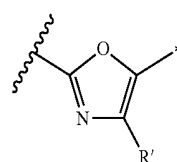
(L-25) 30 (L-20A)



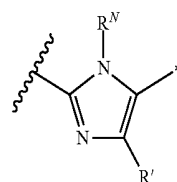
35 (L-21A)



40 (L-23A)



45 (L-24A)



Herein, R, representing an alkyl group having 5 to 19 carbon atoms, which is present on the terminal of the substituent represented by Formula (W) is considered to be a group in which the divalent linking group represented by Formula (L-1) repeats once or plural times. Therefore, the

substituent can be interpreted as either a substituent consisting of only -R in Formula (W) or a substituent consisting of -R-L in Formula (W).

In the present invention, the "alkyl group whose main chain consists of N carbon atoms" present on the terminal of the substituent represented by Formula (W) is interpreted as -L-R in Formula (W) including linking groups as much as possible from the terminal of the substituent but is not interpreted as -R alone. Specifically, the alkyl group is interpreted as a substituent in which "one (L-1) corresponding to L in Formula (W)" is bonded to "a substituted or unsubstituted alkyl group corresponding to R in Formula (W) having a main chain consisting of (N-1) carbon atoms". For example, in a case where a n-octyl group as an alkyl group having 8 carbon atoms is present on the terminal of the substituent, the alkyl group is interpreted as a substituent in which one (L-1), wherein two R's are hydrogen atoms, is bonded to a n-heptyl group having 7 carbon atoms. Furthermore, in a case where the substituent represented by Formula (W) is an alkoxy group having 8 carbon atoms, the alkoxy group is interpreted as a substituent in which one linking group represented by Formula (L-4) representing —O—, one linking group represented by Formula (L-1), in which two R's are hydrogen atoms, and a n-heptyl group having 7 carbon atoms are bonded to each other.

In a case where L forms a linking group in which divalent linking groups represented by any of Formulae (L-1) to (L-25) are bonded to each other, the number of the divalent linking groups bonded to each other represented by any of Formulae (L-1) to (L-25) is preferably 2 to 4, and more preferably 2 or 3.

Examples of the substituent R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) include those exemplified above as the substituents that can be adopted as R to R⁶ in Formula (1). Among these, the substituent R' in Formula (L-6) is preferably an alkyl group. In a case where R' in (L-6) is an alkyl group, the number of carbon atoms of the alkyl group is preferably 1 to 9, more preferably 4 to 9 from the viewpoint of the chemical stability and the carrier transport properties, and even more preferably 5 to 9. In a case where R' in (L-6) is an alkyl group, the alkyl group is preferably a linear alkyl group because then the carrier mobility can be improved.

R^N represents a hydrogen atom or a substituent, and examples of R^N include those exemplified above as substituents that can be adopted as R to R⁶ in Formula (1) described above. Among these, a hydrogen atom or a methyl group is preferable as R^N.

Each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group, and is preferably an alkyl group. The alkyl group that can be adopted as R^{si} is not particularly limited. However, the number of carbon atoms of the alkyl group that can be adopted as R^{si} is preferably 1 to 3, and for example, it is preferable that a methyl group, an ethyl group, or an isopropyl group is bonded thereto. The same alkyl groups or different alkyl groups may be bonded to the Si atom. The alkenyl group that can be adopted as R^{si} is not particularly limited. However, the alkenyl group is preferably a substituted or unsubstituted alkenyl group and more preferably a branched alkenyl group, and the number of carbon atoms of the alkenyl group is preferably 2 or 3. The alkynyl group that can be adopted as R^{si} is not particularly limited. However, the alkynyl group is preferably a substituted or unsubstituted alkynyl group and more preferably a branched alkynyl group, and the number of carbon atoms of the alkynyl group is preferably 2 or 3.

From the viewpoint of the chemical stability and the carrier transport properties, L is preferably a divalent linking group containing a divalent linking group represented by Formula (L-1) such that the divalent linking group represented by Formula (L-1) is linked to R.

L is preferably a divalent linking group represented by any of Formulae (L-1) to (L-5) and (L-13) to (L-24) or a divalent linking group in which two or more divalent linking groups represented by any of the above formulae are bonded to each other.

From the viewpoint of improving the heat resistance, L is preferably a divalent linking group represented by any of Formulae (L-1) to (L-3) and (L-13) to (L-24) or a divalent linking group in which a divalent linking group represented by any of Formulae (L-2), (L-3), and (L-13) to (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any of Formulae (L-2), (L-3), and (L-13) to (L-24) are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1). L is more preferably a divalent linking group in which a divalent linking group represented by any of Formulae (L-2), (L-3), and (L-13) to (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any of Formulae (L-2), (L-3), and (L-13) to (L-24) are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1).

From the viewpoint of improving the carrier mobility and the heat resistance, L is preferably a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking group in which a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any of the above formulae are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1). L is more preferably a divalent linking group in which a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any of the above formulae are bonded to each other, is bonded to a divalent linking group represented by Formula (L-1), and particularly preferably a divalent linking group in which a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) is bonded to a divalent linking group represented by Formula (L-1).

From the viewpoint of improving the carrier mobility and the heat resistance, L is preferably a divalent linking group in which a divalent linking group represented by Formula (L-17) or (L-18) is bonded to a divalent linking group represented by Formula (L-1), and more preferably a divalent linking group in which a divalent linking group represented by Formula (L-18) is bonded to a divalent linking group represented by Formula (L-1).

In Formula (W), R represents an alkyl group having 5 to 19 carbon atoms.

In a case where R represents an alkyl group, the alkyl group may be a linear, branched, or cyclic alkyl group. However, R is preferably a linear alkyl group because then the linearity of the molecule is improved, and hence the carrier mobility can be improved.

In contrast, from the viewpoint of improving the solubility in an organic solvent and suppressing the carrier mobility variation, R is preferably a branched alkyl group.

The preferred range of the number of carbon atoms of the alkyl group represented by R varies with the combination of R and L in Formula (W).

In a case where L in Formula (1) is an divalent linking group represented by Formula (L-1), from the viewpoint of improving the carrier mobility, R is preferably an alkyl group having 7 to 19 carbon atoms. In this case, from the viewpoint of improving the carrier mobility, R is more preferably an alkyl group having 8 to 17 carbon atoms. From the viewpoint of improving the carrier mobility and the solubility and suppressing the carrier mobility variation, R is particularly preferably a branched alkyl group having 8 to 17 carbon atoms, and more particularly preferably a branched alkyl group having 8 to 12 carbon atoms. In contrast, from the viewpoint of improving the carrier mobility and the heat resistance, R is particularly preferably a linear alkyl group having 8 to 17 carbon atoms, and more particularly preferably a linear alkyl group having 10 to 14 carbon atoms.

In a case where L in Formula (1) is a divalent linking group in which a divalent linking group represented by any of Formulae (L-2) to (L-25) is bonded to a divalent linking group represented by Formula (L-1), R is preferably an alkyl group having 5 to 18 carbon atoms. In this case, from the viewpoint of improving the carrier mobility, R is more preferably an alkyl group having 5 to 13 carbon atoms. From the viewpoint of improving the carrier mobility and suppressing the carrier mobility variation, R is particularly preferably a branched alkyl group having 7 to 13 carbon atoms, and more particularly preferably a branched alkyl group having 7 to 11 carbon atoms. In contrast, from the viewpoint of improving the carrier mobility and the heat resistance, R is particularly preferably a linear alkyl group having 8 to 17 carbon atoms, and more particularly preferably a linear alkyl group having 10 to 14 carbon atoms.

From the viewpoint of improving the carrier mobility, the solubility in an organic solvent, and the heat resistance and suppressing the carrier mobility variation, R and L in Formula (W) are more preferably in a combination in which L in Formula (1) is a divalent linking group wherein a divalent linking group represented by any one of Formulae (L-2), (L-3), and (L-13) to (L-24) is bonded to a divalent linking group represented by Formula (L-1), and R is a branched alkyl group. R and L in Formula (W) are particularly preferably in a combination in which L in Formula (1) is a divalent linking group represented by any of Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24), and R is a branched alkyl group having 8 to 17 carbon atoms.

In a case where R is an alkyl group having a substituent, examples of the substituent include a halogen atom and the like, and the halogen atom is preferably a fluorine atom. In a case where R is an alkyl group having a fluorine atom, a perfluoroalkyl group may be formed by the substitution of all of the hydrogen atoms of the alkyl group with the fluorine atom. Here, R is preferably an unsubstituted alkyl group.

In Formula (W), the total number of carbon atoms contained in L and R is preferably 6 to 20. For example, in a case where L is (L-1) and R is an alkyl group having 5 to 19 carbon atoms, the total number of carbon atoms contained in L and R is 6 to 20. If the total number of carbon atoms contained in L and R is equal to or greater than the lower limit of the above range, the carrier mobility is improved, and the driving voltage is reduced. If the total number of carbon atoms contained in L and R is equal to or less than the upper limit of the above range, the solubility in an organic solvent is improved.

The total number of carbon atoms contained in L and R is preferably 8 to 20, more preferably 8 to 16, particularly preferably 8 to 14, and more particularly preferably 8 to 12.

In the compound represented by the Formula (1), the number of groups adopted as one of R¹ to R⁶ and represented

by the Formula (W) is preferably 1 to 4 from the viewpoint of improving the carrier mobility and the solubility in an organic solvent, more preferably 1 or 2, and particularly preferably 2.

The group represented by the Formula (W) is positioned in any of R¹ to R⁶ without particular limitation. However, the group is preferably positioned in any of R³ to R⁶, and more preferably positioned in R⁵ or R⁶ from the viewpoint of improving the carrier mobility and the solubility in an organic solvent.

The number of substituents that are adopted as R¹ to R⁶ but other than the substituent represented by the Formula (W) is preferably 0 to 4, more preferably 0 to 2, particularly preferably 0 or 1, and more particularly preferably 0.

In a case where each of R¹ to R⁶ is a substituent other than the substituent represented by Formula (W), the substituent as each of R¹ to R⁶ is preferably a group having a linking group chain length of equal to or less than 3.7 Å, more preferably a group having a linking group chain length of 1.0 Å to 3.7 Å, and even more preferably a group having a linking group chain length of 1.0 Å to 2.1 Å.

The linking group chain length refers to a length from a C atom to the terminal of the substituent R⁰ in a C—R⁰ bond. Structural optimization calculation can be performed using a density functional method (Gaussian 03 (Gaussian Inc.)/basis function: 6-31G*, exchange-correlation functional: B3LYP/LANL2DZ). The molecular lengths of typical substituents are 4.6 Å for a propyl group, 4.6 Å for a pyrrole group, 4.5 Å for a propynyl group, 4.6 Å for a propenyl group, 4.5 Å for an ethoxy group, 3.7 Å for a methylthio group, 3.4 Å for an ethenyl group, 3.5 Å for an ethyl group, 3.6 Å for an ethynyl group, 3.3 Å for a methoxy group, 2.1 Å for a methyl group, and 1.0 Å for a hydrogen atom.

In a case where each of R¹ to R⁶ is a substituent other than the substituent represented by Formula (W), each of the substituents as R¹ to R⁶ is preferably independently a substituted or unsubstituted alkyl group having 2 or less carbon atoms, a substituted or unsubstituted alkynyl group having 2 or less carbon atoms, a substituted or unsubstituted alkenyl group having 2 or less carbon atoms, or a substituted or unsubstituted acyl group having two or less carbon atoms, and more preferably independently a substituted or unsubstituted alkyl group having 2 or less carbon atoms.

In a case where each of R¹ to R⁶ is a substituent other than the substituent represented by Formula (W), and each of the substituents as R¹ to R⁶ independently represents a substituted alkyl group having 2 or less carbon atoms, examples of the substituent that the alkyl group can have include a cyano group, a fluorine atom, a deuterium atom, and the like, and among these, a cyano group is preferable. In a case where each of R¹ to R⁶ is a substituent other than the substituent represented by Formula (W), the substituted or unsubstituted alkyl group having 2 or less carbon atoms that is represented by the substituent as each of R¹ to R⁶ is preferably a methyl group, an ethyl group, or a methyl group substituted with a cyano group, more preferably a methyl group or a methyl group substituted with a cyano group, and particularly preferably a methyl group substituted with a cyano group.

In a case where each of R¹ to R⁶ is a substituent other than the substituent represented by Formula (W), and each of the substituents as R¹ to R⁶ independently represents a substituted alkynyl group having 2 or less carbon atoms, examples of the substituent that the alkynyl group can have include a deuterium atom and the like. In a case where each of R¹ to R⁶ is a substituent other than the substituent represented by Formula (W), examples of the substituted or unsubstituted

alkynyl group having 2 or less carbon atoms that is represented by the substituent as each of R^1 to R^6 include an ethynyl group and an acetylene group substituted with a deuterium atom, and among these, an ethynyl group is preferable.

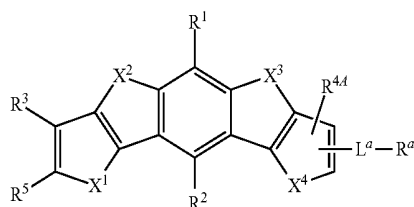
In a case where each of R^1 to R^6 is a substituent other than the substituent represented by Formula (W), and each of the substituents as R^1 to R^6 independently represents a substituted alkenyl group having 2 or less carbon atoms, examples of the substituent that the alkenyl group can have include a deuterium atom and the like. In a case where each of R^1 to R^6 is a substituent other than the substituent represented by Formula (W), examples of a substituted or unsubstituted alkenyl group having 2 or less carbon atoms that is represented by the substituent as each of R^1 to R^6 include an ethenyl group and an ethenyl group substituted with a deuterium atom, and among these, an ethenyl group is preferable.

In a case where each of R^1 to R^6 is a substituent other than the substituent represented by Formula (W), and each of the substituents as R^1 to R^6 independently represents a substituted acyl group having 2 or less carbon atoms, examples of the substituent that the acyl group can have include a fluorine atom and the like. In a case where each of R^1 to R^6 is a substituent other than the substituent represented by Formula (W), examples of a substituted or unsubstituted acyl group having 2 or less carbon atoms that is represented by the substituent as each of R^1 to R^6 include a formyl group, an acetyl group, and an acetyl group substituted with fluorine, and among these, a formyl group is preferable.

The compound represented by the Formula (1) is preferably a compound represented by the following Formula (2-1) or (2-2), and particularly preferably a compound represented by the Formula (2-2) from the viewpoint of high mobility. Furthermore, the compound represented by Formula (2-2) is preferably a compound represented by Formula (2-2A) which will be described later.

First, a case where the compound represented by the Formula (1) is a compound represented by the following Formula (2-1) will be described.

Formula (2-1)

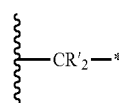


In Formula (2-1), each of X^1 to X^4 independently represents an O atom or a S atom,

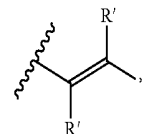
each of R^1 to R^3 , R^{4A} , and R^5 independently represents a hydrogen atom or a substituent and is not a group represented by $-L^a-R^a$,

R^a represents an alkyl group having 5 to 19 carbon atoms, and

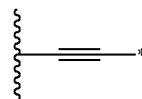
L^a represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



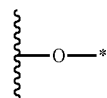
(L-1)



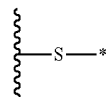
(L-2)



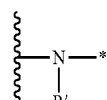
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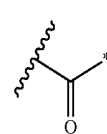
(L-4)



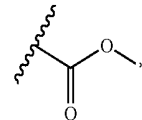
(L-5)



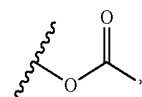
(L-6)



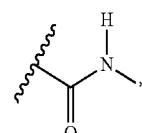
(L-7)



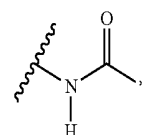
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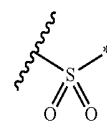
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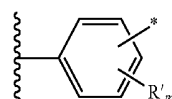
(L-10)



(L-11)



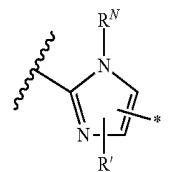
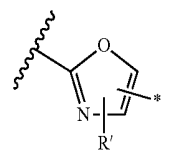
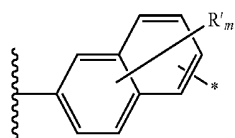
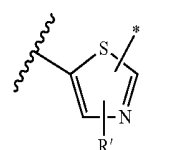
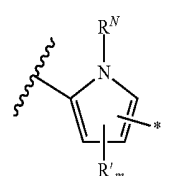
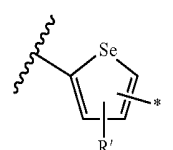
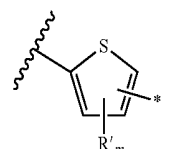
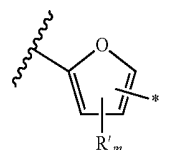
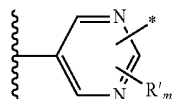
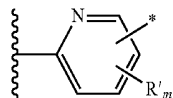
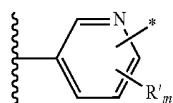
(L-12)



(L-13)

43

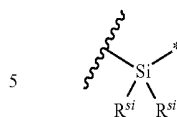
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44

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(L-14)



(L-15)

(L-16)

(L-17)

(L-18)

(L-19)

(L-20)

(L-21)

(L-25)

In Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and

each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

In Formula (2-1), each of X¹ to X⁴ independently represents an O atom or a S atom. The preferred range of X¹ to X⁴ in Formula (2-1) is the same as the preferred range of X¹ to X⁴ in Formula (1).

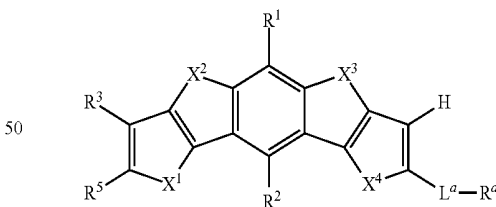
In Formula (2-1), each of R¹ to R³, R^{4,4}, and R⁵ independently represents a hydrogen atom or a substituent and is not a group represented by -L^a-R^a. In a case where each of R¹ to R³, R^{4,4}, and R⁵ in Formula (2-1) represents a substituent, the preferred range of the substituent is the same as the preferred range of the substituent that represented by each of R¹ to R⁶ in Formula (1) and other than the substituent represented by Formula (W).

In Formula (2-1), L^a represents a divalent linking group represented by any of the Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other; and R^a represents an alkyl group having 5 to 19 carbon atoms. The preferred range of L^a and R^a in Formula (2-1) is the same as the preferred range of L and R in Formula (1).

The compound represented by Formula (2-1) is preferably a compound represented by the following Formula (2-1A).

Formula (2-1A)

(L-22)



(L-23)

In Formula (2-1A), each of X¹ to X⁴ independently represents an O atom or a S atom,

each of R¹ to R³ and R⁵ independently represents a hydrogen atom or a substituent and is not a group represented by -L^a-R^a,

R^a represents an alkyl group having 5 to 19 carbon atoms,

L^a represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other; and

the preferred range of X¹ to X⁴ in Formula (2-1A) is the same as the preferred range of X¹ to X⁴ in Formula (1).

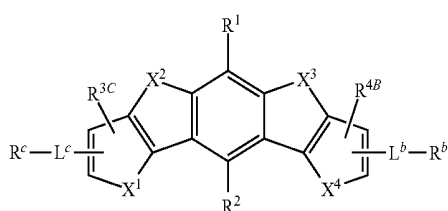
45

In Formula (2-1A), each of R^1 to R^3 and R^5 independently represents a hydrogen atom or a substituent. In a case where each of R^1 to R^3 and R^5 in Formula (2-1A) represents a substituent, the preferred range of the substituent is the same as the preferred range of the substituent that is represented by each of R^1 to R^6 in Formula (1) and other than the substituent represented by Formula (W).

The preferred range of L^a in Formula (2-1A) is the same as the preferred range of L in Formula (1), and the preferred range of R^a in Formula (2-1A) is the same as the preferred range of R in Formula (1).

Next, a case where the compound represented by Formula (1) is a compound represented by the following Formula (2-2) will be described.

Formula (2-2)



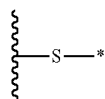
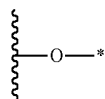
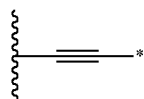
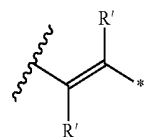
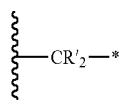
In Formula (2-2),

each of X^1 to X^4 independently represents an O atom or a S atom,

each of R^1 , R^2 , R^{3C} , and R^{4B} independently represents a hydrogen atom or a substituent,

each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other,



(L-1)

45

(L-2)

50

(L-3)

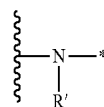
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(L-4)

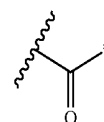
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(L-5)

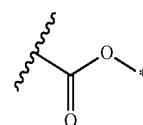
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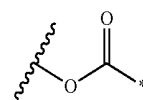
(L-6)



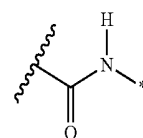
(L-7)



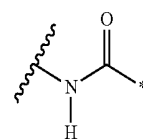
(L-8)



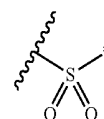
(L-9)



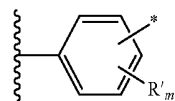
(L-10)



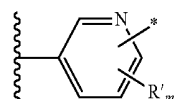
(L-11)



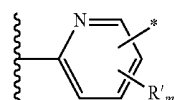
(L-12)



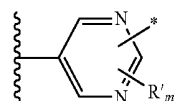
(L-13)



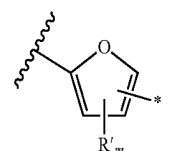
(L-14)



(L-15)



(L-16)



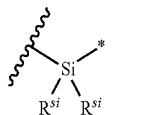
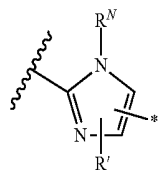
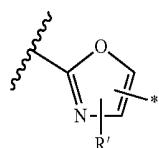
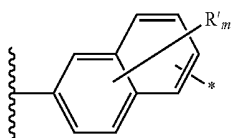
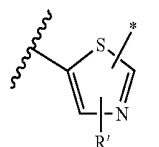
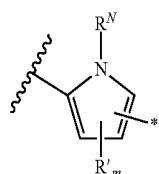
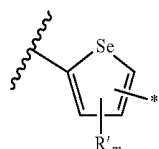
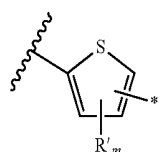
(L-17)

46

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47

-continued



In Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

In Formula (2-2), each of X¹ to X⁴ independently represents an O atom or a S atom. The preferred range of X¹ to X⁴ in Formula (2-2) is the same as the preferred range of X¹ to X⁴ in Formula (1).

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(L-18) In Formula (2-2), each of R¹, R², R^{3C}, and R^{4B} independently represents a hydrogen atom or a substituent. In a case where each of each of R¹, R², R^{3C}, and R^{4B} in Formula (2-2) represents a substituent, the preferred range of the substituent is the same as the preferred range of the substituent that is represented by each of R¹ to R⁶ in Formula (1) and other than the substituent represented by Formula (W).

(L-19) In Formula (2-2), each of L^b and L^c independently represents a divalent linking group represented by any of Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of Formulae (L-1) to (L-25) are bonded to each other; and each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms.

(L-20) The preferred range of L^b and L^c in Formula (2-2) is the same as the preferred range of L in Formula (1), and the preferred range of R^b and R^c in Formula (2-2) is the same as the preferred range of R in Formula (1).

(L-21) The compound represented by Formula (1) is particularly preferably a compound represented by the following Formula (2-2A). The compound with the following structure can easily have a crystal structure having high planarity that results in high carrier mobility. Therefore, such a compound makes it easy to obtain an organic transistor having high carrier mobility.

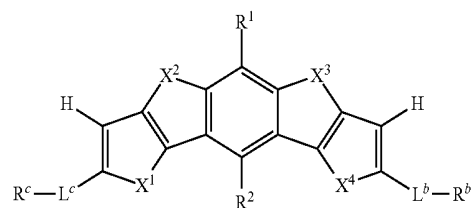
(L-22)

Formula (2-2A)

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(L-23)

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(L-24) In Formula (2-2A), each of X¹ to X⁴ independently represents an O atom or a S atom,

each of R¹ and R² independently represents a hydrogen atom or a substituent,

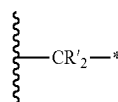
each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

(L-25) each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25);

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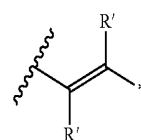
(L-1)

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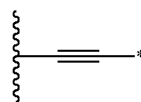


(L-2)

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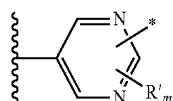
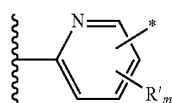
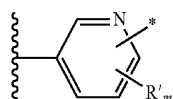
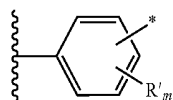
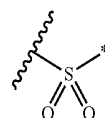
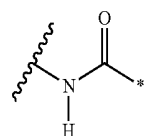
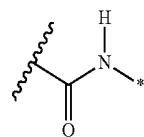
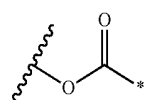
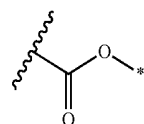
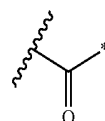
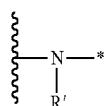
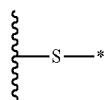
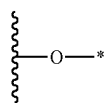


(L-3)



49

-continued



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-continued

(L-4)

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(L-5)

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(L-6)

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(L-7)

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(L-8)

25

(L-9)

(L-10)

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(L-11)

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(L-12)

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(L-13)

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(L-14)

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(L-15)

(L-16)

(L-17)

(L-18)

(L-19)

(L-20)

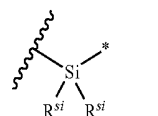
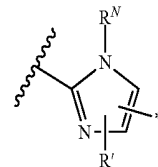
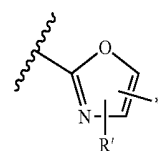
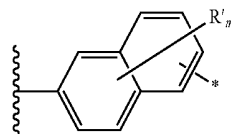
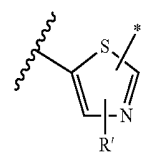
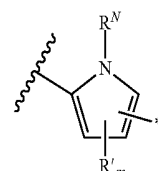
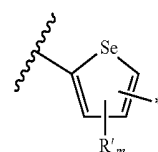
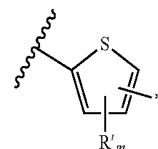
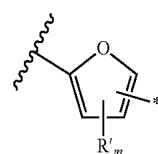
(L-21)

(L-22)

(L-23)

(L-24)

(L-25)



In Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6,

each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

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R^N represents a hydrogen atom or a substituent, and each R^{S^i} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

The preferred range of X^1 to X^4 in Formula (2-2A) is the same as the preferred range of X^1 to X^4 in Formula (1).

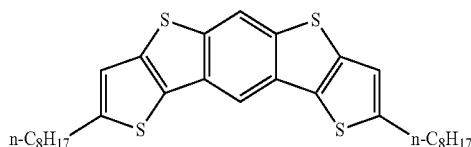
In a case where each of R^1 and R^2 in Formula (2-2A) represents a substituent, the preferred range of the substituent is the same as the preferred range of the substituent that is represented by each of R^1 to R^6 in Formula (1) and other than the substituent represented by Formula (W).

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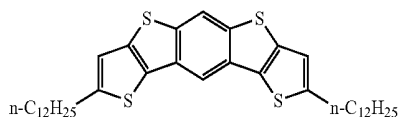
The preferred range of L^b and L^c in Formula (2-2A) is the same as the preferred range of L in Formula (1), and the preferred range of R^b and R^c in Formula (2-2A) is the same as the preferred range of R in Formula (1).

Specific examples of the compound represented by the Formula (1) will be shown below, but the compound represented by Formula (1) that can be used in the present invention is not limited to the specific examples.

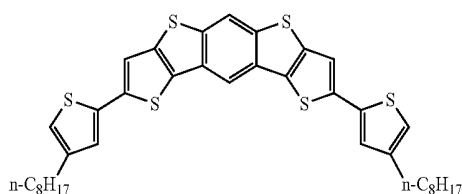
Compound 1



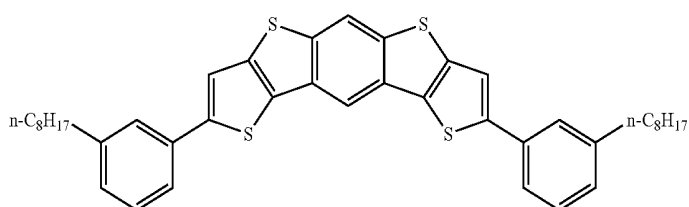
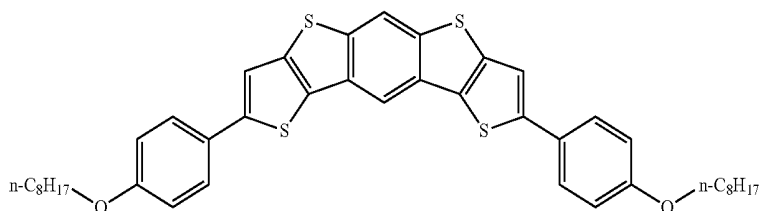
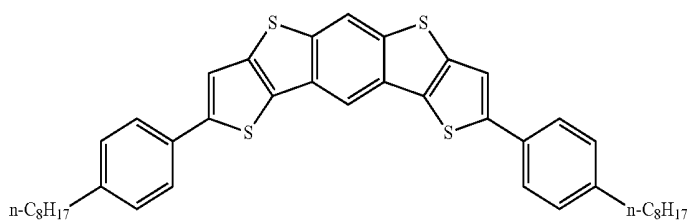
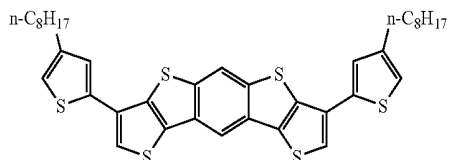
Compound 3



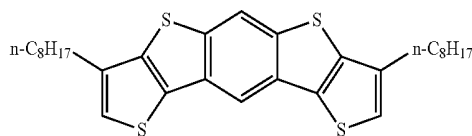
Compound 5



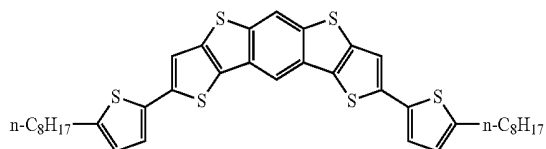
Compound 7



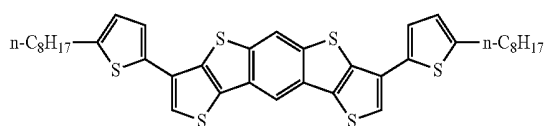
Compound 2



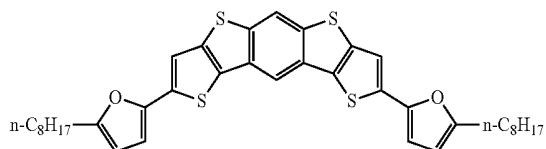
Compound 4



Compound 6



Compound 8

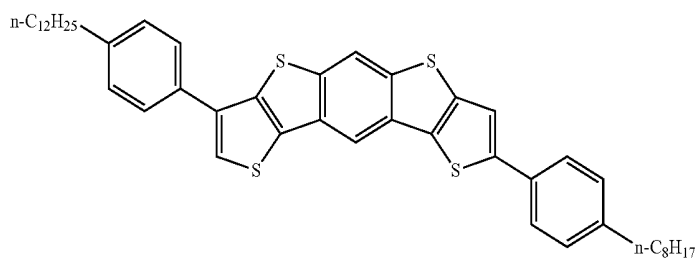


Compound 9

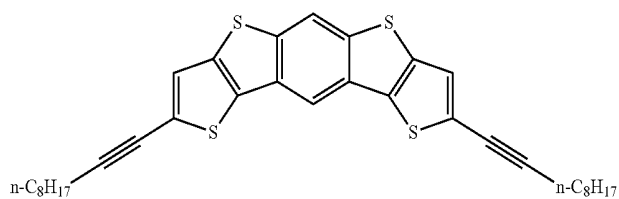
Compound 10

Compound 11

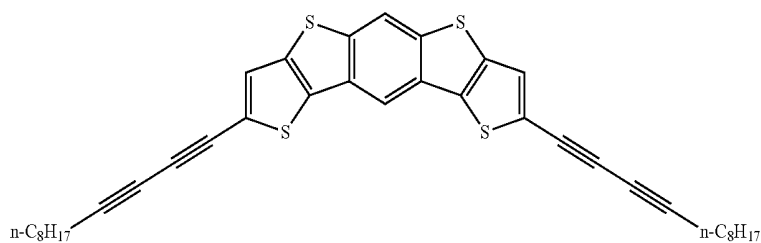
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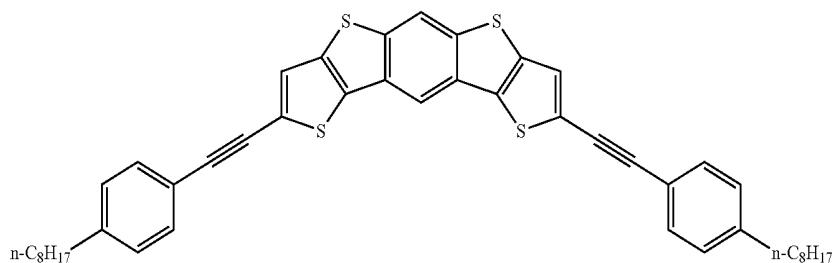
Compound 12



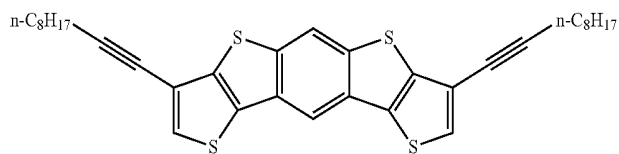
Compound 13



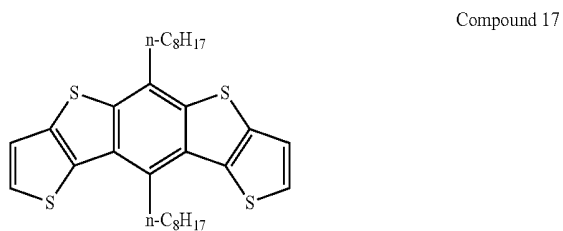
Compound 14



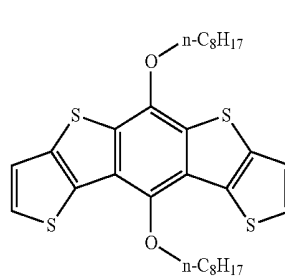
Compound 15



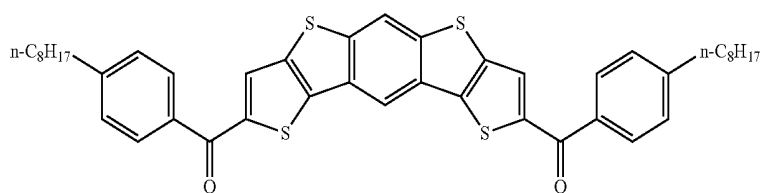
Compound 16



Compound 17



Compound 18



Compound 19

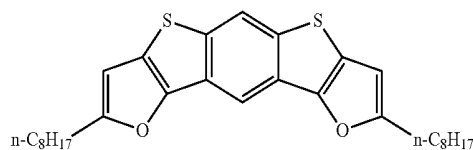
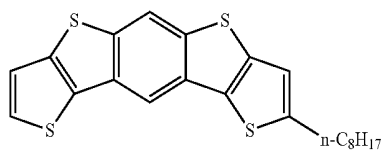
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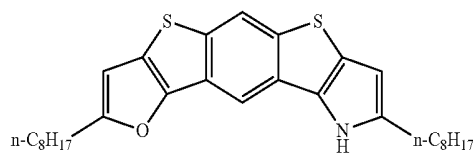
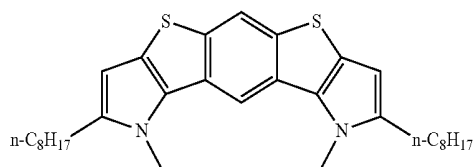
Compound 20

Compound 21



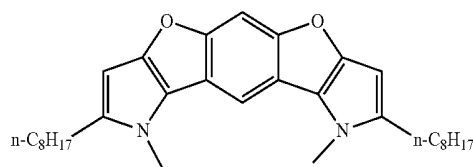
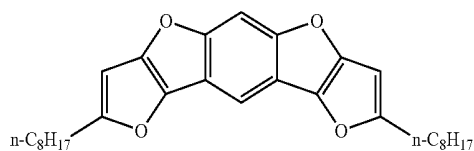
Compound 22

Compound 23



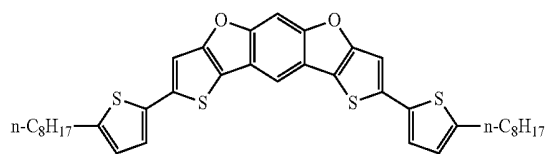
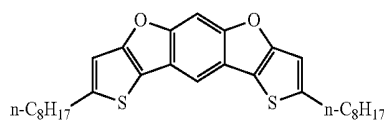
Compound 24

Compound 25



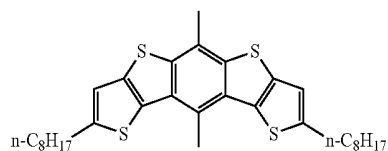
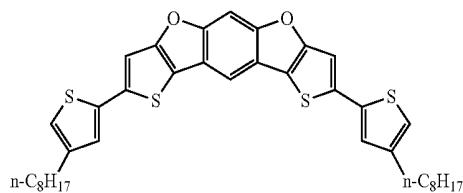
Compound 26

Compound 27

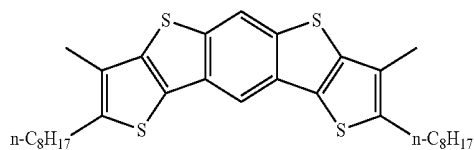


Compound 28

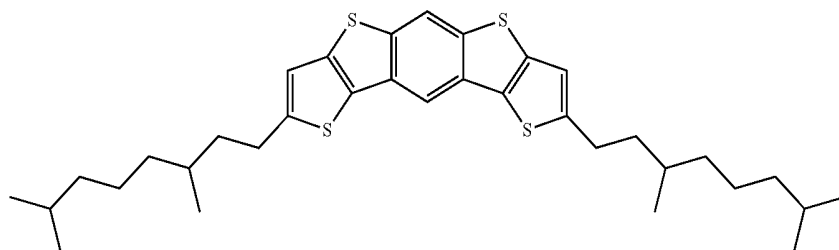
Compound 29



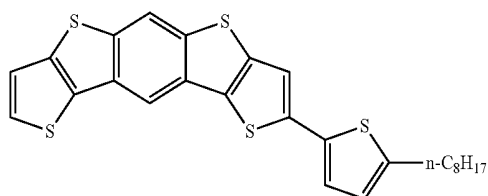
Compound 30



Compound 31



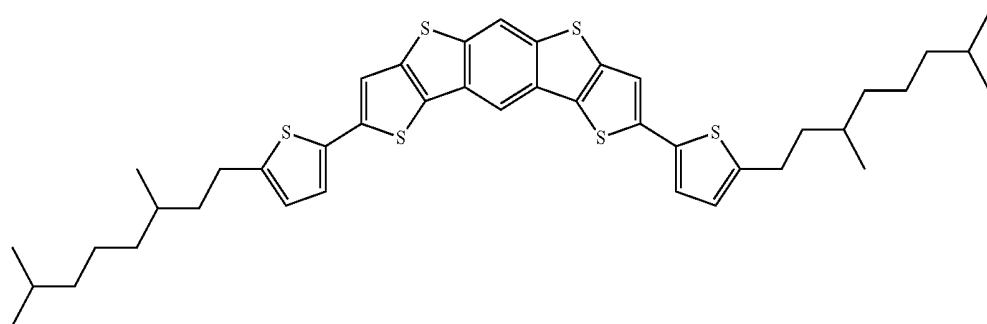
Compound 32



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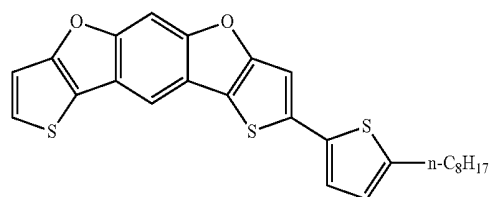
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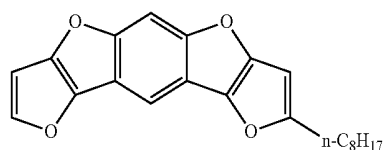
Compound 33

Compound 34

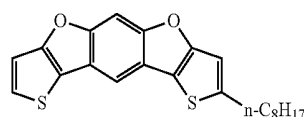
Compound 35



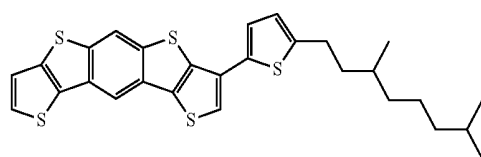
Compound 36



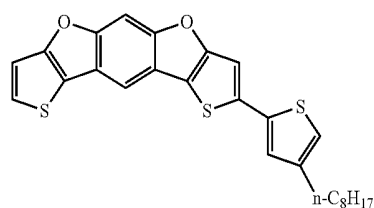
Compound 37



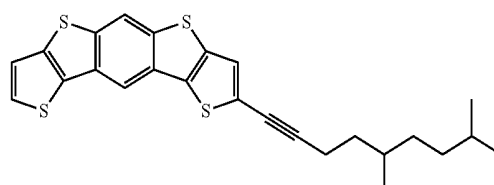
Compound 38



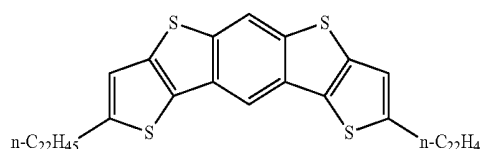
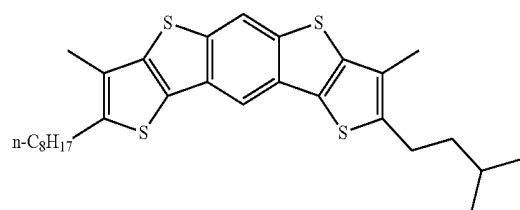
Compound 39



Compound 40



Compound 41



The compound represented by the Formula (1) may have a repeating structure and may be a low-molecular weight compound or a polymer compound. In a case where the compound represented by Formula (1) is a low-molecular weight compound, the molecular weight thereof is preferably equal to or less than 3,000, more preferably equal to or less than 2,000, even more preferably equal to or less than 1,000, and particularly preferably equal to or less than 850. It is preferable that the molecular weight is equal to or less than the upper limit described above because then the solubility in a solvent can be improved.

In contrast, from the viewpoint of the stability of the film quality, the molecular weight is preferably equal to or greater than 400, more preferably equal to or greater than 450, and even more preferably equal to or greater than 500.

Furthermore, in a case where the compound represented by Formula (1) is a polymer compound having a repeating structure, the weight average molecular weight thereof is

preferably equal to or greater than 30,000, more preferably equal to or greater than 50,000, and even more preferably equal to or greater than 100,000. In a case where the compound represented by Formula (1) is a polymer compound having a repeating structure, it is preferable that the weight average molecular weight thereof is equal to or greater than the lower limit described above because then the intermolecular interaction can be enhanced, and hence high mobility is obtained.

Examples of the polymer compound having a repeating structure include a π -conjugated polymer having a repeating structure in which the compound represented by Formula (1) represents at least one or more arylene groups or heteroarylene groups (thiophene or bithiophene), and a pendant-type polymer in which the compound represented by Formula (1) is bonded to the main chain of the polymer via the side chain. As the main chain of the polymer, polyacrylate, polyvinyl, polysiloxane, or the like is preferable, and as

the side chain, an alkylene group, a polyethylene oxide group, or the like is preferable.

The compound represented by Formula (1) can be synthesized with reference to known documents (Bull. Chem. Soc. Jpn., 1987, 60, 4187, J. Am. Chem. Soc. 2011, 133, 5024, Chem. Eur. J. 2013, 19, 3721) by using, as a starting material, a compound described in scheme 1 which will be described later.

In synthesizing the compound of the present invention, any of reaction conditions may be used. As a reaction solvent, any solvent may be used. Furthermore, in order to accelerating a ring forming reaction, an acid or a base is preferably used, and a base is particularly preferably used. The optimal reaction conditions vary with the structure of the intended compound, but can be set with reference to the specific reaction conditions described in the above documents.

The synthetic intermediate having various substituents can be synthesized using known reactions in combination. Furthermore, various substituents may be introduced into the intermediate at any stage. After the intermediate is synthesized, it is preferable to purify the intermediate by column chromatography, recrystallization, or the like and then further purify it by sublimation. By the sublimation purification, it is possible to separate organic impurities and to effectively remove an inorganic salt, a residual solvent, and the like.

<Structure of Organic Transistor>

The organic transistor of the present invention has a semiconductor active layer containing the compound represented by Formula (1).

The organic transistor of the present invention may further have layers other than the semiconductor active layer.

The organic transistor of the present invention is preferably used as an organic field effect transistor (FET), and is more preferably used as an insulated gate-type FET in which the gate is insulated from channels.

Hereinafter, preferred structural aspects of the organic transistor of the present invention will be specifically described by using drawings, but the present invention is not limited to the aspects.

(Lamination Structure)

The lamination structure of an organic field effect transistor is not particularly limited, and various known structures can be adopted.

For example, the organic transistor of the present invention can adopt a structure (bottom gate/top contact type) in which an electrode, an insulator layer, a semiconductor active layer (organic semiconductor layer), and two electrodes are arranged in this order on the upper surface of a substrate which is a lower most layer. In this structure, the electrode on the upper surface of the substrate as the lower most layer is provided in a portion of the substrate, and the insulator layer is so disposed that it comes into contact with the substrate in a portion other than the electrode. The two electrodes provided on the upper surface of the semiconductor active layer are arranged in a state of being separated from each other.

FIG. 1 shows the constitution of a bottom gate/top contact-type element. FIG. 1 is a schematic view showing a section of an exemplary structure of the organic transistor of the present invention. In the organic transistor shown in FIG. 1, a substrate 11 is disposed as a lower most layer, an electrode 12 is provided in a portion of the upper surface thereof, and an insulator layer 13 is provided such that it covers the electrode 12 and comes into contact with the substrate 11 in a portion other than the electrode 12. On the

upper surface of the insulator layer 13, a semiconductor active layer 14 is provided, and in a portion of the upper surface thereof, two electrodes 15a and 15b separated from each other are arranged.

In the organic transistor shown in FIG. 1, the electrode 12 is a gate, and the electrode 15a and the electrode 15b are a drain and a source respectively. The organic transistor shown in FIG. 1 is an insulated gate-type FET in which a channel as a path of electric currents between the drain and the source is insulated from the gate.

As an example of the structure of the organic transistor of the present invention, a bottom gate/bottom contact-type element can be exemplified.

FIG. 2 shows the constitution of the bottom gate/bottom contact-type element. FIG. 2 is a schematic view showing a section of the structure of an organic transistor manufactured as a substrate for measuring FET characteristics in examples of the present invention. In the organic transistor shown in FIG. 2, a substrate 31 is disposed as a lower most layer, an electrode 32 is provided in a portion of the upper surface thereof, and an insulator layer 33 is provided such that it covers the electrode 32 and comes into contact with the substrate 31 in a portion other than the electrode 32. Furthermore, a semiconductor active layer 35 is provided on the upper surface of the insulator layer 33, and electrodes 34a and 34b are in a lower portion of the semiconductor active layer 35.

In the organic transistor shown in FIG. 2, the electrode 32 is a gate, and the electrode 34a and the electrode 34b are a drain and a source respectively. The organic transistor shown in FIG. 2 is an insulated gate-type FET in which a channel as a path of electric currents between the drain and the source is insulated from the gate.

As the structure of the organic transistor of the present invention, a top gate/top contact-type element in which an insulator and a gate electrode are in the upper portion of a semiconductor active layer or a top gate/bottom contact-type element can also be preferably used.

(Thickness)

In a case where the organic transistor of the present invention needs to be a thinner transistor, the total thickness of the transistor is preferably, for example, 0.1 μm to 0.5 μm .

(Sealing)

In order to improve the preservation stability of the organic transistor element by blocking the organic transistor element from the atmosphere or moisture, the entirety of the organic transistor element may be sealed with a metal sealing can, glass, an inorganic material such as silicon nitride, a polymer material such as parylene, a low-molecular weight material, or the like.

Hereinafter, preferred aspects of the respective layers of the organic transistor of the present invention will be described, but the present invention is not limited to the aspects.

<Substrate>

(Material)

The organic transistor of the present invention preferably includes a substrate.

The material of the substrate is not particularly limited, and known materials can be used. Examples of the material include a polyester film such as polyethylene naphthalate (PEN) or polyethylene terephthalate (PET), a cycloolefin polymer film, a polycarbonate film, a triacetylcellulose (TAC) film, a polyimide film, a material obtained by bonding these polymer films to extremely thin glass, ceramics, silicon, quartz, glass, and the like. Among these, silicon is preferable.

<Electrode>

(Material)

The organic transistor of the present invention preferably includes an electrode.

As the material constituting the electrode, known conductive materials such as a metal material like Cr, Al, Ta, Mo, Nb, Cu, Ag, Au, Pt, Pd, In, Ni, or Nd, an alloy material of these, a carbon material, and a conductive polymer can be used without particular limitation.

(Thickness)

The thickness of the electrode is not particularly limited, but is preferably 10 nm to 50 nm.

A gate width (or a channel width) W and a gate length (or a channel length) L are not particularly limited. However, a ratio of W/L is preferably equal to or greater than 10, and more preferably equal to or greater than 20.

<Insulator Layer>

(Material)

The material constituting the insulator layer is not particularly limited as long as an insulating effect is obtained as required. Examples of the material include silicon dioxide, silicon nitride, a fluorine polymer-based insulating material such as PTFE or CYTOP, a polyester insulating material, a polycarbonate insulating material, an acryl polymer-based insulating material, an epoxy resin-based insulating material, a polyimide insulating material, a polyvinyl phenol resin-based insulating material, a poly p-xylylene resin-based insulating material, and the like.

A surface treatment may be performed on the upper surface of the insulator layer. For example, it is possible to preferably use an insulator layer in which the silicon dioxide surface thereof is subjected to the surface treatment by being coated with hexamethyldisilazane (HMDS) or octadecyltrichlorosilane (OTS).

(Thickness)

The thickness of the insulator layer is not particularly limited. However, in a case where the film needs to be thinned, the thickness of the insulator layer is preferably 10 nm to 400 nm, more preferably 20 nm to 200 nm, and particularly preferably 50 nm to 200 nm.

<Semiconductor Active Layer>

(Material)

In the organic transistor of the present invention, the semiconductor active layer contains a compound represented by Formula (1) described above, that is, the compound of the present invention.

The semiconductor active layer may be a layer consisting of the compound of the present invention or a layer further containing a polymer binder, which will be described later, in addition to the compound of the present invention. Furthermore, the semiconductor active layer may contain a residual solvent used at the time of forming a film.

The content of the polymer binder in the semiconductor active layer is not particularly limited. However, the content of the polymer binder is preferably within a range of 0% by mass to 95% by mass, more preferably within a range of 10% by mass to 90% by mass, even more preferably within a range of 20% by mass to 80% by mass, and particularly preferably within a range of 30% by mass to 70% by mass.

(Thickness)

The thickness of the semiconductor active layer is not particularly limited. However, in a case where the film needs to be thinned, the thickness of the semiconductor active layer is preferably 10 nm to 400 nm, more preferably 10 nm to 200 nm, and particularly preferably 10 nm to 100 nm.

[Organic Semiconductor Material for Non-Light-Emitting Organic Semiconductor Device]

The present invention also relates to an organic semiconductor material for a non-light-emitting organic semiconductor device containing the compound represented by Formula (1), that is, the compound of the present invention.

(Non-Light-Emitting Organic Semiconductor Device)

In the present specification, a “non-light-emitting organic semiconductor device” refers to a device which is not used for the purpose of emitting light. The non-light-emitting organic semiconductor device preferably uses an electronic element having a layered structure consisting of films. The non-light-emitting organic semiconductor device includes an organic transistor, an organic photoelectric conversion element (a solid-state imaging element used for a photosensor, a solar cell used for energy conversion, or the like), a gas sensor, an organic rectifying element, an organic inverter, an information recording element, and the like. The organic photoelectric conversion element can be used for both a photosensor (solid-state imaging element) and for energy conversion (a solar cell). Among these, an organic photoelectric conversion element and an organic transistor are preferable, and an organic transistor is more preferable. That is, the organic semiconductor material for a non-light-emitting organic semiconductor device of the present invention is preferably a material for an organic transistor as described above.

(Organic Semiconductor Material)

In the present specification, the “organic semiconductor material” is an organic material showing characteristics of a semiconductor. Just as the semiconductor composed of an inorganic material, the organic semiconductor is classified into a p-type (hole-transporting) organic semiconductor material conducting holes as carriers and an n-type (electron-transporting) organic semiconductor material conducting electrons as carriers.

The compound of the present invention may be used as any of the p-type organic semiconductor material and the n-type organic semiconductor material, but is preferably used as the p-type. The ease with which the carriers flow in the organic semiconductor is represented by a carrier mobility μ . The higher the carrier mobility μ , the better. The carrier mobility μ , is preferably equal to or greater than $1 \times 10^{-3} \text{ cm}^2/\text{Vs}$, more preferably equal to or greater than $5 \times 10^{-3} \text{ cm}^2/\text{Vs}$, particularly preferably equal to or greater than $1 \times 10^{-2} \text{ cm}^2/\text{Vs}$, more particularly preferably equal to or greater than $3 \times 10^{-2} \text{ cm}^2/\text{Vs}$, even more particularly preferably equal to or greater than $5 \times 10^{-2} \text{ cm}^2/\text{Vs}$, and most preferably equal to or greater than $7 \times 10^{-2} \text{ cm}^2/\text{Vs}$. The carrier mobility μ , can be determined by the characteristics of the prepared field effect transistor (FET) element or by a time-of-flight (TOF) measurement method.

[Organic Semiconductor Film for Non-Light-Emitting Organic Semiconductor Device]

(Material)

The present invention also relates to an organic semiconductor film for a non-light-emitting organic semiconductor device containing the compound represented by Formula (1), that is, the compound of the present invention.

As the organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention, an aspect is also preferable in which the organic semiconductor film contains the compound represented by Formula (1), that is, the compound of the present invention, and does not contain a polymer binder.

Furthermore, the organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention may contain the compound represented by Formula (1), that is, the compound of the present invention, and a polymer binder.

Examples of the polymer binder include an insulating polymer such as polystyrene, polycarbonate, polyarylate, polyester, polyamide, polyimide, polyurethane, polysiloxane, polysulfone, polymethyl methacrylate, polymethyl acrylate, cellulose, polyethylene, or polypropylene, a copolymer of these, a photoconductive polymer such as polyvinylcarbazole or polysilane, a conductive polymer such as polythiophene, polypyrrole, polyaniline, or poly p-phenylenevinylene, and a semiconductor polymer.

One kind of the aforementioned polymer binder may be used singly, or plural kinds thereof may be used concurrently.

The organic semiconductor material may be uniformly mixed with the polymer binder. Alternatively, the organic semiconductor material and the polymer binder may be totally or partially in a phase separation state. From the viewpoint of the charge mobility, a structure, in which the organic semiconductor and the binder are in a phase separation state along the film thickness direction in the film, is the most preferable because then the binder does not hinder the organic semiconductor from moving a charge.

Considering the mechanical strength of the film, a polymer binder having a high glass transition temperature is preferable. Furthermore, considering the charge mobility, a polymer binder having a structure not containing a polar group, a photoconductive polymer, and a conductive polymer are preferable.

The amount of the polymer binder used is not particularly limited. However, in the organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention, the amount of the polymer binder used is preferably within a range of 0% by mass to 95% by mass, more preferably within a range of 10% by mass to 90% by mass, even more preferably within a range of 20% by mass to 80% by mass, and particularly preferably within a range of 30% by mass to 70% by mass.

In the present invention, by adopting the aforementioned structure as the structure of the compound, an organic film having excellent film quality can be obtained. Specifically, because the compound obtained in the present invention has excellent crystallinity, a sufficient film thickness can be obtained, and the obtained organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention has excellent quality.

(Film Forming Method)

The compound of the present invention may be formed into a film on a substrate by any method.

At the time of forming the film, the substrate may be heated or cooled. By varying the temperature of the substrate, it is possible to control the film quality or the packing of molecules in the film. The temperature of the substrate is not particularly limited. However, it is preferably between 0° C. to 200° C., more preferably between 15° C. to 100° C., and particularly preferably between 20° C. to 95° C.

The compound of the present invention can be formed into a film on a substrate by a vacuum process or a solution process, and both of the processes are preferable.

Specific examples of the film forming method by a vacuum process include a physical vapor deposition method such as a vacuum vapor deposition method, a sputtering method, an ion plating method, or a molecular beam epitaxy (MBE) method and a chemical vapor deposition (CVD)

method such as plasma polymerization, and it is particularly preferable to use a vacuum vapor deposition method.

Herein, the film forming method by a solution process refers to a method of dissolving an organic compound in a solvent which can dissolve the compound and forming a film by using the solution. Specifically, it is possible to use general methods like a coating method such as a casting method, a dip coating method, a die coater method, a roll coater method, a bar coater method, or a spin coating method, various printing methods such as an ink jet method, a screen printing method, a gravure printing method, a flexographic printing method, an offset printing method, or a micro-contact printing method, and a Langmuir-Blodgett (LB) method. It is particularly preferable to use a casting method, a spin coating method, an ink jet method, a gravure printing method, a flexographic printing method, an offset printing method, or a micro-contact printing method.

The organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention is preferably prepared by a solution coating method. As the solution coating method, an ink jet method is preferable. The coating method by the ink jet method will be described later. In a case where the organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention contains a polymer binder, it is preferable to prepare a coating solution by dissolving or dispersing a material, which will be formed into a layer, and a polymer binder in an appropriate solvent and to form the organic semiconductor film by various coating methods.

Hereinafter, a coating solution for a non-light-emitting organic semiconductor device of the present invention that can be used for forming a film by a solution process will be described.

[Coating Solution for Non-Light-Emitting Organic Semiconductor Device]

The present invention also relates to a coating solution containing the compound represented by Formula (1), that is a coating solution for a non-light-emitting organic semiconductor device containing the compound of the present invention.

In a case where a film is formed on a substrate by using a solution process, a material which will be formed into a layer is dissolved or dispersed in either or both of an appropriate organic solvent (for example, a hydrocarbon-based solvent such as hexane, octane, decane, toluene, xylene, mesitylene, ethylbenzene, decalin, or 1-methylnaphthalene, a ketone-based solvent such as acetone, methyl ethyl ketone, methyl isobutyl ketone, or cyclohexanone, a halogenated hydrocarbon-based solvent such as dichloromethane, chloroform, tetrachloromethane, dichloroethane, trichloroethane, tetrachloroethane, chlorobenzene, dichlorobenzene, or chlorotoluene, an ester-based solvent such as ethyl acetate, butyl acetate, or amyl acetate, an alcohol-based solvent such as methanol, propanol, butanol, pentanol, hexanol, cyclohexanol, methyl cellosolve, ethyl cellosolve, or ethylene glycol, an ether-based solvent such as dibutylether, tetrahydrofuran, dioxane, or anisole, an amide-based solvent such as N,N-dimethylformamide, N,N-dimethylacetamide, 1-methyl-2-pyrrolidone, or 1-methyl-2-imidazolidinone, a sulfoxide-based solvent such as dimethyl sulfoxide, or a nitrile-based solvent such as acetonitrile) and water so as to obtain a coating solution, and a film can be formed by various coating methods by using the coating solution. One kind of the solvent may be used singly, or plural kinds thereof may be used in combination. Among these, from the viewpoint of small environmental load, a non-halogen-based solvent is preferable, a hydrocarbon-

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based solvent and an ether-based solvent are preferable, toluene, xylene, mesitylene, tetralin, dichlorobenzene, and anisole are particularly preferable, and toluene, xylene, tetralin, and anisole are more particularly preferable. The concentration of the compound represented by Formula (1) in the coating solution is preferably 0.1% by mass to 80% by mass, more preferably 0.1% by mass to 10% by mass, and particularly preferably 0.5% by mass to 10% by mass. In this way, a film having an arbitrary thickness can be formed.

In order to form a film by a solution process, the material needs to dissolve in the solvent exemplified above, but simply dissolving in a solvent is not good enough. Generally, even the material formed into a film by a vacuum process can dissolve in a solvent to some extent. The solution process includes a step of coating a substrate with a material by dissolving the material in a solvent and then forming a film by evaporating the solvent, and many of the materials not suitable for being formed into a film by the solution process have high crystallinity. Therefore, the material is inappropriately crystallized (aggregated) in the aforementioned step, and hence it is difficult to form an excellent film. The compound represented by Formula (1) is also excellent in the respect that it is not easily crystallized (aggregated).

As the coating solution for a non-light-emitting organic semiconductor device of the present invention, an aspect is also preferable in which the coating solution contains the compound represented by Formula (1), that is, the compound of the present invention, and does not contain a polymer binder.

Furthermore, the coating solution for a non-light-emitting organic semiconductor device of the present invention may contain the compound represented by Formula (1), that is, the compound of the present invention, and a polymer binder. In this case, a material, which will be formed into a layer, and a polymer binder are dissolved or dispersed in an appropriate solvent described above so as to prepare a coating solution, and by using the coating solution, a film can be formed by various coating methods. The polymer binder can be selected from those described above.

[Method for Manufacturing Organic Semiconductor Film for Non-Light-Emitting Organic Semiconductor Device]

In a method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention, by performing coating using the coating solution for a non-light-emitting organic semiconductor device of the present invention by an ink jet method, an organic semiconductor film for a non-light-emitting organic semiconductor device is formed.

In the method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device, it is preferable that a certain substrate is coated with the coating solution for a non-light-emitting organic semiconductor device of the present invention by an ink jet method such that an organic semiconductor film for a non-light-emitting organic semiconductor device is formed on the substrate.

As the ink jet method that can be used in the present invention, the method described in JP2003-306623A can be adopted, and the content described in the document are incorporated into the present invention.

Hereinafter, preferred aspects of the method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device of the present invention in which the ink jet method is used will be described.

Examples of preferred aspects of the ink jet method that can be used in the present invention include a methods

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described in a known document ("Organic transistor by ink jet printing method", Applied physics, Vol. 70, No. 12, p. 1452, 200). Furthermore, a double-shot ink jet printing method, described in Nature, 2011. 475, 364, in which an ink containing a dissolved organic semiconductor and an ink accelerating crystallization of an organic semiconductor are alternately printed in the form of microdroplets can also be preferably used because then a semiconductor film having high mobility is obtained.

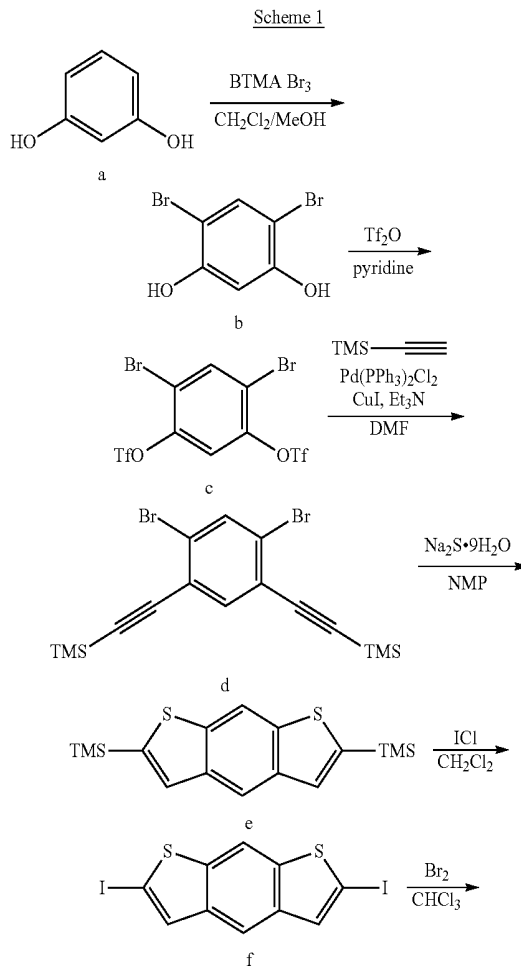
EXAMPLES

Hereinafter, the characteristics of the present invention will be more specifically explained by describing examples and comparative examples. The materials, the amount thereof used, the proportion thereof, the content of treatment, the treatment procedure, and the like described in the following examples can be appropriately modified within a range that does not depart from the gist of the present invention. Accordingly, the scope of the present invention is not limited to the following specific examples.

Example 1

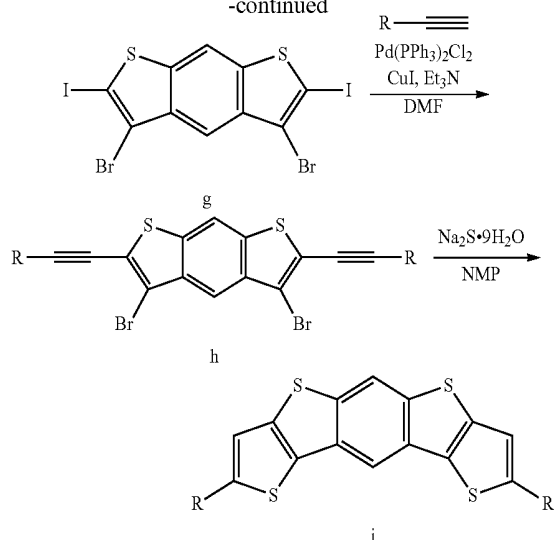
<Synthesis Example 1> Synthesis of Compounds 1 to 5, 8 to 10, 21, 31, 33, and 41

According to a specific synthesis procedure shown in the following scheme 1, compounds 1 to 5, 8 to 10, 21, 31, 33, and 41 as the compound represented by Formula (1) were synthesized.



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-continued



The synthesis procedure of the compound 1 will be specifically described below.

Synthesis of Compound 1

b was synthesized according to a known document (Bull. Chem. Soc. Jpn., 1987, 60, 4187) by using a as a starting material.

c to e, h, and i were synthesized with reference to a known document (J. Am. Chem. Soc., 2011, 133, 5024). Herein, in the synthesis of the compound 1, R in h and i in the scheme 1 is a n-octyl group, and I represents the compound 1.

f was synthesized with reference to a known document (Org. Lett., 2001, 3, 3471).

g was synthesized with reference to a known document (J. Am. Chem. Soc., 2012, 134, 8944).

The structure of the compound 1 was identified by 1H -NMR.

Synthesis of Compound e

By a synthesis method analogous to the synthesis method of the compound 1, other compounds represented by Formula (1) were synthesized according to the scheme 1.

Each of the obtained compounds represented by Formula (1) was identified by elementary analysis, NRM, and MASS spectrometry.

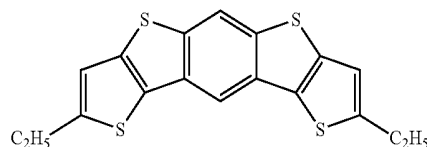
The structures of comparative compounds 1 to 4 used in the semiconductor active layer (organic semiconductor layer) of comparative elements are shown below.

The comparative compounds 1 to 3 were synthesized according to the method described in JP2009-54810A, and the comparative compound 4 was synthesized according to the method described in WO2010/000670A.

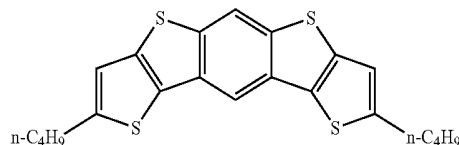
The comparative compounds 1 and 2 are compounds 25 and 27 described in JP2009-54810A respectively. The comparative compound 4 has the same skeleton as that of compounds 2 and 4 described in WO2010/000670A, and is a compound having, as a substituent, an alkyl group containing carbon atoms in a number between the number of carbon atoms in the compound 2 and the number of carbon atoms in the compound 4.

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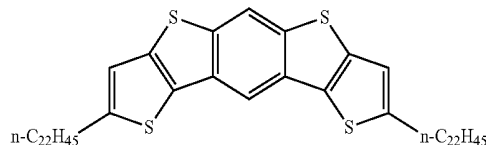
Comparative compound 1



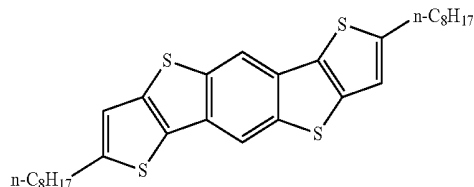
Comparative compound 2



Comparative compound 3



Comparative compound 4



Example 2

Preparation/Evaluation of Element

All of the materials used for preparing elements were purified by sublimation. Through high-performance liquid chromatography (TOSOH CORPORATION, TSKgel ODS-100Z), it was confirmed that the materials had purity (area ratio for absorption intensity at 254 nm) of equal to or higher than 99.5%.

<Formation of Semiconductor Active Layer (Organic Semiconductor Layer) by Using Compound Alone>

Each of the compounds of the present invention or the comparative compounds (1 mg each) was mixed with toluene (1 mL) and heated to 100° C., thereby obtaining a coating solution for a non-light-emitting organic semiconductor device. In a nitrogen atmosphere, the coating solution was cast onto a substrate for measuring FET characteristics that was heated to 90° C., thereby forming an organic semiconductor film for a non-light-emitting organic semiconductor device. In this way, an organic transistor element of Example 2 for measuring FET characteristics was obtained. As the substrate for measuring FET characteristics, a silicon substrate comprising a bottom gate/bottom contact structure was used which included chromium/gold (gate width $W=100$ mm, gate length $L=100$ μ m) arranged to form a comb pattern as source and drain electrodes and included SiO_2 (film thickness: 200 nm) as an insulating layer (the structure is schematically shown in FIG. 2).

Evaluation

By using a semiconductor parameter analyzer (4156C manufactured by Agilent Technologies) connected to a semi-

automatic prober (AX-2000 manufactured by Vector Semiconductor Co., Ltd.), the FET characteristics of the organic transistor element of Example 2 were evaluated under a normal pressure/nitrogen atmosphere, from the viewpoint of the carrier mobility, the threshold voltage shift after repeated driving, the variation in the element, and the heat resistance. Furthermore, the solubility of each of the compounds used for preparing the organic transistor elements of Example 2 was evaluated.

Each of the evaluation methods are described below, and the obtained results are shown in the following Table 1.

(a) Carrier Mobility

Between the source electrode and the drain electrode of each organic film transistor element (FET element), a voltage of -80 V was applied, and the gate voltage was varied within a range of 20 V to -100 V. In this way, a carrier mobility μ , was calculated using the following equation showing a drain current I_d .

$$I_d = (w/2L)\mu C_i (V_g - V_{th})^2$$

In the equation, L represents a gate length, W represents a gate width, C_i represents a capacity of the insulator layer per unit area, V_g represents a gate voltage, and V_{th} represents a threshold voltage.

(b) Threshold Voltage Shift after Repeated Driving

Between the source electrode and the drain electrode of each organic transistor element (FET element), a voltage of -80 V was applied, and the element was repeatedly driven 100 times by varying the gate voltage within a range of $+20$ V to -100 V. In this way, the element was measured in the same manner as in the section (a), and a difference between a threshold voltage V_{before} before the repeated driving and a threshold voltage V_{after} after the repeated driving ($|V_{after} - V_{before}|$) was evaluated into 3 levels as below. The smaller

the difference, the higher the stability of the element against repeated driving. Therefore, the smaller the difference, the more preferable.

$$A: |V_{after} - V_{before}| \leq 5 \text{ V}$$

$$B: 5 \text{ V} < |V_{after} - V_{before}| \leq 10 \text{ V}$$

$$C: |V_{after} - V_{before}| > 10 \text{ V}$$

(c) Solubility

Each of the compounds of the present invention or the comparative examples (20 mg each) was mixed with toluene (1 mL), and the solubility was evaluated into 2 levels as shown below.

A: The compound was completely dissolved.

B: A bit of the compound was left undissolved.

C: Most of the compound was left undissolved.

(d) Variation of Element

Each of the organic transistor elements was prepared again, and the carrier mobility thereof was measured. Furthermore, a difference in carrier mobility between the first element and the second element was determined, and the variation in the element was evaluated.

A: The difference in carrier mobility was less than 20%.

B: The difference in carrier mobility was equal to or greater than 20% and less than 50%.

C: The difference in carrier mobility was equal to or greater than 50%.

(e) Heat Resistance

Each of the organic transistor elements was heated for 30 minutes at 150° C. on a hot plate, and the decrease in mobility was evaluated.

A: The decrease in mobility was less than 10%.

B: The decrease in mobility was equal to or greater than 10% and less than 30%.

C: The decrease in mobility was equal to or greater than 30%.

TABLE 1

Element No.	Organic semiconductor material	Carrier mobility (cm^2/Vs)	Threshold voltage shift after repeated driving	Solubility	Variation	Heat resistance	Note
Element 1	Compound 1	5.0×10^{-2}	A	B	B	B	Present invention
Element 2	Compound 2	8.1×10^{-3}	A	B	B	B	Present invention
Element 3	Compound 3	7.4×10^{-2}	A	B	A	A	Present invention
Element 4	Compound 4	4.9×10^{-2}	A	B	B	A	Present invention
Element 5	Compound 5	7.3×10^{-2}	A	B	B	A	Present invention
Element 6	Compound 8	1.5×10^{-2}	A	B	B	A	Present invention
Element 7	Compound 9	3.4×10^{-2}	B	B	B	A	Present invention
Element 8	Compound 10	8.7×10^{-3}	A	B	B	B	Present invention
Element 9	Compound 21	5.0×10^{-2}	A	B	B	B	Present invention
Element 10	Compound 31	5.8×10^{-2}	A	A	A	B	Present invention
Element 11	Compound 33	8.0×10^{-2}	A	A	A	A	Present invention
Element 12	Compound 41	7.4×10^{-3}	A	B	B	B	Present invention
Comparative element 1	Comparative compound 1	5.4×10^{-4}	C	C	C	C	Comparative example
Comparative element 2	Comparative compound 2	8.3×10^{-4}	B	C	C	C	Comparative example

TABLE 1-continued

Element No.	Organic semiconductor material	Carrier mobility (cm ² /Vs)	Threshold voltage shift after repeated driving	Solubility	Variation	Heat resistance	Note
Comparative element 3	Comparative compound 3	8.5×10^{-4}	B	B	B	C	Comparative example
Comparative element 4	Comparative compound 4	1.5×10^{-4}	B	C	C	B	Comparative example

From the above Table 1, it was understood that the organic transistor element using the compound of the present invention has high carrier solubility. Therefore, it was understood that the compound of the present invention can be preferably used as an organic semiconductor material for a non-light-emitting organic semiconductor device.

In contrast, it was understood that the comparative compounds 1 to 4 have low carrier mobility.

The compound of the present invention exhibited excellent solubility in an organic solvent. The organic transistor element using the compound of the present invention showed only a slight threshold voltage shift after repeated driving and small variation in the element and had excellent heat resistance.

Example 3

Formation of Semiconductor Active Layer (Organic Semiconductor Layer) by Using Compound and Binder Together

Each of the compounds of the present invention or the comparative compounds (1 mg each) was mixed with 1 mg of PαMS (poly(α-methylstyrene, Mw=300,000), manufactured by Sigma-Aldrich Co, LLC.) and toluene (1 mL), and the mixture was heated to 100° C., thereby obtaining a coating solution. Organic transistor elements for measuring FET characteristics were prepared in the same manner as in Example 2, except that the coating solution obtained as above was used. Furthermore, the organic transistor elements were evaluated according to the same criteria as in Example 2, from the viewpoint of the carrier mobility and the threshold voltage shift after repeated driving.

The obtained results are shown in the following Table 2.

TABLE 2

Element No.	Organic semiconductor material	Carrier mobility (cm ² /Vs)	Threshold voltage shift after repeated driving
Element 12	Compound 1	8.8×10^{-2}	A
Element 13	Compound 2	9.1×10^{-3}	A
Element 14	Compound 3	3.3×10^{-2}	A
Element 15	Compound 4	7.5×10^{-2}	A
Element 16	Compound 5	9.4×10^{-2}	A
Comparative element 5	Comparative compound 1	2.2×10^{-4}	C
Comparative element 6	Comparative compound 2	4.1×10^{-4}	C

From the above Table 2, it was understood that the organic transistor element including a semiconductor active layer formed using the compound of the present invention with a binder has high carrier mobility. Therefore, it was understood that the compound of the present invention can be preferably used as an organic semiconductor material for a non-light-emitting organic semiconductor device.

In contrast, the organic transistor element including a semiconductor active layer formed using the comparative compound 1 or 2 with a binder had low carrier mobility.

Each of the organic transistor elements obtained in Example 2 was observed by unaided eyes and an optical microscope. As a result, it was understood that all of the films using PαMS as a binder have extremely high smoothness and uniformity.

Herein, the organic transistor element using the compound of the present invention showed only a slight voltage shift after repeated driving and small variation in the element and had excellent heat resistance.

From the above results, it was understood that in a case where the semiconductor active layer for the comparative element is formed using a binder and a comparative compound in combination, the carrier mobility becomes extremely low; however, in a case where the semiconductor active layer for the organic transistor element of the present invention is formed using the compound of the present invention with a binder, it is possible to obtain an element which exhibits excellent carrier mobility and has extremely high smoothness/uniformity of the film.

Example 4

Formation of Semiconductor Active Layer (Organic Semiconductor Layer)

The surface of a silicon wafer, which comprised SiO₂ (film thickness: 370 nm) as a gate insulating film, was treated with octyltrichlorosilane.

Each of the compounds of the present invention or the comparative compounds (1 mg each) was mixed with toluene (1 mL), and the mixture was heated to 100° C., thereby preparing a coating solution for a non-light-emitting organic semiconductor device. In a nitrogen atmosphere, the coating solution was cast onto the silicon wafer which had been heated to 90° C. and undergone surface treatment with octylsilane, thereby forming an organic semiconductor film for a non-light-emitting organic semiconductor device.

Furthermore, gold was deposited onto the surface of the film by using a mask so as to prepare source and drain electrodes, thereby obtaining an organic transistor element having a bottom gate/top contact structure with a gate width W=5 mm and a gate length L=80 μm (the structure is schematically shown in FIG. 1).

By using a semiconductor parameter analyzer (4156C manufactured by Agilent Technologies) connected to a semi-automatic prober (AX-2000 manufactured by Vector Semiconductor Co., Ltd.), the FET characteristics of the organic transistor element of Example 4 were evaluated according to the same criteria as in Example 2 under a normal pressure/

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nitrogen atmosphere, from the viewpoint of the carrier mobility and the threshold voltage shift after repeated driving.

The obtained results are shown in the following Table 3.

TABLE 3

Element No.	Organic semiconductor material	Carrier mobility (cm ² /Vs)	Threshold voltage shift after repeated driving	Note
Element 17	Compound 1	5.5×10^{-2}	A	Present invention
Element 18	Compound 3	3.6×10^{-2}	A	Present invention
Element 19	Compound 4	8.5×10^{-2}	A	Present invention
Element 20	Compound 9	8.8×10^{-2}	A	Present invention
Comparative element 7	Comparative compound 1	8.5×10^{-5}	C	Comparative example

From the above Table 3, it was understood that the organic transistor element using the compound of the present invention has high carrier mobility. Therefore, it was understood that the compound of the present invention can be preferably used as an organic semiconductor material for a non-light-emitting organic semiconductor device.

In contrast, the organic transistor element using the comparative compound 1 had low carrier mobility.

Herein, the organic transistor element using the compound of the present invention showed only a slight threshold voltage shift after repeated driving.

Example 5

Formation of Semiconductor Active Layer (Organic Semiconductor Layer) by Ink Jet Method

By using a coating solution for an ink jet containing each of the compounds 1 to 5, 8 to 10, 21, 31, 33, and 41 of the present invention or each of the comparative compounds 1 to 4 (1 mg each), a semiconductor active layer (organic semiconductor layer) was formed by an ink jet method, thereby preparing organic transistor elements.

The obtained organic transistor elements were evaluated in the same manner as in Example 2.

As a result, it was understood that the organic transistor elements show almost the same trend as in Example 2.

EXPLANATION OF REFERENCES

11: substrate

12: electrode

13: insulator layer

14: semiconductor active layer (organic substance layer, organic semiconductor layer)

15a, 15b: electrode

31: substrate

32: electrode

33: insulator layer

34a, 34b: electrode

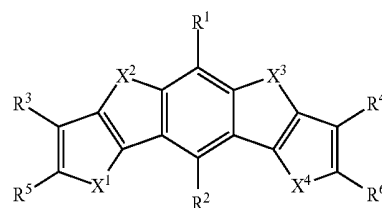
35: semiconductor active layer (organic substance layer, organic semiconductor layer)

What is claimed is:

1. An organic transistor comprising a compound represented by the following Formula (1) in a semiconductor active layer;

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Formula (1)



in Formula (1),

each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom,

R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group,

each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by the following Formula (W):

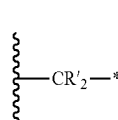
-L-R

Formula (W)

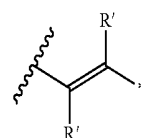
in Formula (W),

R represents an alkyl group having 5 to 19 carbon atoms, and

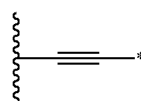
L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



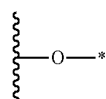
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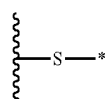
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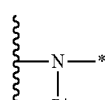
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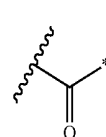
(L-4)



(L-5)



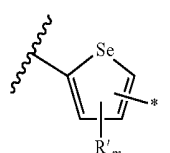
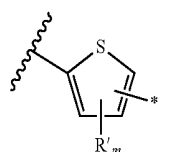
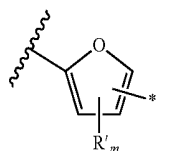
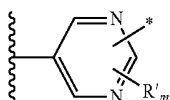
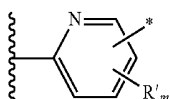
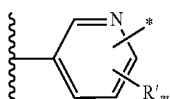
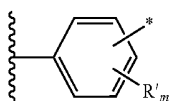
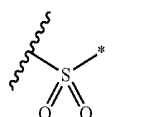
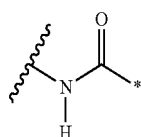
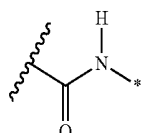
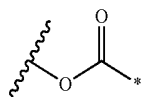
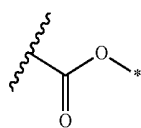
(L-6)



(L-7)

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(L-8)

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(L-9)

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(L-10)

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(L-11)

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(L-12)

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(L-13)

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(L-14)

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(L-15)

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(L-16)

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(L-17)

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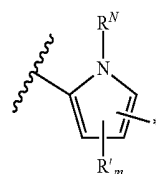
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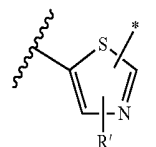
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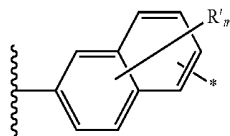
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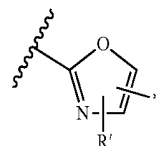
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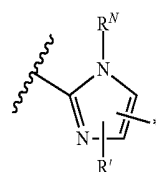
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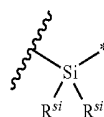
(L-22)



(L-23)



(L-24)



(L-25)

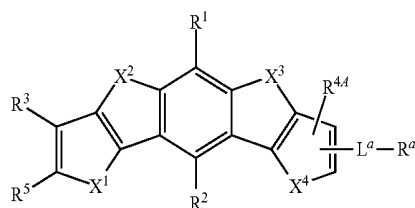
in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

2. The organic transistor according to claim 1, wherein the compound represented by the Formula (1) is a compound represented by the following Formula (2-1) or (2-2);

Formula (2-1)



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in Formula (2-1),

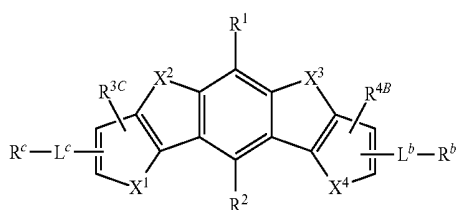
each of X^1 to X^4 independently represents an O atom or a S atom,

each of R^1 to R^3 , R^{4A} , and R^5 independently represents a hydrogen atom or a substituent and is not a group represented by $-L^a-R^a$,

R^a represents an alkyl group having 5 to 19 carbon atoms, and

L^a represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

Formula (2-2)



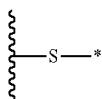
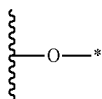
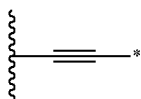
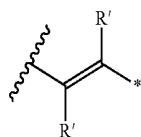
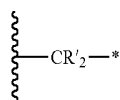
in Formula (2-2),

each of X^1 to X^4 independently represents an O atom or a S atom,

each of R^1 , R^2 , R^{3C} , and R^{4B} independently represents a hydrogen atom or a substituent,

each of R^b and L^c independently represents an alkyl group having 5 to 19 carbon atoms, and

each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



(L-1)

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(L-2)

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(L-3)

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(L-4)

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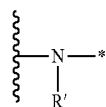
(L-5)

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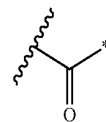
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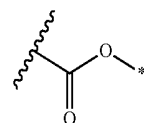
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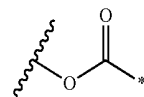
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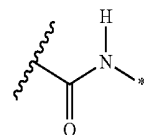
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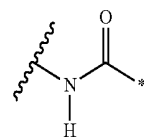
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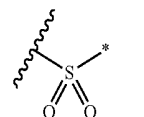
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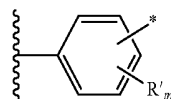
(L-11)



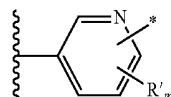
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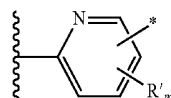
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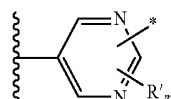
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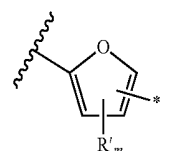
(L-15)



(L-16)

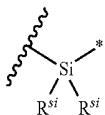
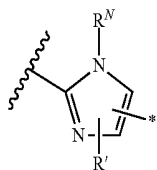
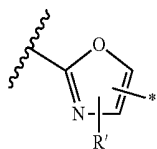
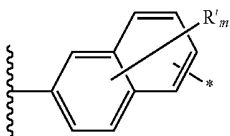
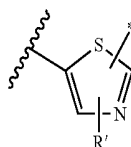
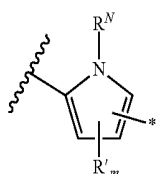
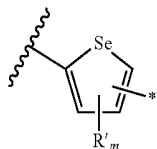
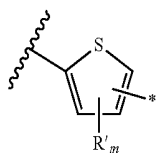


(L-17)



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in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

3. The organic transistor according to claim 1, wherein the compound represented by the Formula (1) is a compound represented by the following Formula (2-2A);

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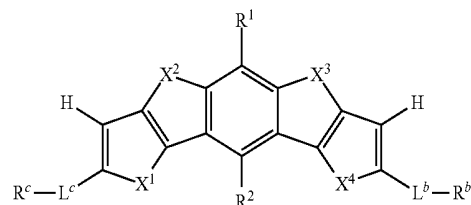
Formula (2-2A)

(L-18)

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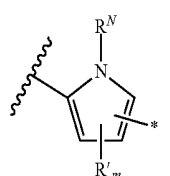
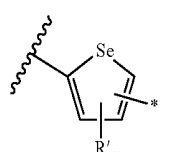
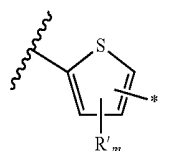
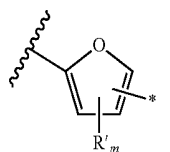
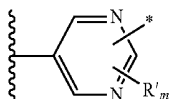
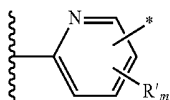
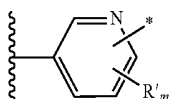
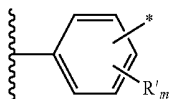
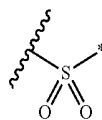
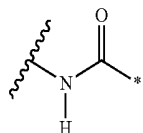
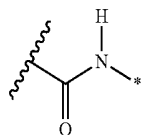
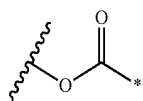
(L-19)

10



81

-continued



82

-continued

(L-9)

5

(L-10)

10

(L-11)

15

(L-12)

20

(L-13)

25

(L-14)

30

(L-15)

35

(L-16)

40

(L-17)

45

(L-18)

50

(L-19)

55

(L-20)

60

(L-21)

(L-22)

(L-23)

(L-24)

(L-25)

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

4. The organic transistor according to claim 1,

wherein in the Formula (1), L is a divalent linking group represented by any of the Formulae (L-1) to (L-5) and (L-13) to (L-24) or a divalent linking group in which two or more divalent linking groups represented by any of the Formulae (L-1) to (L-5) and (L-13) to (L-24) are bonded to each other.

5. The organic transistor according to claim 1,

wherein in the Formula (1), L is a divalent linking group represented by any of the Formulae (L-1) to (L-5) and (L-13) to (L-24), or a divalent linking group in which a divalent linking group represented by any one of the Formulae (L-2), (L-3), and (L-13) to (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any of the Formulae (L-2), (L-3), and (L-13) to (L-24) are bonded to each other, is bonded to a divalent linking group represented by the Formula (L-1).

6. The organic transistor according to claim 1,

wherein in the Formula (1), L is a divalent linking group represented by any of the Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking

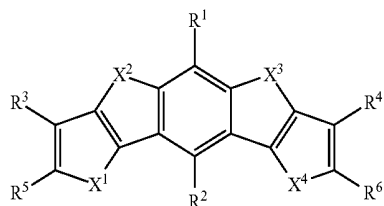
83

group in which a divalent linking group, in which two or more divalent linking groups represented by any of the Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) are bonded to each other, is bonded to a divalent linking group represented by the Formula (L-1).

7. The organic transistor according to claim 1, wherein in the Formula (1), R is an unsubstituted alkyl group.

8. The organic transistor according to claim 1, wherein in the Formula (1), R is a branched alkyl group.

9. A compound represented by the following Formula (1):



in Formula (1),

each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom,

R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group,

each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by the following Formula (W);

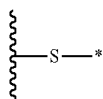
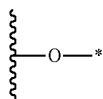
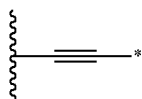
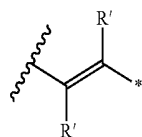
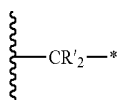
-L-R

Formula (W)

in Formula (W),

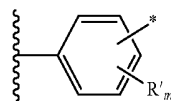
R represents an alkyl group having 5 to 19 carbon atoms, and

L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



(L-1)

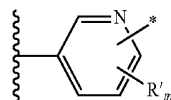
45



(L-6)

(L-2)

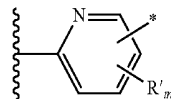
50



(L-7)

(L-3)

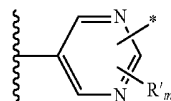
55



(L-8)

(L-4)

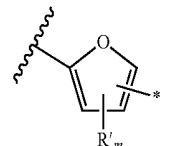
60



(L-9)

(L-5)

65



(L-10)

(L-11)

(L-12)

(L-13)

(L-14)

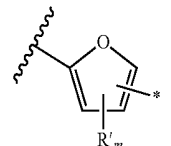
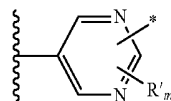
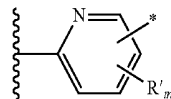
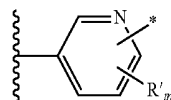
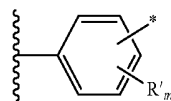
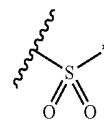
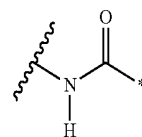
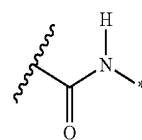
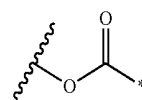
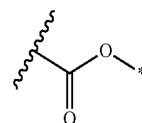
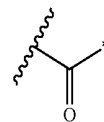
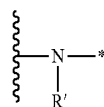
(L-15)

(L-16)

(L-17)

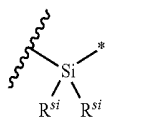
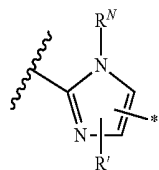
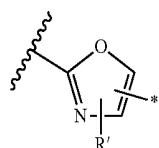
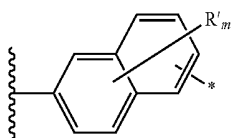
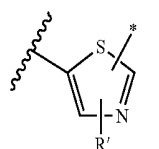
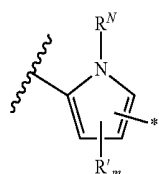
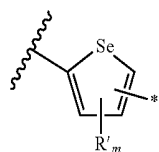
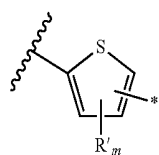
84

-continued



85

-continued



in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

10. The compound according to claim 9, wherein the compound represented by the Formula (1) is a compound represented by the following Formula (2-1) or (2-2):

86

Formula (2-1)

(L-18)

5

(L-19)

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(L-20)

15

(L-21)

20

25

(L-22)

30

(L-23)

35

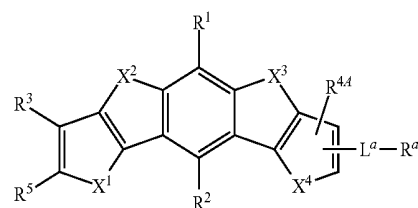
(L-24)

40

(L-25)

45

50



in Formula (2-1), each of X¹ to X⁴ independently represents an O atom or a S atom,

each of R¹ to R³, R^{4a}, and R⁵ independently represents a hydrogen atom or a substituent and is not a group represented by -L^a-R^a,

R^a represents an alkyl group having 5 to 19 carbon atoms, and

L^a represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

Formula (2-2)

(L-22)

30

(L-23)

35

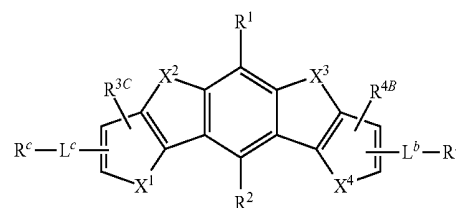
(L-24)

40

(L-25)

45

50



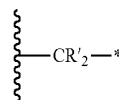
in Formula (2-2), each of X¹ to X⁴ independently represents an O atom or a S atom,

each of R¹, R², R^{3c}, and R^{4b} independently represents a hydrogen atom or a substituent,

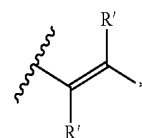
each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;

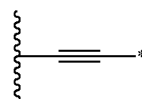
(L-1)



(L-2)

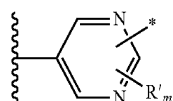
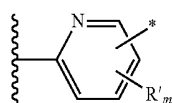
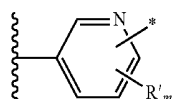
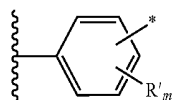
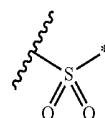
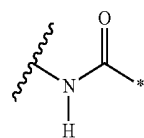
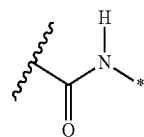
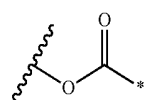
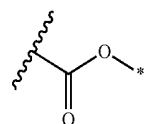
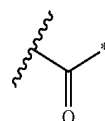
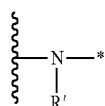
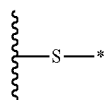
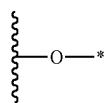


(L-3)



87

-continued



88

-continued

(L-4)

5

(L-5)

(L-6)

(L-7)

(L-8)

(L-9)

(L-10)

(L-11)

(L-12)

(L-13)

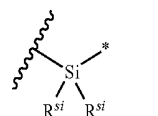
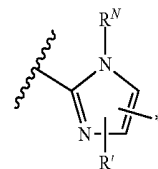
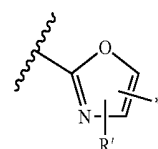
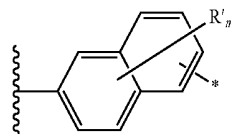
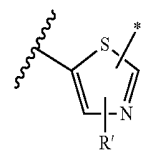
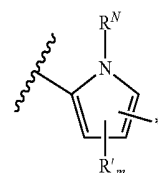
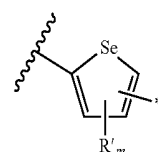
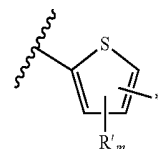
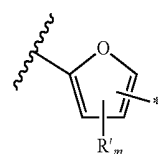
(L-14)

(L-15)

(L-16)

60

65



(L-17)

(L-18)

(L-19)

(L-20)

(L-21)

(L-22)

(L-23)

(L-24)

(L-25)

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

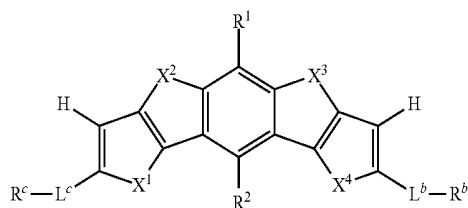
m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

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R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

11. The compound according to claim 9, wherein the compound represented by the Formula (1) is a compound represented by the following Formula (2-2A);

Formula (2-2A)



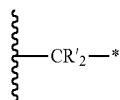
in Formula (2-2A),

each of X^1 to X^4 independently represents an O atom or a S atom,

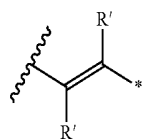
each of R^1 and R^2 independently represents a hydrogen atom or a substituent,

each of R^b and R^c independently represents an alkyl group having 5 to 19 carbon atoms, and

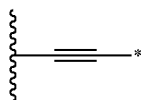
each of L^b and L^c independently represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



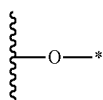
(L-1)



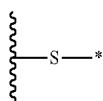
(L-2)



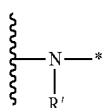
(L-3)



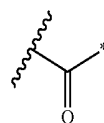
(L-4)



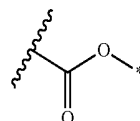
(L-5)



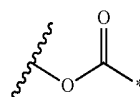
(L-6)



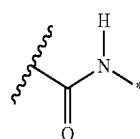
(L-7)



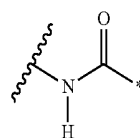
(L-8)



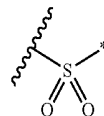
(L-9)



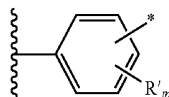
(L-10)



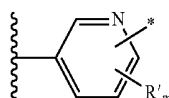
(L-11)



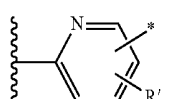
(L-12)



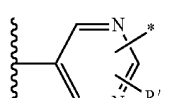
(L-13)



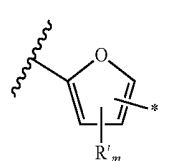
(L-14)



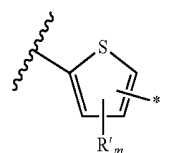
(L-15)



(L-16)



(L-17)



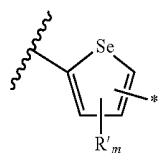
(L-18)

90

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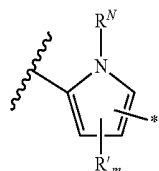
91

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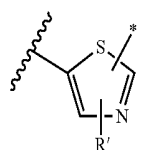
(L-19)

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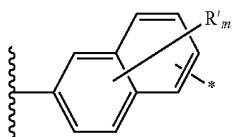
(L-20)

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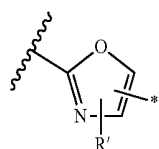


(L-21)

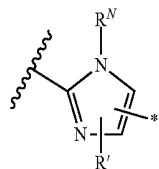
15



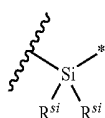
(L-22)



(L-23)



(L-24)



(L-25)

40

in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

R^N represents a hydrogen atom or a substituent, and each R^{si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

12. The compound according to claim 9, wherein in the Formula (1), L is a divalent linking group represented by any of the Formulae (L-1) to (L-5) and (L-13) to (L-24) or a divalent linking group in which two or more divalent linking groups represented by any of the Formulae (L-1) to (L-5) and (L-13) to (L-24) are bonded to each other.

13. The compound according to claim 9, wherein in the Formula (1), L is a divalent linking group represented by any of the Formulae (L-1) to (L-5) and

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(L-13) to (L-24) or a divalent linking group in which a divalent linking group represented by any one of the Formula (L-2), (L-3), and (L-13) to (L-24) or a divalent linking group, in which two or more divalent linking groups represented by any one of the Formula (L-2), (L-3), and (L-13) to (L-24) are bonded to each other, is bonded to a divalent linking group represented by the Formula (L-1).

14. The compound according to claim 9, wherein in the Formula (1), L is a divalent linking group represented by any of the Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) or a divalent linking group in which a divalent linking group, in which two or more divalent linking groups represented by any of the Formulae (L-2), (L-3), (L-14) to (L-21), (L-23), and (L-24) are bonded to each other, is bonded to a divalent linking group represented by the Formula (L-1).

15. The compound according to claim 9, wherein in the Formula (1), R is independently an unsubstituted alkyl group.

16. The compound according to claim 9, wherein in the Formula (1), R is a branched alkyl group.

17. An organic semiconductor material for a non-light-emitting organic semiconductor device, comprising the compound according to claim 9.

18. A material for an organic transistor, comprising the compound according to claim 9.

19. A coating solution for a non-light-emitting organic semiconductor device, comprising the compound according to claim 9.

20. The coating solution for a non-light-emitting organic semiconductor device according to claim 19, comprising a polymer binder.

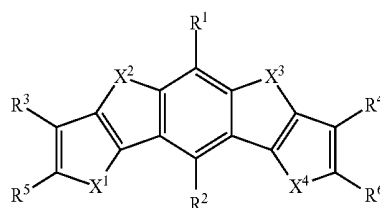
21. The coating solution for a non-light-emitting organic semiconductor device according to claim 19, further comprising a non-halogen-based solvent.

22. An organic semiconductor film for a non-light-emitting organic semiconductor device, comprising the compound according to claim 9.

23. The organic semiconductor film for a non-light-emitting organic semiconductor device according to claim 22, containing a polymer binder.

24. The organic semiconductor film for a non-light-emitting organic semiconductor device according to claim 22 that is prepared by a solution coating method.

25. The organic semiconductor film for a non-light-emitting organic semiconductor device according to claim 22 that is prepared by performing coating using a coating solution for a non-light-emitting organic semiconductor device comprising a compound represented by the following Formula (1) by an ink jet method:



Formula (1)

in Formula (1), each of X¹ to X⁴ independently represents NR¹⁰⁰, an O atom, or a S atom,

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R¹⁰⁰ represents a hydrogen atom, an alkyl group, an alkenyl group, an alkynyl group, an acyl group, an aryl group, or a heteroaryl group,

each of R¹ to R⁶ independently represents a hydrogen atom or a substituent, and at least one of R¹, R², R³, R⁴, R⁵, or R⁶ is a substituent represented by the following Formula (W);

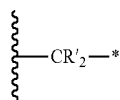
-L-R

Formula (W)

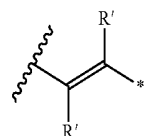
in Formula (W),

R represents an alkyl group having 5 to 19 carbon atoms, and

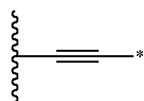
L represents a divalent linking group represented by any of the following Formulae (L-1) to (L-25) or a divalent linking group in which two or more divalent linking groups represented by any of the following Formulae (L-1) to (L-25) are bonded to each other;



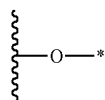
(L-1)



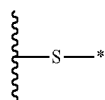
(L-2)



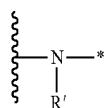
(L-3)



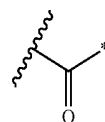
(L-4)



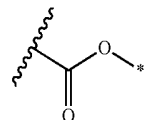
(L-5)



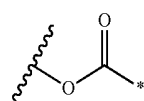
(L-6)



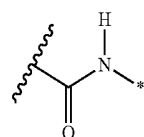
(L-7)



(L-8)



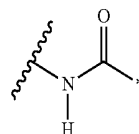
(L-9)



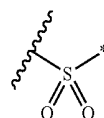
(L-10)

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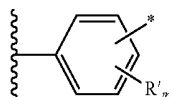
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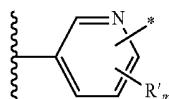
(L-11)



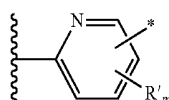
(L-12)



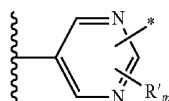
(L-13)



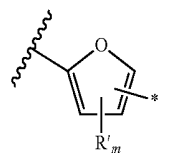
(L-14)



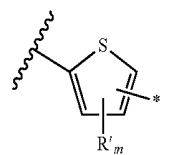
(L-15)



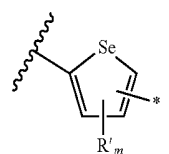
(L-16)



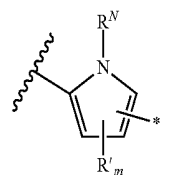
(L-17)



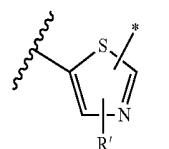
(L-18)



(L-19)



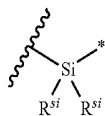
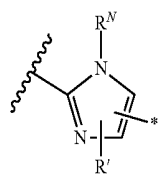
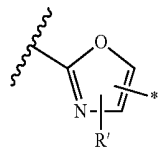
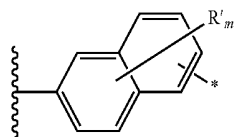
(L-20)



(L-21)

95

-continued



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in Formulae (L-1) to (L-25), the portion of a wavy line represents a position of bonding to a condensed heterocyclic skeleton,

(L-22)

5 m in Formula (L-13) represents 4, m in Formulae (L-14) and (L-15) represents 3, m in Formulae (L-16) to (L-20) represents 2, m in Formula (L-22) represents 6, each R' in Formulae (L-1), (L-2), (L-6), and (L-13) to (L-24) independently represents a hydrogen atom or a substituent,

(L-23)

10

(L-24)

R^N represents a hydrogen atom or a substituent, and each R^{Si} independently represents a hydrogen atom, an alkyl group, an alkenyl group, or an alkynyl group.

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26. A method for manufacturing an organic semiconductor film for a non-light-emitting organic semiconductor device, comprising:

(L-25)

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forming an organic semiconductor film for a non-light-emitting organic semiconductor device by performing coating using the coating solution for a non-light-emitting organic semiconductor device according to claim 19 by an ink jet method.

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* * * * *

专利名称(译)	用于非发光有机半导体器件的有机晶体管，化合物，有机半导体材料，用于有机晶体管的材料，用于非发光有机半导体器件的涂覆溶液，用于非发光有机半导体器件的有机半导体膜，以及方法用于制造用于非发光有机半导体器件的有机半导体膜		
公开(公告)号	US9705096	公开(公告)日	2017-07-11
申请号	US15/203506	申请日	2016-07-06
[标]申请(专利权)人(译)	富士胶片株式会社		
申请(专利权)人(译)	富士胶片株式会社		
当前申请(专利权)人(译)	富士胶片株式会社		
[标]发明人	YOUFU KATSUYUKI HIRAI YUKI MASUI KENSUKE		
发明人	YOUFU, KATSUYUKI HIRAI, YUKI MASUI, KENSUKE		
IPC分类号	H01L51/00 C07D495/04 C07D495/22 C09D5/24 C07D491/22 C07D493/22 H01L51/05		
CPC分类号	H01L51/0074 C07D491/22 C07D493/22 C07D495/04 C07D495/22 C09D5/24 H01L51/0065 H01L51/0068 H01L51/0071 H01L51/0005 H01L51/0545 H01L51/0558 H01L51/0566 C09B57/00		
代理机构(译)	史蒂倍克与BRACKETT PC		
优先权	2014003664 2014-01-10 JP		
其他公开文献	US20160315272A1		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种具有高载流子迁移率的有机晶体管，其在半导体活性层中含有由下式表示的化合物（X 1 至X 4 均表示NR 100，O原子或S原子；NR 100 表示氢原子，烷基，链烯基，炔基，酰基，芳基或杂芳基；R 1 至R 6 各自代表氢原子或取代基；R 1 中的至少一个，R 2，R 3，R 4，R 5 或R 6 是取代基由-LR表示；L是具有特定结构的二价连接基团；并且R是具有5-19个碳原子的烷基）；化合物；用于非发光有机半导体器件的有机半导体材料；有机晶体管的材料；用于非发光有机半导体器件的涂层溶液；用于非发光有机半导体器件的有机半导体膜；以及制造用于非发光有机半导体器件的有机半导体膜的方法。

