[0021]

The compound represented by the formula (ii) (hereafter also called "compound (ii)") employs a phosphorus-containing ligand as a neutral donor for imparting electronic and three-dimensional characteristics. As a result, the compound (ii) can achieve an excellent low melting point, high volatility, and thermal stability, can introduce phosphorus atoms into a phosphorus-containing film, and can be applied to a solid electrolyte for a solid-state battery.

[0021a]

In one aspect, there is provided compound represented by the formula (ii), wherein in the formula (ii), E_1 and E_2 are independently a carbon atom, a silicon atom, a germanium atom, or a tin atom; Z_1 and Z_2 are independently a single bond or a divalent linking group; R_{21} to R_{28} are independently a hydrogen atom or a C1-10 alkyl group having a constituent atom optionally substituted with a heteroatom; however, all of R_{21} to R_{28} may not be a hydrogen atom; D_2 is a monodentate or bidentate neutral ligand structure; x2 is 0 or an integer of 1 or greater; and y2 is an integer of 1 or greater, however, if none of the carbon atoms constituting R_{23} to R_{26} is substituted with a heteroatom, x2 is a number of 1 or greater and y2 is a number of 1 or greater.

[0022]

In one embodiment, E_1 and E_2 in the compound (ii) are preferably a carbon atom or a silicon atom;

Z_1 and Z_2 are preferably a methylene group or an ethylene group;

R_{21}, R_{22}, R_{27}, and R_{28} are preferably a methyl group, an ethyl group, an n-propyl group, an i-propyl group, an n-butyl group, an i-butyl group, or a t-butyl group;

R_{22} to R_{26} are preferably a hydrogen atom, a methyl group, or an ethyl group;

D_2 is preferably a chain or cyclic ether, a chain or cyclic thioether, or a tertiary amine;

x2 is preferably 0 or 1; and y2 is preferably 1.

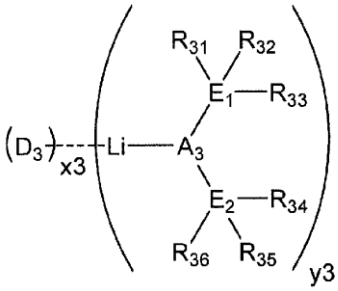
[0023]

By specifically having this structure, the compound (ii) can achieve a low melting point, high volatility, and a high level of thermal stability.

[0024]

In a further embodiment, this compound is preferably represented by the following formula (iii).

[CHEMICAL EXPRESSION 4]



(iii)

(In the formula (iii), A_3 is a phosphorus atom, a boron atom, or an aluminum atom;

E_1 and E_2 are defined the same as in the formula (1);

R_{31} to R_{36} are independently a hydrogen atom or a C1–10 alkyl group having a constituent atom optionally substituted with a heteroatom; however, all of R_{31} to R_{36} may not be a hydrogen atom;

D_3 is a monodentate or bidentate neutral ligand structure;

x3 is 0 or an integer of 1 or greater; and y2 is an integer of 1 or greater.)

[0024a]

In another aspect, there is provided a compound, represented by formula (iii), wherein in the formula (iii), A_3 is a boron atom, or an aluminum atom; E_1 and E_2 are independently a carbon atom, a silicon atom, a germanium atom, or a tin atom; R_{31} to R_{36} are independently a hydrogen atom or a C1–10 alkyl group having a constituent atom optionally substituted with a heteroatom; however, all of R_{31} to R_{36} may not be a hydrogen atom; D_3 is a monodentate or bidentate neutral ligand structure; and x3 is 0 or an integer of 1 or greater; and y2 is an integer of 1 or greater.

[0025]

The compound represented by the formula (iii) (hereafter also called "compound (iii)") can achieve a low melting point, high volatility, and a high level of thermal stability by introduction of a bulky ligand. Development into a solid electrolyte for a solid-state battery can furthermore be anticipated as a result of introduction of phosphorus atoms, boron atoms or aluminum atoms.

[0026]

In one embodiment, A_3 in the compound (iii) is preferably a phosphorus atom;

E_1 and E_2 are preferably a silicon atom;

R_{31} to R_{36} are preferably a methyl group, an ethyl group, an n-propyl group, or an i-propyl group;

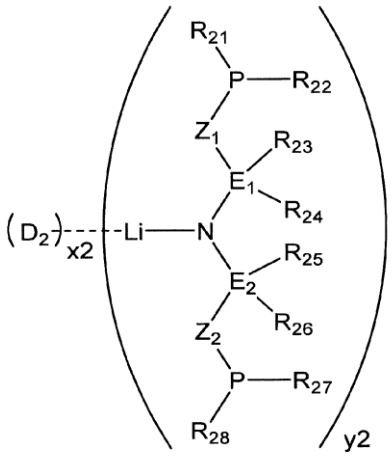
D_3 is preferably N,N,N',N'-tetramethylethylenediamine, N,N,N',N'-tetraethylethylenediamine, N,N,N',N'-tetramethyl-1,3-diaminopropane, or N,N,N',N",N"-pentamethyldiethylenetriamine;

DOCUMENT TITLE: CLAIMS

CLAIM 1

A compound represented by the following formula (ii):

[CHEMICAL EXPRESSION 3]



(ii)

wherein in the formula (ii), E_1 and E_2 are independently a carbon atom, a silicon atom, a germanium atom, or a tin atom;

Z_1 and Z_2 are independently a single bond or a divalent linking group;

R_{21} to R_{28} are independently a hydrogen atom or a C1–10 alkyl group having a constituent atom optionally substituted with a heteroatom; however, all of R_{21} to R_{28} may not be a hydrogen atom;

D_2 is a monodentate or bidentate neutral ligand structure;

x2 is 0 or an integer of 1 or greater; and y2 is an integer of 1 or greater, however, if none of the carbon atoms constituting R_{23} to R_{26} is substituted with a heteroatom, x2 is a number of 1 or greater and y2 is a number of 1 or greater.

CLAIM 2

The compound according to claim 1, wherein E_1 and E_2 are a carbon atom or a silicon atom;

Z_1 and Z_2 are a methylene group or an ethylene group;

R_{21}, R_{22}, R_{27}, and R_{28} are a methyl group, an ethyl group, an n-propyl group, an i-propyl group, an n-butyl group, an i-butyl group, or a t-butyl group;

R_{23} to R_{26} are a hydrogen atom, a methyl group, or an ethyl group;

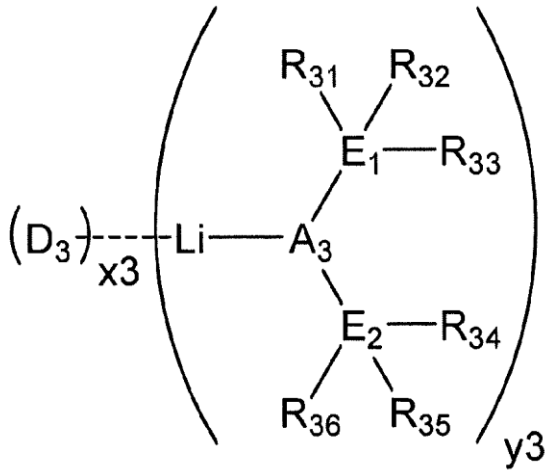
D_2 is a chain or cyclic ether, a chain or cyclic thioether, or a tertiary amine;

x2 is 0 or 1; and y2 is 1.

CLAIM 3

A compound, represented by the following formula (iii).

[CHEMICAL EXPRESSION 4]



(iii)

wherein in the formula (iii), A_3 is a boron atom, or an aluminum atom;

E_1 and E_2 are independently a carbon atom, a silicon atom, a germanium atom, or a tin atom;

R_{31} to R_{36} are independently a hydrogen atom or a C1-10 alkyl group having a constituent atom optionally substituted with a heteroatom; however, all of R_{31} to R_{36} may not be a hydrogen atom;

D_3 is a monodentate or bidentate neutral ligand structure;

x3 is 0 or an integer of 1 or greater; and y2 is an integer of 1 or greater.

CLAIM 4

The compound according to claim 3, wherein

E_1 and E_2 are a silicon atom;

R_{31} to R_{36} are a methyl group, an ethyl group, an n-propyl group, or an i-propyl group;

D_3 is N,N,N',N'-tetramethylethylenediamine, N,N,N',N'-tetraethylethylenediamine, N,N,N',N'-tetramethyl-1,3-diaminopropane, or N,N,N',N",N"-pentamethyldiethylenetriamine;

x3 is 0 or 1; and y3 is 1.

CLAIM 5

The compound according to any one of claims 1 to 4, which is a liquid at 25° C, or a temperature demonstrating a vapor pressure of 133.3 Pa is 100° C or less.

CLAIM 6

The compound according to any one of claims 1 to 5, wherein a region having 95% or greater weight loss at 300° C or less is present according to thermogravimetric analysis.

CLAIM 7

The compound according to any one of claims 1 to 6, which is for thin film vapor deposition.

CLAIM 8

A method for producing a lithium-containing film comprising the steps of:

preparing a reaction chamber having at least one substrate placed inside;

introducing a gas containing the vaporized compound according to any one of claims 1 to 7 into the reaction chamber: and

forming a lithium-containing film on at least a portion of the surface of the substrate using a vapor deposition process for contacting the substrate with the gas.

CLAIM 9

The method for producing a lithium-containing film according to claim 8, wherein the vapor deposition process is carried out at 200° C or less.