

The present invention relates to a metal compound; a catalyst component for addition polymerization comprising the metal compound; a catalyst for addition polymerization using
10 the catalyst component for addition polymerization; and a process for producing an addition polymer.

Background of the Invention

Since olefin polymers such as polypropylene and
15 polyethylene are excellent in mechanical properties and chemical resistance, and excellent in balance between those properties and economical efficiency, they have been widely used in various fields such as a packaging field. These olefin polymers have conventionally been produced by polymerizing
20 an olefin using a conventional type solid catalyst (multi-site catalyst), which combines a solid catalyst component obtained by using a metal compound of the Group IV such as titanium trichloride or titanium tetrachloride, with a metal compound of the Group 13 represented by an organoaluminum compound.

25 However, as a catalyst providing addition polymers having less stickiness and more excellent strength than those produced by the conventional catalyst, a so-called single site catalyst prepared by combining a catalyst component such as a metallocene complex or half metallocene complex with a co-catalyst
30 component for activation such as an aluminoxane, and

diethylzinc and pentafluorophenol has been developed as a co-catalyst component for activation, and a catalyst prepared by contacting said co-catalyst component with the metallocene complex has been proposed as a high activity catalyst (e.g. US6586356).

However, according to the inventor's studies, when an olefin is addition-polymerized with the above-mentioned catalyst, its polymerization activity is not completely satisfactory.

Summary of the Invention

Under the above-situations, an object of the present invention is to provide a metal compound used as a catalyst component of a catalyst for addition polymerization having an excellent polymerization activity; a catalyst component for addition polymerization comprising the metal compound; a catalyst for addition polymerization using the catalyst component for addition polymerization; and a process for producing an addition polymer using the catalyst for addition polymerization.

Namely, the present invention is a metal compound obtained by a process comprising the step of contacting the following components (a) to (c), wherein the amount of the component (b) contacted is from 0.1 to 8 mol, and the amount of the component (c) contacted is from 0.5 to 8 mol, per 1

(b) a compound represented by the following formula [2]



10 (c) a compound represented by the following formula [3],



15 wherein M^1 is a metal atom of the Groups 12 to 15 in the periodic table or a boron atom; r is a valence of M^1 ; L^1 is a hydrogen atom, a halogen atom, a hydrocarbon group or a hydrocarbon oxy group, and when two or more L^1 's exist, they may be the same or different from one another; T is a non-metal atom of the Group 15 or 16 in the periodic table; s is a valence of
20 T ; R^1 is an electron-withdrawing group or an electron-withdrawing group-containing group, and when two or more R^1 's exist, they may be the same or different from one another; n is the number of from 2 to 4; J is a non-metal atom of the Group 14 in the periodic table; and R^2 represents a
25 hydrocarbon group, and when two or more R^2 's exist, they may be the same or different from one another.

Also, the present invention is a catalyst component for addition polymerization comprising the above-mentioned metal compound.

30 Further, the present invention is a catalyst for addition

(C).

Still further, the present invention is a process for producing an addition polymer comprising the step of polymerizing an addition polymerizable monomer in the presence of the above-mentioned catalyst for addition polymerization.

Detailed Description of the Invention

Examples of M^1 in the formula [1] are a zinc atom, a cadmium atom, a mercury atom, an aluminum atom, a gallium atom, an indium atom, a thallium atom, a germanium atom, a tin atom, a lead atom, an antimony atom, a bismuth atom and a boron atom. M^1 is preferably a zinc atom, an aluminum atom, a gallium atom, an indium atom, a thallium atom, an antimony atom, a bismuth atom or a boron atom, and more preferably an aluminum atom, a bismuth atom or a boron atom. In the formula [1], r is an integer of from 2 to 5, and preferably 3.

Examples of the halogen atom of L^1 are a fluorine atom, a chlorine atom, a bromine atom and an iodine atom. The hydrocarbon group of L^1 is preferably an alkyl group, an aryl group or an aralkyl group. The hydrocarbon oxy group of L^1 is preferably an alkoxy group or an aryloxy group.

Examples of the above-mentioned alkyl group are a methyl group, an ethyl group, a n-propyl group, an isopropyl group, a n-butyl group, a sec-butyl group, a tert-butyl group, an

and an iodine atom. Examples of the alkyl group substituted with the halogen atom are a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, a chloromethyl group, a dichloromethyl group, a trichloromethyl group, a bromomethyl group, a dibromomethyl group, a tribromomethyl group, an iodomethyl group, a diiodomethyl group, a triiodomethyl group, a fluoroethyl group, a difluoroethyl group, a trifluoroethyl group, a tetrafluoroethyl group, a pentafluoroethyl group, a chloroethyl group, a dichloroethyl group, a trichloroethyl group, a tetrachloroethyl group, a pentachloroethyl group, a bromoethyl group, a dibromoethyl group, a tribromoethyl group, a tetrabromoethyl group, a pentabromoethyl group, a perfluoropropyl group, a perfluorobutyl group, a perfluoropentyl group, a perfluorohexyl group, a perfluorooctyl group, a perfluorododecyl group, a perfluoropentadecyl group, a perfluoroeicosyl group, a perchloropropyl group, a perchlorobutyl group, a perchloropentyl group, a perchlorohexyl group, a perchlorooctyl group, a perchlorododecyl group, a perchloropentadecyl group, a perchloroeicosyl group, a perbromopropyl group, a perbromobutyl group, a perbromopentyl group, a perbromohexyl group, a perbromooctyl group, a perbromododecyl group, a perbromopentadecyl group and a perbromoeicosyl group.

The alkyl group as L^1 is preferably an alkyl group having 1 to 20 carbon atoms, and more preferably a methyl group, an

a 3,4-xylyl group, a 3,5-xylyl group, a 2,3,4-trimethylphenyl group, a 2,3,5-trimethylphenyl group, a 2,3,6-trimethylphenyl group, a 2,4,6-trimethylphenyl group, a 3,4,5-trimethylphenyl group, a 2,3,4,5-tetramethylphenyl group, a
10 2,3,4,6-tetramethylphenyl group, a 2,3,5,6-tetramethylphenyl group, a pentamethylphenyl group, an ethylphenyl group, a n-propylphenyl group, an isopropylphenyl group, a n-butylphenyl group, a sec-butylphenyl group, a tert-butylphenyl group, an isobutylphenyl group, a
15 n-pentylphenyl group, a neopentylphenyl group, a n-hexylphenyl group, a n-octylphenyl group, a n-decylphenyl group, a n-dodecylphenyl group, a n-tetradecylphenyl group, a naphthyl group and an anthracenyl group.

The aryl group is preferably an aryl group having 6 to
20 20 carbon atoms, and more preferably a phenyl group or a 2-, 3-, or 4-tolyl group.

Examples of the aralkyl group as L¹ are a benzyl group, a (2-methylphenyl)methyl group, a (3-methylphenyl)methyl group, a (4-methylphenyl)methyl group, a
25 (2,3-dimethylphenyl)methyl group, a (2,4-dimethylphenyl)methyl group, a (2,5-dimethylphenyl)methyl group, a (2,6-dimethylphenyl)methyl group, a (3,4-dimethylphenyl)methyl group, a
30 (3,5-dimethylphenyl)methyl group, a

(2,3,4,5-tetramethylphenyl)methyl group, a
(2,3,4,6-tetramethylphenyl)methyl group, a
(2,3,5,6-tetramethylphenyl)methyl group, a
(pentamethylphenyl)methyl group, an (ethylphenyl)methyl
10 group, a (n-propylphenyl)methyl group, an
(isopropylphenyl)methyl group, a (n-butylphenyl)methyl group,
a (sec-butylphenyl)methyl group, a (tert-butylphenyl)methyl
group, a (n-pentylphenyl)methyl group, a
(neopentylphenyl)methyl group, a (n-hexylphenyl)methyl group,
15 a (n-octylphenyl)methyl group, a (n-decylphenyl)methyl group,
a (tetradecylphenyl)methyl group, a naphthylmethyl group and
an anthracenylmethyl group.

The aralkyl group as L^1 is preferably an aralkyl group
having 7 to 20 carbon atoms, and more preferably a benzyl group.

20 Examples of the alkoxy group as L^1 are a methoxy group,
an ethoxy group, a n-propoxy group, an isopropoxy group, a
n-butoxy group, a sec-butoxy group, a tert-butoxy group, an
isobutoxy group, a n-pentyloxy group, a neopentyloxy group,
a tert-pentyloxy group, a n-hexyloxy group, a n-heptyloxy group,
25 a n-octyloxy group, a n-decyloxy group, a n-dodecyloxy group,
a n-pentadecyloxy group and a n-eicosyl oxy group.

The alkoxy group as L^1 is preferably an alkoxy group having
1 to 20 carbon atoms, and more preferably a methoxy group,
an ethoxy group, an isopropoxy group, a tert-butoxy group,
30 an isobutoxy group, a neopentoxyl group or a tert-pentyloxy

5 xylyloxy group, a 2,6-xylyloxy group, a 3,4-xylyloxy group,
a 3,5-xylyloxy group, a 2,3,4-trimethylphenoxy group, a
2,3,5-trimethylphenoxy group, a 2,3,6-trimethylphenoxy group,
a 2,4,6-trimethylphenoxy group, a 3,4,5-trimethylphenoxy
group, a 2,3,4,5-tetramethylphenoxy group, a
10 2,3,4,6-tetramethylphenoxy group, a
2,3,5,6-tetramethylphenoxy group, a pentamethylphenoxy group,
an ethylphenoxy group, a n-propylphenoxy group, an
isopropylphenoxy group, a n-butylphenoxy group, a
sec-butylphenoxy group, a tert-butylphenoxy group, an
15 isobutylphenoxy group, a n-pentylphenoxy group, a
neopentylphenoxy group, a n-hexylphenoxy group, a
n-octylphenoxy group, a n-decylphenoxy group, a
n-tetradecylphenoxy group, a naphthoxy group and an
anthrathenoxy group.

20 The aryloxy group is preferably an aryloxy group having
6 to 20 carbon atoms, and more preferably a phenoxy group.

These alkyl, aryl, aralkyl, alkoxy and aryloxy groups
above-mentioned as L¹ may be respectively substituted with a
halogen atom such as a fluorine atom, a chlorine atom, a bromine
25 atom and an iodine atom; an alkoxy group such as a methoxy
group and an ethoxy group; an aryloxy group such as a phenoxy
group; or an aralkyloxy group such as a benzyloxy group.

Examples of the compound (a) represented by the formula [1], wherein M^1 is a bismuth atom, are a halogenated bismuth (III) such as bismuth (III) fluoride, bismuth (III) chloride, bismuth (III) bromide and bismuth (III) iodide; a trialkyl bismuth such as trimethyl bismuth; a triaryl bismuth such as triphenyl bismuth; a trialkoxy bismuth such as trimethoxy bismuth, triethoxy bismuth, triisopropoxy bismuth, tri(tert-butoxy) bismuth, triisobutoxy bismuth, trineopentyloxy bismuth and tri(tert-pentyloxy) bismuth; a triaryloxy bismuth such as triphenoxy bismuth, tri(2-tolyloxy) bismuth, tri(3-tolyloxy) bismuth, tri(4-tolyloxy) bismuth, tri(2,3-xylyloxy) bismuth, tri(2,4-xylyloxy) bismuth, tri(2,5-xylyloxy) bismuth, tri(2,6-xylyloxy) bismuth, tri(3,4-xylyloxy) bismuth, tri(3,5-xylyloxy) bismuth, tri(2,3,4-trimethylphenoxy) bismuth, tri(2,3,5-trimethylphenoxy) bismuth, tri(2,3,6-trimethylphenoxy) bismuth, tri(2,4,6-trimethylphenoxy) bismuth, tri(3,4,5-trimethylphenoxy) bismuth, tri(2,3,4,5-tetramethylphenoxy) bismuth, tri(2,3,4,6-tetramethylphenoxy) bismuth, tri(2,3,5,6-tetramethylphenoxy) bismuth, tri(pentamethylphenoxy) bismuth, tri(ethylphenoxy) bismuth, tri(n-propylphenoxy) bismuth, tri(isopropylphenoxy) bismuth, tri(n-butylphenoxy) bismuth, tri(sec-butylphenoxy) bismuth,

and trianthracenyloxy bismuth; a halogenated bismuth(V) such as bismuth(V)fluoride, bismuth(V)chloride, bismuth(V)bromide and bismuth(V)iodide; a pentaalkyl bismuth such as pentamethyl bismuth; a pentaalkoxy bismuths such as pentamethoxy bismuth and pentaethoxy bismuth; and a pentaaryloxy bismuths such as pentaphenoxy bismuth.

Examples of the compound (a) represented by the formula [1], wherein M^1 is an aluminum atom, are a trialkylaluminum such as trimethylaluminum, triethylaluminum, tripropylaluminum, tri-n-butylaluminum, triisobutylaluminum, tri-n-hexyl aluminum and tri-n-octylaluminum; a triarylaluminum such as triphenylaluminum, trinaphthylaluminum and tri(pentafluorophenyl)aluminum; a trialkenylaluminum such as triallylaluminum; tri(cyclopentadienyl)aluminum; and a halogenated aluminum such as a halogenated dialkylaluminum, for example, dimethylaluminum chloride, diethylaluminum chloride, dipropylaluminum chloride, di-n-butylaluminum chloride, diisobutylaluminum chloride, di-n-hexylaluminum chloride, dimethylaluminum bromide, diethylaluminum bromide, dipropylaluminum bromide, di-n-butylaluminum bromide, diisobutylaluminum bromide, di-n-hexylaluminum bromide, dimethylaluminum iodide, diethylaluminum iodide, dipropylaluminum iodide, di-n-butylaluminum iodide, diisobutylaluminum iodide and di-n-hexylaluminum iodide.

or a trialkylaluminum such as trimethylaluminum, triethylaluminum, tripropylaluminum, tri-n-butylaluminum, triisobutylaluminum, tri-n-hexyl aluminum and tri-n-octylaluminum; and particularly preferably a triaryl bismuth such as triphenyl bismuth, or a trialkylaluminum such as trimethylaluminum, triethylaluminum, triisobutylaluminum and tri-n-octylaluminum.

Examples of the non-metal atom of T of the Group 15 are a nitrogen atom and a phosphorous atom, and examples of the non-metal atom of T of the Group 16 are an oxygen atom and a sulfur atom. T is preferably a nitrogen atom or an oxygen atom, and particularly preferably an oxygen atom.

In the above formula [2], when T is a non-metal atom of the Group 15, s is 3, and when T is a non-metal atom of the Group 16, s is 2.

In the formula [2], as an index of the electron-withdrawing property, the substituent constant σ of the Hammett's rule is known, and a functional group, in which the substituent constant σ of the Hammett's rule is positive, can be mentioned as an electron-withdrawing group.

Examples of the electron-withdrawing group are a fluorine atom, a chlorine atom, a bromine atom, an iodine atom, a cyano group, a nitro group, a carbonyl group, a sulfonyl group, and a phenyl group. Examples of a group containing an

an aralkyloxycarbonyl group and an aryloxycarbonyl group; and an acyloxy group.

Examples of the halogenated alkyl group as R^1 are a fluoromethyl group, a chloromethyl group, a bromomethyl group, 10 an iodomethyl group, a difluoromethyl group, a dichloromethyl group, a dibromomethyl group, a diiodomethyl group, a trifluoromethyl group, a trichloromethyl group, a tribromomethyl group, a triiodomethyl group, a 2,2,2-trifluoroethyl group, a 2,2,2-trichloroethyl group, a 15 2,2,2-tribromoethyl group, a 2,2,2-triiodoethyl group, a 2,2,3,3,3-pentafluoropropyl group, a 2,2,3,3,3-pentachloropropyl group, a 2,2,3,3,3-pentabromopropyl group, a 2,2,3,3,3-pentaiodopropyl group, a 20 2,2,2-trifluoro-1-trifluoromethylethyl group, a 2,2,2-trichloro-1-trichloromethylethyl group, a 2,2,2-tribromo-1-tribromomethylethyl group, a 2,2,2-triiodo-1-triiodomethylethyl group, a bis(trifluoromethyl)methyl group, a 25 bis(trichloromethyl)methyl group, a bis(tribromomethyl)methyl group, a bis(triiodomethyl)methyl group, a 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl group, a 1,1-bis(trichloromethyl)-2,2,2-trichloroethyl group, a 1,1-bis(tribromomethyl)-2,2,2-tribromoethyl group, and a 30 1,1-bis(triiodomethyl)-2,2,2-triiodoethyl group.

group, a 2-bromophenyl group, a 3-bromophenyl group, a
4-bromophenyl group, a 2-iodophenyl group, a 3-iodophenyl group,
a 4-iodophenyl group, a 2,6-difluorophenyl group, a
3,5-difluorophenyl group, a 3,4,5-trifluorophenyl group, a
10 2,6-dichlorophenyl group, a 3,5-dichlorophenyl group, a
2,6-dibromophenyl group, a 3,5-dibromophenyl group, a
2,6-diiodophenyl group, a 3,5-diiodophenyl group, a
2,4,6-trifluorophenyl group, a 2,4,6-trichlorophenyl group,
a 2,4,6-tribromophenyl group, a 2,4,6-triiodophenyl group,
15 a pentafluorophenyl group, a pentachlorophenyl group, a
pentabromophenyl group, and a pentaiodophenyl group.

Further, examples of the (halogenated alkyl)aryl group
as R^1 are aryl groups substituted with a halogenated alkyl group
such as a 2-(trifluoromethyl)phenyl group, a
20 3-(trifluoromethyl)phenyl group, a 4-(trifluoromethyl)phenyl
group, a 2,6-bis(trifluoromethyl)phenyl group, a
3,5-bis(trifluoromethyl)phenyl group, and a
2,4,6-tris(trifluoromethyl)phenyl group.

Examples of the cyanated aryl group as R^1 are a
25 2-cyanophenyl group, a 3-cyanophenyl group and a 4-cyanophenyl
group.

Examples of the nitrated aryl group as R^1 are a
2-nitrophenyl group, a 3-nitrophenyl group and a 4-nitrophenyl
group.

30 Examples of the alkoxycarbonyl group as R^1 are a

Examples of the aryloxycarbonyl group as R¹ are a phenoxycarbonyl group and a pentafluorophenoxycarbonyl group.

Examples of the acyloxycarbonyl group as R¹ are a methycarbonyloxy group and an ethylcarbonyloxy group.

10 R¹ is preferably a halogenated hydrocarbon group; more preferably a halogenated alkyl group or a halogenated aryl group; further preferably a fluoroalkyl group, a fluoroaryl group, a chloroalkyl group or a chloroaryl group; furthermore preferably a fluoroalkyl group or a fluoroaryl group;
15 particularly preferably a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, a 2,2,2-trifluoroethyl group, a 2,2,3,3,3-pentafluoropropyl group, a 2,2,2-trifluoro-1-trifluoromethylethyl group, a bis(trifluoromethyl)methyl group, a
20 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl group, a 4-fluorophenyl group, a 2,6-difluorophenyl group, a 3,5-difluorophenyl group, a 2,4,6-trifluorophenyl group, a 3,4,5-trifluorophenyl group or a pentafluorophenyl group; and most preferably a trifluoromethyl group, a
25 2,2,2-trifluoro-1-trifluoromethylethyl group, a bis(trifluoromethyl)methyl group, a 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl group, a 3,4,5-trifluorophenyl group, or a pentafluorophenyl group.

When the compound (b) represented by the above formula
30 [2] is an amine, examples thereof are di(fluoromethyl)amine,

bis(triiodomethyl)amine, bis(2,2,2-trifluoroethyl)amine,
bis(2,2,2-trichloroethyl)amine,
bis(2,2,2-tribromoethyl)amine,
bis(2,2,2-triiodoethyl)amine,
10 bis(2,2,3,3,3-pentafluoropropyl)amine,
bis(2,2,3,3,3-pentachloropropyl)amine,
bis(2,2,3,3,3-pentabromopropyl)amine,
bis(2,2,3,3,3-pentaiodopropyl)amine,
bis(2,2,2-trifluoro-1-trifluoromethylethyl)amine,
15 bis(2,2,2-trichloro-1-trichloromethylethyl)amine,
bis(2,2,2-tribromo-1-tribromomethylethyl)amine,
bis(2,2,2-triiodo-1-triiodomethylethyl)amine,
bis(1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl)amine,
bis(1,1-bis(trichloromethyl)-2,2,2-trichloroethyl)amine,
20 bis(1,1-bis(tribromomethyl)-2,2,2-tribromoethyl)amine,
bis(1,1-bis(triiodomethyl)-2,2,2-triiodoethyl)amine,
bis(2-fluorophenyl)amine, bis(3-fluorophenyl)amine,
bis(4-fluorophenyl)amine, bis(2-chlorophenyl)amine,
bis(3-chlorophenyl)amine, bis(4-chlorophenyl)amine,
25 bis(2-bromophenyl)amine, bis(3-bromophenyl)amine,
bis(4-bromophenyl)amine, bis(2-iodophenyl)amine,
bis(3-iodophenyl)amine, bis(4-iodophenyl)amine,
bis(2,6-difluorophenyl)amine, bis(3,5-difluorophenyl)amine,
bis(2,6-dichlorophenyl)amine, bis(3,5-dichlorophenyl)amine,
30 bis(2,6-dibromophenyl)amine, bis(3,5-dibromophenyl)amine,

bis(pentachlorophenyl)amine, bis(pentabromophenyl)amine,
bis(pentaiodophenyl)amine,
bis(2-(trifluoromethyl)phenyl)amine,
bis(3-(trifluoromethyl)phenyl)amine,
10 bis(4-(trifluoromethyl)phenyl)amine,
bis(2,6-di(trifluoromethyl)phenyl)amine,
bis(3,5-di(trifluoromethyl)phenyl)amine,
bis(2,4,6-tri(trifluoromethyl)phenyl)amine,
bis(2-cyanophenyl)amine, bis(3-cyanophenyl)amine,
15 bis(4-cyanophenyl)amine, bis(2-nitrophenyl)amine,
bis(3-nitrophenyl)amine and bis(4-nitrophenyl)amine.

When the compound (b) is a phosphine, examples thereof
are phosphine compounds in which a nitrogen atom is replaced
with a phosphorus atom in the above-mentioned amine compounds.

20 When the compound (b) represented by the above formula
[2] is an alcohol, examples thereof are fluoromethanol,
chloromethanol, bromomethanol, iodomethanol,
difluoromethanol, dichloromethanol, dibromomethanol,
diiodomethanol, trifluoromethanol, trichloromethanol,
25 tribromomethanol, triiodomethanol, 2,2,2-trifluoroethanol,
2,2,2-trichloroethanol, 2,2,2-tribromoethanol,
2,2,2-triiodoethanol, 1,1,1,3,3,3-hexafluoro-2-propanol,
1,1,1,3,3,3-hexachloro-2-propanol,
1,1,1,3,3,3-hexabromo-2-propanol,
30 1,1,1,3,3,3-hexaiodo-2-propanol,

1H,1H,3H-perbromopropanol, 1H,1H,3H-periodopropanol,
1H,1H-perfluoropropanol, 1H,1H-perchloropropanol,
1H,1H-perbromopropanol, 1H,1H-periodopropanol,
1H,1H,4H-perfluorobutanol, 1H,1H,4H-perchlorobutanol,
10 1H,1H,4H-perbromobutanol, 1H,1H,4H-periodobutanol,
1H,1H-perfluorobutanol, 1H,1H-perchlorobutanol,
1H,1H-perbromobutanol, 1H,1H-periodobutanol,
1H,1H,5H-perfluoropentanol, 1H,1H,5H-perchloropentanol,
1H,1H,5H-perbromopentanol, 1H,1H,5H-periodopentanol,
15 1H,1H-perfluoropentanol, 1H,1H-perchloropentanol,
1H,1H-perbromopentanol, 1H,1H-periodopentanol,
1H,1H,6H-perfluorohexanol, 1H,1H,6H-perchlorohexanol,
1H,1H,6H-perbromohexanol, 1H,1H,6H-periodohexanol,
1H,1H-perfluorohexanol, 1H,1H-perfchlorohexanol,
20 1H,1H-perbromohexanol, 1H,1H-periodohexanol,
1H,1H,8H-perfluorooctanol, 1H,1H,8H-perchlorooctanol,
1H,1H,8H-perbromooctanol, 1H,1H,8H-periodooctanol,
1H,1H-perfluorooctanol, 1H,1H-perchlorooctanol,
1H,1H-perbromooctanol and 1H,1H-periodooctanol.

25 When the compound (b) is a thiol compound, examples
thereof are thiol compounds in which an oxygen atom is replaced
with a sulfur atom in the above-mentioned alcohol compounds .

 When the compound (b) is a phenol, examples thereof are
2-fluorophenol, 3-fluorophenol, 4-fluorophenol,
30 2-chlorophenol, 3-chlorophenol, 4-chlorophenol,

3,4,5-trifluorophenol, 2,4,6-trichlorophenol,
2,4,6-tribromophenol, 2,4,6-triiodophenol,
pentafluorophenol, pentachlorophenol, pentabromophenol,
pentaiodophenol, 2-(trifluoromethyl)phenol,
10 3-(trifluoromethyl)phenol, 4-(trifluoromethyl)phenol,
2,6-bis(trifluoromethyl)phenol,
3,5-bis(trifluoromethyl)phenol, 2-cyanophenol,
3-cyanophenol, 4-cyanophenol, 2-nitrophenol, 3-nitrophenol
and 4-nitrophenol.

15 When the compound (b) is a thiophenol compound, examples
thereof are thiophenol compounds in which an oxygen atom is
replaced with a sulfur atom in the above-mentioned phenol
compounds.

 When the compounds (b) is a carboxylic acid, examples
20 thereof are 2-fluorobenzoic acid, 3-fluorobenzoic acid,
4-fluorobenzoic acid, 2,3-difluorobenzoic acid,
2,4-difluorobenzoic acid, 2,5-difluorobenzoic acid,
2,6-difluorobenzoic acid, 2,3,4-trifluorobenzoic acid,
2,3,5-trifluorobenzoic acid, 2,3,6-trifluorobenzoic acid,
25 2,4,5-trifluorobenzoic acid, 2,4,6-trifluorobenzoic acid,
2,3,4,5-tetrafluorobenzoic acid, 2,3,4,6-tetrafluorobenzoic
acid, pentafluorobenzoic acid, fluoroacetic acid,
difluoroacetic acid, trifluoroacetic acid,
pentafluoropropanoic acid, heptafluorobutanoic acid and
30 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethanoic acid.

sulfonic acid.

A preferable amine of the compound (b) is bis(trifluoromethyl)amine, bis(2,2,2-trifluoromethyl)amine, bis(2,2,3,3,3-pentafluoropropyl)amine, 10 bis(2,2,2-trifluoro-1-trifluoromethylethyl)amine, bis(1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl)amine or bis(pentafluorophenyl)amine; preferable alcohols thereof are trifluoromethanol, 2,2,2-trifluoroethanol, 2,2,3,3,3-pentafluoropropanol, 15 1,1,1,3,3,3-hexafluoro-2-propanol, 2,2,2-trifluoro-1-trifluoromethylethanol or 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethanol; a preferable phenol thereof is 2-fluorophenol, 3-fluorophenol, 4-fluorophenol, 2,6-difluorophenol, 3,5-difluorophenol, 20 2,4,6-trifluorophenol, 3,4,5-trifluorophenol, pentafluorophenol, 2-(trifluoromethyl)phenol, 3-(trifluoromethyl)phenol, 4-(trifluoromethyl)phenol, 2,6-bis(trifluoromethyl)phenol, 3,5-bis(trifluoromethyl)phenol or 25 2,4,6-tris(trifluoromethyl)phenol; a preferable carboxylic acid thereof is pentafluorobenzoic acid or trifluoroacetic acid; and a preferable sulfonic acid thereof is trifluoromethanesulfonic acid.

A more preferable compound (b) is

4-(trifluoromethyl)phenol, 2,6-bis(trifluoromethyl)phenol
or 2,4,6-tris(trifluoromethyl)phenol; and a further
preferable compound (b) is 3,4,5-trifluorophenol,
pentafluorophenol, 1,1,1,3,3,3-hexafluoro-2-propanol or
10 1,1,1,3,3,3-hexafluoro-2-(trifluoromethyl)-2-propanol.

Examples of J in the above-mentioned formula [3] are
a carbon atom and a silicon atom. Among them, a silicon atom
is preferable. In the above-mentioned formula [3], n is the
number of from 2 to 4, preferably 2 or 3, and more preferably
15 2.

Examples of the hydrocarbon group as R² are hydrocarbon
groups as L¹, and halogenated hydrocarbon groups as R¹ mentioned
above, respectively. R² is preferably an alkyl group or an aryl
group, more preferably an aryl group, and further preferably
20 a phenyl group.

Examples of the compound (c) represented by the formula
[3] are dimethylsilanediol, diethylsilanediol,
di(n-propyl)silanediol, diisopropylsilanediol,
di(n-butyl)silanediol, di(sec-butyl)silanediol,
25 di(tert-butyl)silanediol, diisobutylsilanediol,
di(n-pentyl)silanediol, dineopentylsilanediol,
di(n-hexyl)silanediol, di(n-heptyl)silanediol,
di(n-octyl)silanediol, di(n-decyl)silanediol,
di(n-dodecyl)silanediol, di(n-pentadecyl)silanediol,

di(3,5-xylyl)silanediol,
di(2,3,4-trimethylphenyl)silanediol,
di(2,3,5-trimethylphenyl)silanediol,
di(2,3,6-trimethylphenyl)silanediol,
10 di(2,4,6-trimethylphenyl)silanediol,
di(3,4,5-trimethylphenyl)silanediol,
di(2,3,4,5-tetramethylphenyl)silanediol,
di(2,3,4,6-tetramethylphenyl)silanediol,
di(2,3,5,6-tetramethylphenyl)silanediol,
15 di(pentamethylphenyl)silanediol, di(ethylphenyl)silanediol,
di(n-propylphenyl)silanediol,
di(isopropylphenyl)silanediol, di(n-butylphenyl)silanediol,
di(sec-butylphenyl)silanediol,
di(tert-butylphenyl)silanediol,
20 di(isobutylphenyl)silanediol, di(n-pentylphenyl)silanediol,
di(neopentylphenyl)silanediol, di(n-hexylphenyl)silanediol,
di(n-octylphenyl)silanediol, di(n-decylphenyl)silanediol,
di(n-dodecylphenyl)silanediol,
di(n-tetradecylphenyl)silanediol, dinaphthylsilanediol,
25 dianthracenylsilanediol,
di(pentafluorophenyl)silanediol, methylsilanetriol,
ethylsilanetriol, n-propylsilanetriol, isopropylsilanetriol,
n-butylsilanetriol, sec-butylsilanetriol,

phenylsilanetriol, 2-tolylsilanetriol, 3-tolylsilanetriol,
 4-tolylsilanetriol, 2,3-xylylsilanetriol,
 2,4-xylylsilanetriol, 2,5-xylylsilanetriol,
 2,6-xylylsilanetriol, 3,4-xylylsilanetriol,
 10 3,5-xylylsilanetriol, 2,3,4-trimethylphenylsilanetriol,
 2,3,5-trimethylphenylsilanetriol,
 2,3,6-trimethylphenylsilanetriol,
 2,4,6-trimethylphenylsilanetriol,
 3,4,5-trimethylphenylsilanetriol,
 15 2,3,4,5-tetramethylphenylsilanetriol,
 2,3,4,6-tetramethylphenylsilanetriol,
 2,3,5,6-tetramethylphenylsilanetriol,
 pentamethylphenylsilanetriol, ethylphenylsilanetriol,
 n-propylphenylsilanetriol, isopropylphenylsilanetriol,
 20 n-butylphenylsilanetriol, sec-butylphenylsilanetriol,
 tert-butylphenylsilanetriol, isobutylphenylsilanetriol,
 n-pentylphenylsilanetriol, neopentylphenylsilanetriol,
 n-hexylphenylsilanetriol, n-octylphenylsilanetriol,
 n-decylphenylsilanetriol, n-dodecylphenylsilanetriol,
 25 n-tetradecylphenylsilanetriol, naphthylsilanetriol,
 anthracenylsilanetriol, pentafluorophenylsilanetriol and
 tetrahydroxysilane.

The compound (c) is preferably

pentafluorophenylsilanetriol or
di(pentafluorophenyl)silanediol; and most preferably
diphenylsilanediol.

A method for contacting the compounds (a) to (c) is not
10 particularly limited. Examples thereof are as follows.

① A method of contacting (c) after contacting (a) and
(b).

② A method of contacting (b) after contacting (a) and
(c).

15 ③ A method of contacting (a) after contacting (b) and
(c).

Preferred is ① or ②. Namely, the metal compound
according to the present invention is preferably obtained by
contacting (c) with a contact product obtained by contacting
20 (a) and (b), or by contacting (b) with a contact product obtained
by contacting (a) and (c). Further, there may be carried out
either a method comprising the steps of:

(1) contacting (a) and (b), (a) and (c), or (b) and (c)
to obtain a contact product, and

25 (2) contacting the contact product with the remaining
compound,

or a method comprising the steps of:

(1) contacting (a) and (b), (a) and (c), or (b) and (c)
to obtain a contact product,

(a) to (c) is preferably carried out under an inert gas atmosphere.

The treatment temperature is usually from -100 to 300°C, preferably from -80 to 200°C, and further preferably from 0 to 150°C. The treatment time is usually from 1 minute to 200 hours, and preferably from 10 minutes to 100 hours. Further, a solvent may be used in the treatment, or these compounds may be directly contact-treated using no solvent. There can be used any solvent selected from a non-polar solvent such as an aliphatic hydrocarbon solvent and an aromatic hydrocarbon solvent, and a polar solvent such as a halogenated solvent and an etheral solvent, which is inert to the compounds (a) to (c). Examples of the solvent are butane, hexane, heptane, octane, 2,2,4-trimethylpentane, cyclohexane, benzene, toluene, xylene, dichloromethane, difluoromethane, chloroform, 1,2-dichloroethane, 1,2-dibromoethane, 1,1,2-trichloro-1,2,2-trifluoroethane, tetrachloroethylene, chlorobenzene, bromobenzene, o-dichlorobenzene, dimethyl ether, diethyl ether, diisopropyl ether, di-n-butyl ether, methyl tert-butyl ether, anisole, 1,4-dioxane, 1,2-dimethoxyethane, bis(2-methoxyethyl) ether, tetrahydrofuran and tetrahydropyran.

Regarding the amounts of the respective compounds used in the preparation of the metal compound, when the molar ratio of the amounts of the respective compounds used is defined as a molar ratio of (a):(b):(c) = 1 : y : z, y is from 0.1 to

compounds (a) to (c), which are raw materials, may remain as an unreacted matter in the metal compound according to the present invention.

When the compounds (a) to (c) are triphenyl bismuth,
10 pentafluorophenol and diphenylsilanediol, respectively, an example of a process for producing the metal compound according to the present invention comprises the steps of:

(1) adding dropwise a toluene solution containing
pentafluorophenol in amount of three times by mole to triphenyl
15 bismuth to a toluene solution of triphenyl bismuth,

(2) stirring for from 10 minutes to 24 hours at room temperature,

(3) stirring under a refluxing condition for from 10 minutes to 24 hours,

20 (4) concentrating the solution,

(5) filtering a precipitated solid component,

(6) drying the solid component,

(7) adding toluene and diphenylsilanediol to the obtained solid component,

25 (8) stirring under a refluxing condition for from 10 minutes to 24 hours,

(9) concentrating the solution,

(10) filtering a precipitated solid component, and

(11) drying the solid component,

30 The metal compound (hereinafter, referred to as

compound (A) with the compound (B), and (2) a catalyst obtained by a process comprising the step of contacting the compound (A) with the compound (B) and the compound (C). In order to obtain a catalyst having a high polymerization activity, the
10 above latter catalyst is preferable.

Preferable examples of the compound (B) are a metal compound represented by the following formula [4], and a μ -oxo type metal compound thereof:



wherein a is a number satisfying $0 < a \leq 8$; b is a number satisfying $0 < b \leq 8$; M^2 is a metal atom of the Groups 3 to 11 or Lanthanide Series of the Periodic Table of the Elements;
20 L^2 is a group having a cyclopentadienyl type anion skeleton, or a group containing a hetero-atom, a plurality of L^2 groups may be the same or different each other, and a plurality of L^2 groups may be optionally linked in direct, or through a group containing a carbon atom, a silicon atom, a nitrogen atom,
25 an oxygen atom, a sulfur atom or a phosphorus atom; X^1 is a halogen atom, a hydrocarbon group (excluding the group having a cyclopentadienyl type anion skeleton) or a hydrocarbonoxy group, and a plurality of X^1 groups may be the same or different each other.

30 Examples of M^2 are a scandium atom, an yttrium atom, a

particularly preferably a titanium atom, a zirconium atom or a hafnium atom.

Examples of the group having a cyclopentadienyl type anion skeleton as L^2 are an η^5 -(substituted)cyclopentadienyl group, an η^5 -(substituted)indenyl group, and an η

⁵-(substituted) fluorenyl group. Specific examples thereof are an η^5 -cyclopentadienyl group, an η^5 -methylcyclopentadienyl group, an η^5 -tert-butylcyclopentadienyl group, an η

⁵-1,2-dimethylcyclopentadienyl group, an η ⁵-1,3-dimethylcyclopentadienyl group, an η ⁵-1-tert-butyl-2-methylcyclopentadienyl group, an η ⁵-1-tert-butyl-3-methylcyclopentadienyl group, an η ⁵-1-methyl-2-isopropylcyclopentadienyl group, an η ⁵-1-methyl-3-isopropylcyclopentadienyl group, an η ⁵-1,2,3-trimethylcyclopentadienyl group, an η ⁵-1,2,4-trimethylcyclopentadienyl group, an η ⁵-tetramethylcyclopentadienyl group, an η ⁵-pentamethylcyclopentadienyl group, an η^5 -indenyl group, an η^5 -4,5,6,7-tetrahydroindenyl group, an η^5 -2-methylindenyl

group, an η^5 -3-methylindenyl group, an η^5 -4-methylindenyl

group, an η^5 -5-methylindenyl group, an η^5 -6-methylindenyl

group, an η^5 -7-methylindenyl group, an η

⁵-2-tert-butylindenyl group, an η^5 -3-tert-butylindenyl group,

an η^5 -4-tert-butylindenyl group, an η^5 -5-tert-butylindenyl

group, an η^5 -6-tert-butylindenyl group, an η

⁵-4-phenylindenyl group, an η^5 -2-methyl-5-phenylindenyl group, an η^5 -2-methyl-4-phenylindenyl group, an η^5 -2-methyl-4-naphthylindenyl group, an η^5 -fluorenyl group, an η^5 -2,7-dimethylfluorenyl group and an η^5 -2,7-di-tert-butylfluorenyl group; and substitution groups thereof.

Examples of the hetero-atom in the group containing a hetero-atom as L² are an oxygen atom, a sulfur atom, a nitrogen atom and a phosphorus atom. Examples of the group containing a hetero-atom are an alkoxy group; an aryloxy group; a thioalkoxy group; a thioaryloxy group; an alkylamino group; an arylamino group; an alkylphosphino group; an arylphosphino group; an aromatic or aliphatic heterocyclic group containing in its ring at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, a nitrogen atom and a phosphorus atom; and a chelating ligand.

Examples of the group containing a hetero-atom are a methoxy group, an ethoxy group, a n- or iso-propoxy group, a n-, sec-, iso- or tert-butoxy group, a phenoxy group, a 2-methylphenoxy group, a 2,6-dimethylphenoxy group, a 2,4,6-trimethylphenoxy group, a 2-ethylphenoxy group, a 4-n-propylphenoxy group, a 2-isopropylphenoxy group, a 2,6-diisopropylphenoxy group, a 4-sec-butylphenoxy group, a 4-tert-butylphenoxy group, a 2,6-di-sec-butylphenoxy group, a 4-tert-butyl-4-methylphenoxy group, a

group, a 2,4,6-trifluorophenoxy group, a thiomethoxy group,
a dimethylamino group, a diethylamino group, a di-n- or
iso-propylamino group, a diphenylamino group, an
isopropylamino group, a tert-butylamino group, a pyrrolyl group,
10 a dimethylphosphino group, a 2-(2-oxy-1-propyl)phenoxy group,
a catecholato group, a 2-hydroxyphenoxy group, a resorcinolato
group, a 3-hydroxyphenoxy group, a 4-isopropyl-catecholato
group, a 2-hydroxy-4-isopropyl-phenoxy group, a
3-methoxycatecholato group, a 2-hydroxy-3-methoxyphenoxy
15 group, a 1,8-dihydroxynaphthyl group, a 1,2-dihydroxynaphthyl
group, a 2,2'-biphenyldiol group, a 1,1'-bi-2-naphthol group,
a 2,2'-dihydroxy-6,6'-dimethylbiphenyl group, a
4,4',6,6'-tetra-tert-butyl-2,2'-methylenediphenoxy group,
and a 4,4',6,6'-tetramethyl-2,2'-isobutylidenediphenoxy
20 group.

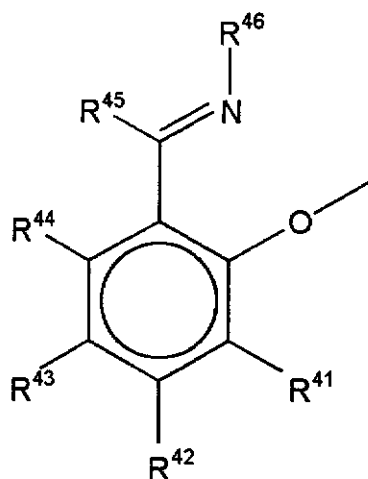
A further example of the hetero atom-containing group
is a group represented by the following formula [5]:



25 wherein R^3 is a hydrogen atom, a halogen atom or a hydrocarbon
group, three R^3 groups may be the same or different, and two
or more thereof may be bonded mutually, or may form a ring.

Examples of R^3 in the formula [5] are a hydrogen atom,
30 a fluorine atom, a chlorine atom, a bromine atom, an iodine

group is a group represented by the following formula [6]:



[6]

10 wherein respective R⁴¹ to R⁴⁶ groups are independently a hydrogen atom, a halogen atom, a hydrocarbon group, a hydrocarbon oxy group, a silyl group or an amino group, they may be the same or different, and two or more thereof may be bonded mutually, or may form a ring.

15 Examples of R⁴¹ to R⁴⁶ in the above formula [6] are a hydrogen atom, a fluorine atom, a chlorine atom, a bromine atom, an iodine atom, a phenyl group, a 1-naphtyl group, a 2-naphtyl group, a tert-butyl group, a 2,6-dimethylphenyl group, a 2-fluorenyl group, a 2-methylphenyl group, a
20 4-trifluoromethylphenyl group, a 4-methoxyphenyl group, a 4-pyridyl group, a cyclohexyl group, a 2-isopropylphenyl group, a benzyl group, a methyl group, a triethylsilyl group, a diphenylmethylsilyl group, a 1-methy-1-phenylethyl group, a

terpyridine, acylhydrazone, diethylenetriamine, triethylenetetramine, porphyrin, crown ether and cryptate.

Examples of the heterocyclic group as L^2 are a pyridyl group, an N-substituted imidazolyl group and an N-substituted indazolyl group, and preferred is a pyridyl group.

Examples of the above-mentioned group, through which plural L^2 groups are linked, are an alkylene group such as a methylene group, an ethylene group and a propylene group; a substituted alkylene group such as a dimethylmethylene group (an isopropylidene group) and a diphenylmethylene group; a silylene group; a substituted silylene group such as a dimethylsilylene group, a diethylsilylene group, a diphenylsilylene group, a tetramethyldisilylene group and a dimethoxysilylene group; and a hetero-atom such as a nitrogen atom, an oxygen atom, a sulfur atom and a phosphorus atom. Among them, particularly preferred is a methylene group, an ethylene group, a dimethylmethylene group (an isopropylidene group), a diphenylmethylene group, a dimethylsilylene group, a diethylsilylene group, a diphenylsilylene group or a dimethoxysilylene group.

Examples of the halogen atom as X^1 are a fluorine atom, a chlorine atom, a bromine atom and an iodine atom. Examples of the hydrocarbon group as X^1 are an alkyl group, an aralkyl group, an aryl group and an alkenyl group.

Examples of the alkyl group as X^8 are a methyl group,

Each of these alkyl groups may be substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom. Examples of such an alkyl group are a fluoromethyl group, a trifluoromethyl group, a chloromethyl group, a trichloromethyl group, a fluoroethyl group, a pentafluoroethyl group, a perfluoropropyl group, a perfluorobutyl group, a perfluorohexyl group, a perfluorooctyl group, a perchloropropyl group, a perchlorobutyl group and a perbromopropyl group.

Further, these alkyl groups may be substituted with an alkoxy group such as a methoxy group and an ethoxy group; an aryloxy group such as a phenoxy group; or an aralkyloxy group such as a benzyloxy group.

The alkyl group as X^1 is preferably an alkyl group having 1 to 20 carbon atoms, and more preferably a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, an isobutyl group or an amyl group.

Examples of the aralkyl group as X^1 are a benzyl group, a (2-methylphenyl)methyl group, a (3-methylphenyl)methyl group, a (4-methylphenyl)methyl group, a (2,3-dimethylphenyl)methyl group, a (2,4-dimethylphenyl)methyl group, a (2,5-dimethylphenyl)methyl group, a (2,6-dimethylphenyl)methyl group, a (3,4-dimethylphenyl)methyl group, a

(2,4,6-trimethylphenyl)methyl group, a
(2,3,4,5-tetramethylphenyl)methyl group, a
(2,3,4,6-tetramethylphenyl)methyl group, a
(2,3,5,6-tetramethylphenyl)methyl group, a
10 (pentamethylphenyl)methyl group, an (ethylphenyl)methyl
group, a (n-propylphenyl)methyl group, an
(isopropylphenyl)methyl group, a (n-butylphenyl)methyl group,
a (sec-butylphenyl)methyl group, a (tert-butylphenyl)methyl
group, a (n-pentylphenyl)methyl group, a
15 (neopentylphenyl)methyl group, a (n-hexylphenyl)methyl group,
a (n-octylphenyl)methyl group, a (n-decylphenyl)methyl group,
a (tetradecylphenyl)methyl group, a naphthylmethyl group and
an anthracenylmethyl group.

Each of these aralkyl groups may be substituted with
20 a halogen atom such as a fluorine atom, a chlorine atom, a
bromine atom and an iodine atom; an alkoxy group such as a
methoxy group and an ethoxy group; an aryloxy group such as
a phenoxy group; or an aralkyloxy group such as a benzyloxy
group.

25 The aralkyl group as X^1 is preferably an aralkyl group
having 7 to 20 carbon atoms, and more preferably a benzyl group.

Examples of the aryl group as X^1 are a phenyl group, a
2-tolyl group, a 3-tolyl group, a 4-tolyl group, a 2,3-xylyl
group, a 2,4-xylyl group, a 2,5-xylyl group, a 2,6-xylyl group,
30 a 3,4-xylyl group, a 3,5-xylyl group, a 2,3,4-trimethylphenyl

n-propylphenyl group, an isopropylphenyl group, a
n-butylphenyl group, a sec-butylphenyl group, a
tert-butylphenyl group, an isobutylphenyl group, a
n-pentylphenyl group, a neopentylphenyl group, a n-hexylphenyl
10 group, a n-octylphenyl group, a n-decylphenyl group, a
n-dodecylphenyl group, a n-tetradecylphenyl group, a naphthyl
group and an anthracenyl group.

Each of these aryl groups may be substituted with a halogen
atom such as a fluorine atom, a chlorine atom, a bromine atom
15 and an iodine atom; an alkoxy group such as a methoxy group
and an ethoxy group; an aryloxy group such as a phenoxy group;
or an aralkyloxy group such as a benzyloxy group.

The aryl group is preferably an aryl group having 6 to
20 carbon atoms, and more preferably a phenyl group.

20 Examples of the alkenyl group as X^1 are an ally group,
a methally group, a crotyl group and a 1,3-diphenyl-2-propenyl
group. The alkenyl group is preferably an alkenyl group having
3 to 20 carbon atoms, and more preferably an ally group or
a methally group.

25 Examples of the hydrocarbonoxy group as X^1 are an alkoxy
group, an aryloxy group and an aralkyloxy group. Preferred
is an alkoxy group having 1 to 20 carbon atoms, an aryloxy
group having 6 to 20 carbon atoms, or an aralkyloxy group having
7 to 20 carbon atoms. Examples thereof are hydrocarbonoxy groups
30 as above-exemplified as L^1 , a (2-methylphenyl)methoxy group,

(3,4-dimethylphenyl)methoxy group, a
(3,5-dimethylphenyl)methoxy group, a
(2,3,4-trimethylphenyl)methoxy group, a
(2,3,5-trimethylphenyl)methoxy group and a benzyloxy group.

10 More preferred is a methoxy group, an ethoxy group, an
isopropoxy group, a tert-butyl group, an isobutoxy group,
a phenoxy group, a 2,6-di(tert-butyl)phenoxy group or a
benzyloxy group; further preferred is a methoxy group, a
phenoxy group, a 2,6-di(tert-butyl)phenoxy group or a
15 benzyloxy group; and particularly preferred is a methoxy group
or a phenoxy group.

X^1 is more preferably a chlorine atom, a methyl group,
an ethyl group, a n-propyl group, an isopropyl group, a n-butyl
group, a benzyl group, an allyl group, a methallyl group, a
20 methoxy group, an ethoxy group or a phenoxy group, and further
preferably a chlorine atom, a methyl group, a methoxy group
or a phenoxy group.

In the formula [4], respective numbers of a and b depend
upon the valency of M^2 .

25 Examples of the metal compound represented by the formula
[4], wherein M^2 is a titanium atom, are
dimethylsilylenebis(cyclopentadienyl)titanium dichloride,
dimethylsilylenebis(2-methylcyclopentadienyl) titanium
dichloride, dimethylsilylenebis(3-methylcyclopentadienyl)
30 titanium dichloride,

dimethylsilylenebis(2,4-dimethylcyclopentadienyl) titanium
dichloride,
dimethylsilylenebis(2,5-dimethylcyclopentadienyl) titanium
dichloride,
10 dimethylsilylenebis(3,4-dimethylcyclopentadienyl) titanium
dichloride,
dimethylsilylenebis(2,3-ethylmethylcyclopentadienyl)
titanium dichloride,
dimethylsilylenebis(2,4-ethylmethylcyclopentadienyl)
15 titanium dichloride,
dimethylsilylenebis(2,5-ethylmethylcyclopentadienyl)
titanium dichloride,
dimethylsilylenebis(3,5-ethylmethylcyclopentadienyl)
titanium dichloride,
20 dimethylsilylenebis(2,3,4-trimethylcyclopentadienyl)
titanium dichloride,
dimethylsilylenebis(2,3,5-trimethylcyclopentadienyl)
titanium dichloride,
dimethylsilylenebis(tetramethylcyclopentadienyl) titanium
25 dichloride, dimethylsilylenebis(indenyl)titanium dichloride,
dimethylsilylenebis(4,5,6,7-tetrahydroindenyl) titanium
dichloride,
dimethylsilylene(cyclopentadienyl)(indenyl)titanium
dichloride, dimethylsilylene(methylcyclopentadienyl)
30 (indenyl)titanium dichloride,

dichloride,

dimethylsilylene(methylcyclopentadienyl)(fluorenyl)

titanium dichloride,

dimethylsilylene(n-butylcyclopentadienyl)(fluorenyl)

10 titanium dichloride,

dimethylsilylene(tetramethylcyclopentadienyl) (fluorenyl)

titanium dichloride, and

dimethylsilylene(indenyl)(fluorenyl)titanium dichloride;

and compounds obtained by changing "dimethylsilylene" in the

15 above compounds to "diethylsilylene", "diphenylsilylene" or
"dimethoxysilylene".

Further examples of the metal compound represented by
the formula [4], wherein M^2 is a titanium atom, are

bis(cyclopentadienyl)titanium dichloride,

20 bis(methylcyclopentadienyl)titanium dichloride,

bis(n-butylcyclopentadienyl)titanium dichloride,

bis(dimethylcyclopentadienyl)titanium dichloride,

bis(ethylmethylcyclopentadienyl)titanium dichloride,

bis(trimethylcyclopentadienyl)titanium dichloride,

25 bis(tetramethylcyclopentadienyl)titanium dichloride,

bis(pentamethylcyclopentadienyl)titanium dichloride,

bis(indenyl)titanium dichloride,

bis(4,5,6,7-tetrahydroindenyl)titanium dichloride,

bis(fluorenyl)titanium dichloride,

30 bis(2-phenylindenyl)titanium dichloride,

bis[2-(3,5-dimethylphenyl)indenyl]titanium dichloride,
bis[2-(pentafluorophenyl)indenyl]titanium dichloride,
cyclopentadienyl(pentamethylcyclopentadienyl) titanium
dichloride, cyclopentadienyl(indenyl) titanium dichloride,
10 cyclopentadienyl(fluorenyl) titanium dichloride,
indenyl(fluorenyl)titanium dichloride,
pentamethylcyclopentadienyl (indenyl)titanium dichloride,
pentamethylcyclopentadienyl(fluorenyl)titanium dichloride,
cyclopentadienyl(2-phenylindenyl)titanium dichloride,
15 pentamethylcyclopentadienyl(2-phenylindenyl)titanium
dichloride, ethylenebis(cyclopentadienyl)titanium
dichloride, ethylenebis(2-methylcyclopentadienyl)titanium
dichloride, ethylenebis(3-methylcyclopentadienyl)titanium
dichloride, ethylenebis(2-n-butylcyclopentadienyl)titanium
20 dichloride, ethylenebis(3-n-butylcyclopentadienyl)titanium
dichloride,
ethylenebis(2,3-dimethylcyclopentadienyl)titanium
dichloride,
ethylenebis(2,4-dimethylcyclopentadienyl)titanium
25 dichloride,
ethylenebis(2,5-dimethylcyclopentadienyl)titanium
dichloride,
ethylenebis(3,4-dimethylcyclopentadienyl)titanium
dichloride,
30 ethylenebis(2,3-ethylmethylcyclopentadienyl)titanium

ethylenebis(3,5-ethylmethylcyclopentadienyl)titanium
dichloride,
ethylenebis(2,3,4-trimethylcyclopentadienyl)titanium
dichloride,
10 ethylenebis(2,3,5-trimethylcyclopentadienyl)titanium
dichloride, ethylenebis(tetramethylcyclopentadienyl)
titanium dichloride, ethylenebis(indenyl)titanium dichloride,
ethylenebis(4,5,6,7-tetrahydroindenyl)titanium dichloride,
ethylenebis(2-phenylindenyl)titanium dichloride,
15 ethylenebis(fluorenyl)titanium dichloride,
ethylene(cyclopentadienyl)
(pentamethylcyclopentadienyl)titanium dichloride,
ethylene(cyclopentadienyl)(indenyl)titanium dichloride,
ethylene(methylcyclopentadienyl) (indenyl)titanium
20 dichloride,
ethylene(n-butylcyclopentadienyl)(indenyl)titanium
dichloride, ethylene(tetramethylcyclopentadienyl)
(indenyl)titanium dichloride,
ethylene(cyclopentadienyl)(fluorenyl)titanium dichloride,
25 ethylene(methylcyclopentadienyl) (fluorenyl)titanium
dichloride, ethylene
(pentamethylcyclopentadienyl)(fluorenyl)titanium
dichloride, ethylene(n-butylcyclopentadienyl)
(fluorenyl)titanium dichloride, ethylene
30 (tetramethylpentadienyl)(fluorenyl)titanium dichloride,

dichloride,
isopropylidenebis(2-n-butylcyclopentadienyl)titanium
dichloride,
isopropylidenebis(3-n-butylcyclopentadienyl)titanium
10 dichloride,
isopropylidenebis(2,3-dimethylcyclopentadienyl) titanium
dichloride,
isopropylidenebis(2,4-dimethylcyclopentadienyl) titanium
dichloride,
15 isopropylidenebis(2,5-dimethylcyclopentadienyl) titanium
dichloride,
isopropylidenebis(3,4-dimethylcyclopentadienyl) titanium
dichloride,
isopropylidenebis(2,3-ethylmethylcyclopentadienyl)
20 titanium dichloride,
isopropylidenebis(2,4-ethylmethylcyclopentadienyl)
titanium dichloride,
isopropylidenebis(2,5-ethylmethylcyclopentadienyl)
titanium dichloride,
25 isopropylidenebis(3,5-ethylmethylcyclopentadienyl)
titanium dichloride,
isopropylidenebis(2,3,4-trimethylcyclopentadienyl)
titanium dichloride,
isopropylidenebis(2,3,5-trimethylcyclopentadienyl)
30 titanium dichloride,

isopropylidene(cyclopentadienyl)
(tetramethylcyclopentadienyl)titanium dichloride,
isopropylidene(cyclopentadienyl)(indenyl)titanium
dichloride, isopropylidene(methylcyclopentadienyl)
10 (indenyl)titanium dichloride,
isopropylidene(n-butylcyclopentadienyl)(indenyl) titanium
dichloride, isopropylidene(tetramethylcyclopentadienyl)
(indenyl)titanium dichloride, isopropylidene
(cyclopentadienyl)(fluorenyl)titanium dichloride,
15 isopropylidene(methylcyclopentadienyl)(fluorenyl) titanium
dichloride,
isopropylidene(n-butylcyclopentadienyl)(fluorenyl)
titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)
20 (fluorenyl)titanium dichloride, isopropylidene
(indenyl)(fluorenyl)titanium dichloride,
cyclopentadienyl(dimethylamido)titanium dichloride,
cyclopentadienyl(phenoxy)titanium dichloride,
cyclopentadienyl(2,6-dimethylphenyl)titanium dichloride,
25 cyclopentadienyl(2,6-diisopropylphenyl)titanium dichloride,
cyclopentadienyl(2,6-di-tert-butylphenyl)titanium
dichloride,
pentamethylcyclopentadienyl(2,6-dimethylphenyl)titanium
dichloride,
30 pentamethylcyclopentadienyl(2,6-diisopropylphenyl)

(tert-butylamido)tetramethylcyclopentadienyl-1,2-ethanediyltitanium dichloride,
(methylamido)tetramethylcyclopentadienyl-1,2-ethanediyltitanium dichloride,
10 (ethylamido)tetramethylcyclopentadienyl-1,2-ethanediyltitanium dichloride,
(tert-butylamido)tetramethylcyclopentadienyl dimethylsilanetitanium dichloride, (benzylamido)tetramethylcyclopentadienyl
15 dimethylsilanetitanium dichloride,
(phenylphosphido)tetramethylcyclopentadienyl dimethylsilanetitanium dichloride,
(tert-butylamido)indenyl-1,2-ethanediyltitanium dichloride,
(tert-butylamido)tetrahydroindenyl-1,2-ethanediyl titanium
20 dichloride,
(tert-butylamido)fluorenyl-1,2-ethanediyltitanium dichloride, (tert-butylamido)indenyldimethylsilanetitanium dichloride,
(tert-butylamido)tetrahydroindenyldimethylsilane titanium
25 dichloride,
(tert-butylamido)fluorenyldimethylsilanetitanium dichloride,
(dimethylaminomethyl)tetramethylcyclopentadienyl titanium(III) dichloride,
30 (dimethylaminoethyl)tetramethylcyclopentadienyl

(B-dimethylaminoborabenzene)cyclopentadienylzirconium
dichloride,
cyclopentadienyl(9-mesitylboraanthracenyl)zirconium
dichloride,

10 2,2'-thiobis(4-methyl-6-tert-butylphenoxy)titanium
dichloride,
2,2'-thiobis[4-methyl-6-(1-methylethyl)phenoxy] titanium
dichloride, 2,2'-thiobis[4,6-dimethylphenoxy]titanium
dichloride,

15 2,2'-methylenebis(4-methyl-6-tert-butylphenoxy) titanium
dichloride,
2,2'-ethylenebis(4-methyl-6-tert-butylphenoxy) titanium
dichloride, 2,2'-sulfinylbis(4-methyl-6-tert-butylphenoxy)
titanium dichloride,

20 2,2'-(4,4',6,6'-tetra-tert-butyl-1,1'-biphenoxy) titanium
dichloride, (di-tert-butyl-1,3-propanediamido)titanium
dichloride, (dicyclohexyl-1,3-propanediamido)titanium
dichloride,
[bis(trimethylsilyl)-1,3-propanediamido]titanium

25 dichloride,
[bis(tert-butyltrimethylsilyl)-1,3-propanediamido]
titanium dichloride,
[bis(2,6-dimethylphenyl)-1,3-propanediamido]titanium
dichloride,

30 [bis(2,6-diisopropylphenyl)-1,3-propanediamido] titanium

[bis(trimethylsilyl)naphthalenediamido]titanium dichloride,
[bis(tert-butyl dimethylsilyl)naphthalenediamido] titanium
dichloride,

10 [bis(tert-butyl dimethylsilyl)naphthalenediamido]titanium
dibromide, cyclopentadienyltitanium trichloride,
pentamethylcyclopentadienyltitanium trichloride,
[hydrotris(3,5-dimethylpyrazolyl)borate]titanium
trichloride,
[hydrotris(3,5-diethylpyrazolyl)borate]titanium
15 trichloride,
[hydrotris(3,5-di-tert-butylpyrazolyl)borate] titanium
trichloride, [tris(3,5-dimethylpyrazolyl)methyl]titanium
trichloride, [tris(3,5-diethylpyrazolyl)methyl]titanium
trichloride and
20 [tris(3,5-di-tert-butylpyrazolyl)methyl]titanium
trichloride.

Still further examples of the metal compound represented
by the formula [4], wherein M^2 is a titanium atom, are compounds
in which "dichloride" in the above-mentioned compounds is
25 changed to "difluoride", "dibromide", "diiodide", "dimethyl",
"diethyl", "diisopropyl", "diphenyl", "dibenzyl",
"dimethoxide", "diethoxide", "di-n-propoxide",
"diisopropoxide", "di-n-butoxide", "diisobutoxide",
"di-tert-butoxide", "diphenoxide" or
30 "di(2,6-di-tert-butylphenoxide", and compounds in which

"tri-tert-butoxide", "triphenoxide" or
"tri(2,6-di-tert-butylphenoxide".

Examples of the metal compound represented by the formula
[4], wherein M^2 is a zirconium atom or a hafnium atom, are those
10 in which a "titanium atom" in the above-mentioned compounds
is changed to a "zirconium atom" or a "hafnium atom".

Examples of the metal compound represented by the formula
[4], wherein M^2 is a nickel atom, are
2,2'-methylenebis[(4R)-4-phenyl-5,5'-
15 dimethyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5'-
diethyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5'-
di-n-propyloxazoline]nickel dibromide,
20 2,2'-methylenebis[(4R)-4-phenyl-5,5'-
diisopropyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5'-
dicyclohexyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5'-
25 dimethoxyoxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5'-diethoxyoxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5'-diphenyloxazoline]
nickel dibromide,
30 methylenebis[(4R)-4-methyl-5,5'-di-(2-methylphenyl)

methylenebis[(4R)-4-methyl-5,5'-di-(2-methoxyphenyl)
oxazoline]nickel dibromide,
methylenebis[(4R)-4-methyl-5,5'-di-(3-methoxyphenyl)
oxazoline]nickel dibromide,
10 methylenebis[(4R)-4-methyl-5,5'-di-(4-methoxyphenyl)
oxazoline]nickel dibromide,
methylenebis[spiro{(4R)-4-methyloxazoline-5,1'-
cyclobutane}]nickel dibromide,
methylenebis[spiro{(4R)-4-methyloxazoline-5,1'-
15 cyclopentane}]nickel dibromide,
methylenebis[spiro{(4R)-4-methyloxazoline-5,1'-
cyclohexane}]nickel dibromide,
methylenebis[spiro{(4R)-4-methyloxazoline-5,1'-
cycloheptane}]nickel dibromide,
20 2,2'-methylenebis[(4R)-4-isopropyl-5,5-dimethyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-isopropyl-5,5-diethyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-n-
25 propyloxazoline]nickel dibromide,
methylenebis[(4R)-4-isopropyl-5,5-diisopropyloxazoline]
nickel dibromide, 2,2'-methylenebis[(4R)-4-isopropyl-5,5-
dicyclohexyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isopropyl-5,5-diphenyloxazoline]
30 nickel dibromide,

methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(2-methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(3-methoxyphenyl)oxazoline]nickel dibromide,
10 2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(4-methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-isopropylloxazoline-5,1'-cyclobutane}]nickel dibromide,
15 2,2'-methylenebis[spiro{(4R)-4-isopropylloxazoline-5,1'-cyclopentane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-isopropylloxazoline-5,1'-cyclohexane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-isopropylloxazoline-5,1'-cycloheptane}]nickel dibromide,
20 2,2'-methylenebis[(4R)-4-isobutyl-5,5-dimethyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-diethyloxazoline]nickel dibromide,
25 2,2'-methylenebis[(4R)-4-isobutyl-5,5-di-n-propylloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-diisopropylloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-dicyclohexylloxazoline]nickel dibromide,
30

oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-di-(4-methylphenyl)
oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-di-
10 (2-methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-di-
(3-methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-isobutyl-5,5-di-
(4-methoxyphenyl)oxazoline]nickel dibromide,
15 2,2'-methylenebis[spiro{(4R)-4-isobutyloxazoline-5,1'-
cyclobutane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-isobutyloxazoline-5,1'-
cyclopentane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-isobutyloxazoline-5,1'-
20 cyclohexane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-isobutyloxazoline-5,1'-
cycloheptane}]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-
dimethyloxazoline]nickel dibromide,
25 2,2'-methylenebis[(4R)-4-tert-butyl-5,5-diethyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-n-
propyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-
30 diisopropyloxazoline]nickel dibromide,

methyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(3-
methyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(4-
10 methyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(2-
methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(3-
methoxyphenyl)oxazoline]nickel dibromide,
15 2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(4-
methoxyphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-
cyclobutane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-
20 cyclopentane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-
cyclohexane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-
cycloheptane}]nickel dibromide,
25 2,2'-methylenebis[(4R)-4-phenyl-5,5-dimethyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-diethyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-di-n-propyloxazoline]
30 nickel dibromide,

2,2'-methylenebis[(4R)-4-phenyl-5,5-di-(2-methylphenyl)
oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-di-(3-methylphenyl)
oxazoline]nickel dibromide,
10 2,2'-methylenebis[(4R)-4-phenyl-5,5-di-(4-methylphenyl)
oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-di-(2-methoxyphenyl)
oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-di-(3-methoxyphenyl)
15 oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-di-(4-methoxyphenyl)
oxazoline]nickel dibromide,
methylenebis[spiro{(4R)-4-phenyloxazoline-5,1'-
cyclobutane}]nickel dibromide,
20 2,2'-methylenebis[spiro{(4R)-4-phenyloxazoline-5,1'-
cyclopentane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-phenyloxazoline-5,1'-
cyclohexane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-phenyloxazoline-5,1'-
25 cycloheptane}]nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-dimethyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-diethyloxazoline]
nickel dibromide,
30 2,2'-methylenebis[(4R)-4-benzyl-5,5-di-n-propyloxazoline]

nickel dibromide,

2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(2-methylphenyl)
oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(3-methylphenyl)

10 oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(4-methylphenyl)
oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(2-methoxyphenyl)
oxazoline]nickel dibromide,

15 2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(3-methoxyphenyl)
oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(4-methoxyphenyl)
oxazoline]nickel dibromide,

2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-
20 cyclobutane}]nickel dibromide,

2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-
cyclopentane}]nickel dibromide,

2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-
cyclohexane}]nickel dibromide, and

25 2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-
cycloheptane}]nickel dibromide; and antipodes and iastreomers

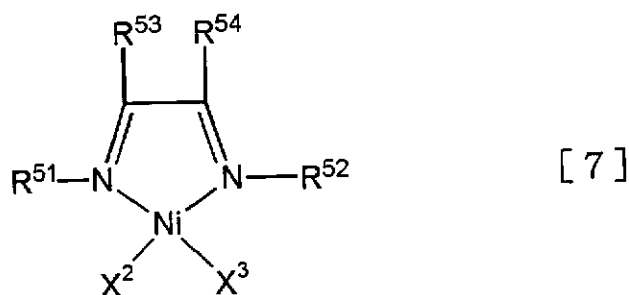
of the above-mentioned compounds. Further examples thereof
are [hydrotris(3,5-dimethylpyrazolyl)borate]nickel bromide,

[hydrotris(3,5-diethylpyrazolyl)borate]nickel bromide, and

30 [hydrotris(3,5-di-tert-butylpyrazolyl)borate]nickel

"diethyl", "diisopropyl", "diphenyl", "dibenzyl",
 "dimethoxide", "diethoxide", "di-n-propoxide",
 "diisopropoxide", "di-n-butoxide", "diisobutoxide",
 "di-tert-butoxide", "diphenoxide" or
 "di(2,6-di-tert-butylphenoxide)".

A further example of the metal compound represented by
 the formula [4], wherein M^2 is a nickel atom, is a compound
 represented by the following formula [7]:



wherein each of R^{51} and R^{52} is a 2,6-diisopropylphenyl group;
 each of R^{53} and R^{54} is independently of each other a hydrogen
 atom or a methyl group, or R^{53} and R^{54} are combined to form an
 acenaphtene group; and each of X^2 and X^3 is independently of
 each other a fluorine atom, a chlorine atom, a bromine atom,
 an iodine atom, a methyl group, an ethyl group, a n-propyl
 group, an isopropyl group, a n-butyl group, a phenyl group,
 a benzyl group, a methoxy group, an ethoxy group, a n-propoxy
 group, an isopropoxy group, a n-butoxy group, an isobutoxy
 or a phenoxy group.

[4], wherein M^2 is an iron atom, are

2,6-bis-[1-(2,6-dimethylphenylimino)ethyl]pyridineiron
dichloride, 2,6-bis-[1-(2,6-diisopropylphenylimino)ethyl]
pyridineiron dichloride,

10 2,6-bis-[1-(2-tert-butylphenylimino)ethyl]pyridineiron
dichloride, [hydrotris(3,5-dimethylpyrazolyl)borate]iron
chloride, [hydrotris(3,5-diethylpyrazolyl) borate]iron
chloride, and
[hydrotris(3,5-di-tert-butylpyrazolyl)borate]iron
15 chloride; and compounds in which "dichloride" in the
above-mentioned iron compounds is changed to "dibromide",
"difluoride", "diiodide", "dimethyl", "diethyl",
"diisopropyl", "diphenyl", "dibenzyl", "dimethoxide",
"diethoxide", "di-n-propoxide", "diisopropoxide",
20 "di-n-butoxide", "diisobutoxide", "di-tert-butoxide",
"diphenoxide" or "di(2,6-di-tert-butylphenoxide)".

Further examples of the metal compound represented by
the formula [4] are compounds obtained by changing an "iron
atom" in the above-mentioned iron compounds to a "cobalt atom"
25 or a "nickel atom".

Examples of the μ -oxo type metal compound of the metal
compound represented by the formula [4] are

μ -oxobis[isopropylidene

(cyclopentadienyl)(2-phenoxy)titanium chloride],

30 μ -oxobis[isopropylidene(cyclopentadienyl)(3-tert-butyl-5-

μ -oxobis[isopropylidene(tetramethylcyclopentadienyl)
(2-phenoxy)titanium chloride],

μ -oxobis[isopropylidene (tetramethylcyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide],

10 μ -oxobis [dimethylsilylene(cyclopentadienyl)
(2-phenoxy)titanium methoxide],

μ -oxobis[dimethylsilylene(cyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride],

μ -oxobis[dimethylsilylene(methylcyclopentadienyl)

15 (2-phenoxy)titanium chloride],

μ -oxobis[dimethylsilylene(methylcyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride],

μ -oxobis[dimethylsilylene(tetramethylcyclopentadienyl)
(2-phenoxy)titanium chloride], and

20 μ -oxobis[dimethylsilylene(tetramethylcyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride].

Further examples are compounds obtained by changing "chloride"
in these compounds to "fluoride", "bromide", "iodide", "methyl",
"ethyl", "isopropyl", "phenyl", "benzyl", "methoxide",
25 "ethoxide", "n-propoxide", "isopropoxide", "n-butoxide",
"isobutoxide", "tert-butoxide", "phenoxide" or
"2,6-di-tert-butylphenoxide".

Further examples of the μ -oxo type metal compound of
the metal compound represented by the formula [4] are

30 di- μ -oxobis[isopropylidene(cyclopentadienyl)

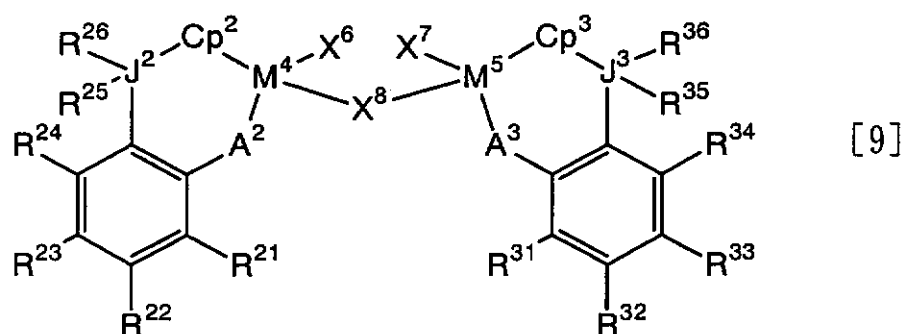
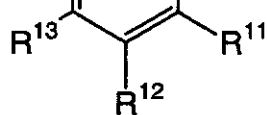
$\text{di-}\mu\text{-oxobis[isopropylidene(methylcyclopentadienyl)}$
 $(3\text{-tert-butyl-5-methyl-2-phenoxy})\text{titanium}]$,
 $\text{di-}\mu\text{-oxobis[isopropylidene}$
 $(\text{tetramethylcyclopentadienyl})(2\text{-phenoxy})\text{titanium}]$,
10 $\text{di-}\mu\text{-oxobis[isopropylidene}(\text{tetramethylcyclopentadienyl})$
 $(3\text{-tert-butyl-5-methyl-2-phenoxy})\text{titanium}]$,
 $\text{di-}\mu\text{-oxobis}[\text{dimethylsilylene(cyclopentadienyl)}$
 $(2\text{-phenoxy})\text{titanium}]$,
 $\text{di-}\mu\text{-oxobis[dimethylsilylene(cyclopentadienyl)}$
15 $(3\text{-tert-butyl-5-methyl-2-phenoxy})\text{titanium}]$,
 $\text{di-}\mu\text{-oxobis[dimethylsilylene(methylcyclopentadienyl)}$
 $(2\text{-phenoxy})\text{titanium}]$,
 $\text{di-}\mu\text{-oxobis[dimethylsilylene(methylcyclopentadienyl)}$
 $(3\text{-tert-butyl-5-methyl-2-phenoxy})\text{titanium}]$,
20 $\text{di-}\mu\text{-oxobis[dimethylsilylene(tetramethylcyclopentadienyl)}$
 $(2\text{-phenoxy})\text{titanium}]$ and
 $\text{di-}\mu\text{-oxobis[dimethylsilylene(tetramethylcyclopentadienyl)}$
 $(3\text{-tert-butyl-5-methyl-2-phenoxy})\text{titanium}]$.

Other examples of the compound (B), wherein the metal
25 atom is a nickel atom, are nickel chloride, nickel bromide,
 nickel iodide, nickel sulfate, nickel nitrate, nickel
 perchlorate, nickel acetate, nickel trifluoroacetate, nickel
 cyanide, nickel oxalate, nickel acetylacetonate, bis(allyl)
 nickel, bis(1,5-cyclooctadiene)nickel,
30 dichloro(1,5-cyclooctadiene) nickel,

tetrakis(triphenylphosphine)nickel, dichloro[1,2- bis
(diphenylphosphino)ethane]nickel,
bis[1,2-bis(diphenylphosphino)ethane]nickel,
dichloro[1,3-bis(diphenylphosphino)propane]nickel,
10 bis[1,3-bis(diphenylphosphino)propane]nickel, tetraamine
nickel nitrate, tetrakis(acetonitrile)nickel
tetrafluoroborate and nickel phthalocyanine.

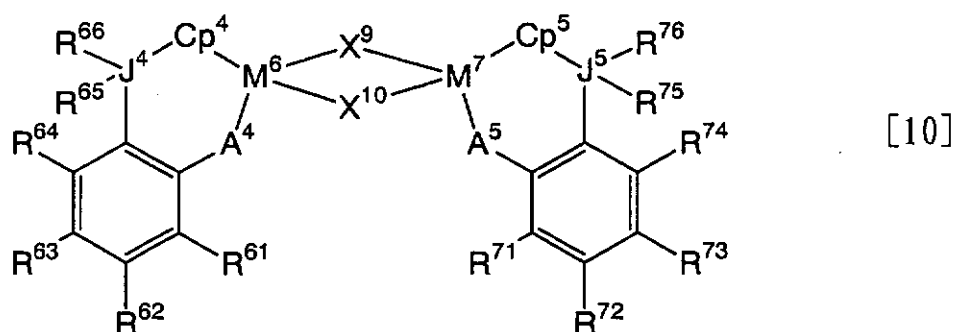
Examples of the compound (B), wherein the metal atom
is a vanadium atom, are vanadium acetylacetonate, vanadium
15 tetrachloride and vanadium oxy trichloride. An example thereof,
wherein the metal atom is a samarium atom, is
bis(pentamethylcyclopentadienyl)samarium
methyln tetrahydrofuran. An example thereof, wherein the metal
atom is an ytterbium atom, is
20 bis(pentamethylcyclopentadienyl)ytterbium
methyln tetrahydrofuran.

Examples of the compound (B) used in order to obtain
the catalyst in accordance with the present invention are those
represented by the following formulas [8] to [10]:



5

and



10 wherein respective M^3 to M^7 are independently an atom of the
 Group 4 of the periodic table of the elements; respective A^1
 to A^5 are independently an atom of the Group 16 of the periodic
 table of the elements; respective J^1 to J^5 are an atom of the
 Group 16 of the periodic table of the elements; respective
 15 Cp^1 to Cp^5 are a group having a cyclopentadienyl anion skeleton;

a single ring or a plurality of rings which may be aromatic ring(s) or non-aromatic ring(s); and respective X^8 to X^{10} are an atom of the Group 16 of the periodic table of the elements.

In the formulae [8] to [10], the metal represented by M^3 to M^7 are a metal atom of the Group 4 of the Periodic Table (IUPAC 1985), and for example, a titanium atom, a zirconium atom and a hafnium atom are exemplified. A titanium atom and a zirconium atom are preferred.

Examples of the group having a cyclopentadienyl type anion skeleton as Cp^1 to Cp^5 are

- an η^5 -(substituted)cyclopentadienyl group,
- an η^5 -(substituted)indenyl group, and
- an η^5 -(substituted)fluorenyl group. Specific examples thereof are an η^5 -cyclopentadienyl group,
- an η^5 -methylcyclopentadienyl group,
- an η^5 -dimethylcyclopentadienyl group,
- an η^5 -trimethylcyclopentadienyl group,
- an η^5 -tetramethylcyclopentadienyl group,
- an η^5 -ethylcyclopentadienyl group,
- an η^5 -n-propylcyclopentadienyl group,
- an η^5 -isopropylcyclopentadienyl group,
- an η^5 -n-butylcyclopentadienyl group,
- an η^5 -sec-butylcyclopentadienyl group,
- an η^5 -tert-butylcyclopentadienyl group.

an η^5 -isopropylindenyl group, an η^5 -n-butylindenyl group,
an η^5 -tert-butylindenyl group, an η^5 -phenylindenyl group,
an η^5 -methylphenylindenyl group, an η^5 -naphthylindenyl group,
an η^5 -trimethylsilylindenyl group, an η^5 -tetrahydroindenyl
10 group, an η^5 -fluorenyl group, an η^5 -methylfluorenyl group,
an η^5 -dimethylfluorenyl group, an η^5 -tert-butylfluorenyl
group, an η^5 -di-tert-butylfluorenyl group,
an η^5 -phenylfluorenyl group, an η^5 -diphenylfluorenyl group,
an η^5 -trimethylsilylfluorenyl group and
15 an η^5 -bistrimethylsilylfluorenyl group; preferably an η
 5 -cyclopentadienyl group, an η^5 -methylcyclopentadienyl group,
an η^5 -n-butylcyclopentadienyl group,
an η^5 -tert-butylcyclopentadienyl group,
an η^5 -tetramethylcyclopentadienyl group,
20 an η^5 -indenyl group, an η^5 -tetrahydroindenyl group and an η
 5 -fluorenyl group.

In X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66}
and R^{71} to R^{76} of the formulas [8] to [10], as a halogen atom,
a fluorine atom, a chlorine atom, a bromine atom and an iodine
25 atom are exemplified, and a chlorine atom or a bromine atom
is preferable, and a chlorine atom is more preferable.

In X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66}
and R^{71} to R^{76} of the formulas [8] to [10], as a hydrocarbon
group, an alkyl group, an aralkyl group and aryl group are
30 exemplified.

group and a n- eicosyl group are exemplified.

These alkyl groups may be substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

10 Examples of such an alkyl group substituted with the halogen atom are a fluoromethyl group, a trifluoromethyl group, a chloromethyl group, a trichloromethyl group, a fluoroethyl group, a pentafluoroethyl group, a perfluoropropyl group, a perfluorobutyl group, a perfluorohexyl group, a perfluorooctyl
15 group, perchloropropyl group, a per chlorobutyl group and perbromopropyl group.

 The alkyl group is preferably an alkyl group having 1 to 20 carbon atoms; and more preferably a methyl group, an ethyl group, an isopropyl group, a tert-butyl group, an isobutyl
20 group or a tert-pentyl group.

 Examples of the aralkyl group are a benzyl group, a (2-methylphenyl)methyl group, a (3-methylphenyl)methyl group, a (4-methylphenyl)methyl group, a (2,3-dimethylphenyl)methyl group, a (2,4-dimethylphenyl)methyl group, a
25 (2,5-dimethylphenyl)methyl group, a (2,6-dimethylphenyl)methyl group, a (3,4-dimethylphenyl)methyl group, a (3,5-dimethylphenyl)methyl group, a (2,3,4-timethylphenyl)methyl group, a
30 (2,3,5-timethylphenyl)methyl group, a

(2,3,5,6-tetramethylphenyl)methyl group, a
(pentamethylphenyl)methyl group, an (ethylphenyl)methyl
group, a (n-propylphenyl)methyl group, an
(isopropylphenyl)methyl group, a (n-butylphenyl)methyl group,
10 a (sec-butylphenyl)methyl group, a (tert-butylphenyl)methyl
group, a (n-pentylphenyl)methyl group, a
(neopentylphenyl)methyl group, a (n-hexylphenyl)methyl group,
a (n-octylphenyl)methyl group, a (n-decylphenyl)methyl group,
a (tetradecylphenyl)methyl group, a naphthylmethyl group and
15 an anthracenylmethyl group.

The aralkyl group is preferably an aralkyl group having
7 to 20 carbon atoms, and more preferably a benzyl group.

Examples of the aryl group are a phenyl group, a 2-tolyl
group, a 3-tolyl group, a 4-tolyl group, a 2,3-xylyl group,
20 a 2,4-xylyl group, a 2,5-xylyl group, a 2,6-xylyl group, a
3,4-xylyl group, a 3,5-xylyl group, a 2,3,4-trimethylphenyl
group, a 2,3,5-trimethylphenyl group, a 2,3,6-trimethylphenyl
group, a 2,4,6-trimethylphenyl group, a 3,4,5-trimethylphenyl
group, a 2,3,4,5-tetramethylphenyl group, a
25 2,3,4,6-tetramethylphenyl group, a 2,3,5,6-tetramethylphenyl
group, a pentamethylphenyl group, an ethylphenyl group, a
n-propylphenyl group, an isopropylphenyl group, a
n-butylphenyl group, a sec-butylphenyl group, a
tert-butylphenyl group, an isobutylphenyl group, a
30 n-pentylphenyl group, a neopentylphenyl group, a n-hexylphenyl

These alkyl, aralkyl and aryl groups above-mentioned as X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10], may be respectively substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; an aryloxy group such as a phenoxy group; or an aralkyloxy group such as a benzyloxy group.

Further, as X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10], the substituted silyl group means a silyl group substituted with a hydrocarbon group, and said hydrocarbon group may be substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; an aryloxy group such as a phenoxy group; or an aralkyloxy group such as benzyloxy group.

The hydrocarbon group is preferably an alkyl group having 1 to 20 carbon atoms such as a methyl group, an ethyl group, a n-propyl group, an isopropyl group, a n-butyl group, a sec-butyl group, a tert-butyl group, an isobutyl group, a n-pentyl group, a n-hexyl group and a cyclohexyl group, or an aryl group having 6 to 20 carbon atoms such as a phenyl group.

Examples of such a substituted silyl group are a mono-substituted silyl group having 1 to 20 carbon atoms such

triethylsilyl group, a tri-n-propylsilyl group, a triisopropylsilyl group, a tri-n-butylsilyl group, a tri-sec-butylsilyl group, a tri-tert-butylsilyl group, a tri-isobutylsilyl group, a tert-butyl-dimethylsilyl group, a tri-n-pentylsilyl group, a tri-n-hexylsilyl group, a tricyclohexylsilyl group and a triphenylsilyl group; and a trimethylsilyl group, a tert-butyl dimethylsilyl group or a triphenylsilyl group is preferable.

Examples of the hydrocarbonoxy group in as X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10] are an alkoxy group, an aralkyloxy group and an aryloxy group.

Examples of the alkoxy group are a methoxy group, an ethoxy group, a n-propoxy group, an isopropoxy group, a n-butoxy group, a sec-butoxy group, a tert-butoxy group, a n-pentoxy group, a neopentoxy group, a n-hexoxy group, a n-octoxy group, a n-dodecoxy group, a n-pentadecoxy group and a n-eicosoxy group. These alkoxy groups may be partially substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; an aryloxy group such as a phenoxy group; or an aralkyloxy group such as a benzyloxy group.

The alkoxy group in X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10] is

group, a (4-methylphenyl)methoxy group, a

(2,3-dimethylphenyl)methoxy group, a

(2,4-dimethylphenyl)methoxy group, a

(2,5-dimethylphenyl)methoxy group, a

10 (2,6-dimethylphenyl)methoxy group, a

(3,4-dimethylphenyl)methoxy group, a

(3,5-dimethylphenyl)methoxy group, a

(2,3,4-trimethylphenyl)methoxy group, a

(2,3,5-trimethylphenyl)methoxy group, a

15 (2,3,6-trimethylphenyl)methoxy group, a

(2,4,5-trimethylphenyl)methoxy group, a

(2,4,6-trimethylphenyl)methoxy group, a

(3,4,5-trimethylphenyl)methoxy group, a

(2,3,4,5-tetramethylphenyl)methoxy group, a

20 (2,3,4,6-tetramethylphenyl)methoxy group, a

(2,3,5,6-tetramethylphenyl)methoxy group, a

(pentamethylphenyl)methoxy group, an (ethylphenyl)methoxy group, a (n-propylphenyl)methoxy group, an

(isopropylphenyl)methoxy group, (n-butylphenyl)methoxy group,

25 a (sec-butylphenyl)methoxy group, a

(tert-butylphenyl)methoxy group, a (n-hexylphenyl)methoxy group, a (n-octylphenyl)methoxy group, a

(n-decylphenyl)methoxy group, a naphthylmethoxy group and an anthracenylmethoxy group.

30 These aralkyloxy groups may be substituted with a halogen

R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10] is preferably an aralkyloxy group having 7 to 20 carbon atoms, and more preferably a benzyloxy group.

Examples of the aryloxy group are a phenoxy group, a
10 2-methylphenoxy group, a 3-methylphenoxy group, a
4-methylphenoxy group, a 2,3-dimethylphenoxy group, a
2,4-dimethylphenoxy group, a 2,5-dimethylphenoxy group, a
2,6-dimethylphenoxy group, a 3,4-dimethylphenoxy group, a
3,5-dimethylphenoxy group, a 2-tert-butyl-3-methylphenoxy
15 group, a 2-tert-butyl-4-methylphenoxy group, a
2-tert-butyl-5-methylphenoxy group, a
2-tert-butyl-6-methylphenoxy group, a 2,3,4-trimethylphenoxy
group, a 2,3,5-trimethylphenoxy group, a
2,3,6-trimethylphenoxy group, a 2,4,5-trimethylphenoxy group,
20 a 2,4,6-trimethylphenoxy group, a
2-tert-butyl-3,4-dimethylphenoxy group, a
2-tert-butyl-3,5-dimethylphenoxy group, a
2-tert-butyl-3,6-dimethylphenoxy group, a
2,6-di-tert-butyl-3-methylphenoxy group, a
25 2-tert-butyl-4,5-dimethylphenoxy group, a
2,6-di-tert-butyl-4-methylphenoxy group, a
3,4,5-trimethylphenoxy group, a 2,3,4,5-tetramethylphenoxy
group, a 2-tert-butyl-3,4,5-trimethylphenoxy group, a
2,3,4,6-tetramethylphenoxy group, a
30 2-tert-butyl-3,4,6-trimethylphenoxy group, a

n-propylphenoxy group, an isopropylphenoxy group, a
n-butylphenoxy group, a sec-butylphenoxy group, a
tert-butylphenoxy group, a n-hexylphenoxy group, a
n-octylphenoxy group, a n-decylphenoxy group, a
10 n-tetradecylphenoxy group, a naphthoxy group and an
anthracenoxy group.

These aryloxy groups may be substituted with a halogen
atom such as a fluorine atom, a chlorine atom, a bromine atom
and an iodine atom; an alkoxy group such as a methoxy group
15 and an ethoxy group; an aryloxy group such as a phenoxy group;
or an aralkyloxy group such as a benzyloxy group.

The aryloxy group in X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31}
to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10] is
preferably an aryloxy group having 6 to 20 carbon atoms.

20 The di-substituted amino group in X^4 to X^7 , R^{11} to R^{16} ,
 R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas
[8] to [10] means an amino group substituted with two hydrocarbon
groups or silyl groups, and said hydrocarbon group and said
silyl group may be substituted with a halogen atom such as
25 a fluorine atom, a chlorine atom, a bromine atom and an iodine
atom; an alkoxy group such as a methoxy group and an ethoxy
group; an aryloxy group such as a phenoxy group; or an aralkyloxy
group such as a benzyloxy group.

Examples of the hydrocarbon group are an alkyl group
30 having 1 to 20 carbon atoms such as a methyl group, an ethyl

benzyl group. Examples of the silyl group are a trimethylsilyl group and a tert-butyldimethylsilyl group. Examples of such a di-substituted amino group are a dimethylamino group, a diethylamino group, a di-n-propylamino group, a diisopropylamino group, a di-n-butylamino group, a di-sec-butylamino group, a di-tert-butylamino group, a di-isobutylamino group, a tert-butylisopropylamino group, a di-n-hexylamino group, a di-n-octylamino group, a diphenylamino group, a bistrimethylsilylamino group and a bis-tert-butyldimethylsilylamino group; and a dimethylamino group, an diethylamino group, a diisopropylamino group, a di-tert-butylamino group or a bis-trimethylsilylamino group is preferred.

Examples of the hydrocarbon thio group in X^4 to X^7 , R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10] are an alkylthio group, an aralkylthio group and arylthio group.

Examples of the alkylthio group are a methylthio group, an ethylthio group, a n-propylthio group, an isopropylthio group, a n-butylthio group, a sec-butylthio group, a tert-butylthio group, a n-pentylthio group, a neopentylthio group, a n-hexylthio group, a n-octylthio group, a n-dodecylthio group, a n-pentadecylthio group and a n-eicosylthio group.

The alkylthio group is preferably an alkylthio group

(3-methylphenyl)methylthio group, a
(4-methylphenyl)methylthio group, a
(2,3-dimethylphenyl)methylthio group, a
(2,4-dimethylphenyl)methylthio group, a
10 (2,5-dimethylphenyl)methylthio group, a
(2,6-dimethylphenyl)methylthio group, a
(3,4-dimethylphenyl)methylthio group, a
(3,5-dimethylphenyl)methylthio group, a
(2,3,4-trimethylphenyl)methylthio group, a
15 (2,3,5-trimethylphenyl)methylthio group, a
(2,3,6-trimethylphenyl)methylthio group, a
(2,4,5-trimethylphenyl)methylthio group, a
(2,4,6-trimethylphenyl)methylthio group, a
(3,4,5-trimethylphenyl)methylthio group, a
20 (2,3,4,5-tetramethylphenyl)methylthio group, a
(2,3,4,6-tetramethylphenyl)methylthio group, a
(2,3,5,6-tetramethylphenyl)methylthio group, a
(pentamethylphenyl)methylthio group, an
(ethylphenyl)methylthio group, a (n-propylphenyl)methylthio
25 group, an (isopropylphenyl)methylthio group, a
(n-butylphenyl)methylthio group, a
(sec-butylphenyl)methylthio group, a
(tert-butylphenyl)methylthio group, a
(n-hexylphenyl)methylthio group, a (n-octylphenyl)methylthio
30 group, a (n-decylphenyl)methylthio group, a

a 2-methylphenylthio group, a 3-methylphenylthio group, a
4-methylphenylthio group, a 2,3-dimethylphenylthio group, a
2,4-dimethylphenylthio group, a 2,5-dimethylphenylthio group,
a 2,6-dimethylphenylthio group, a 3,4-dimethylphenylthio
10 group, a 3,5-dimethylphenylthio group, a
2-tert-butyl-3-methylphenylthio group, a
2-tert-butyl-4-methylphenylthio group, a
2-tert-butyl-5-methylphenylthio group, a
2-tert-butyl-6-methylphenylthio group, a
15 2,3,4-trimethylphenylthio group, a 2,3,5-trimethylphenylthio
group, a 2,3,6-trimethylphenylthio group, a
2,4,5-trimethylphenylthio group, a 2,4,6-trimethylphenylthio
group, a 2-tert-butyl-3,4-dimethylphenylthio group, a
2-tert-butyl-3,5-dimethylphenylthio group, a
20 2-tert-butyl-3,6-dimethylphenylthio group, a
2,6-di-tert-butyl-3-methylphenylthio group, a
2-tert-butyl-4,5-dimethylphenylthio group, a
2,6-di-tert-butyl-4-methylphenylthio group, a
3,4,5-trimethylphenylthio group, a
25 2,3,4,5-tetramethylphenylthio group, a
2,3,4,6-tetramethylphenylthio group, a
2-tert-butyl-3,4,6-trimethylphenylthio group, a
2,6-di-tert-butyl-3,4-dimethylphenylthio group, a
2,3,5,6-tetramethylphenylthio group, a
30 2-tert-butyl-3,5,6-trimethylphenylthio group, a

neopentylphenylthio group, a n-hexylphenylthio group, a n-octylphenylthio group, a n-decylphenylthio group, a n-tetradecylphenylthio group, a naphthylthio group and an anthracenylthio group.

10 The arylthio group is preferably an arylthio group having 6 to 20 carbon atoms.

 Further, these alkylthio, aralkylthio and arylthio groups above-mentioned may be respectively substituted with a halogen atom such as a fluorine atom, a chlorine atom, a
15 bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; an aryloxy group such as a phenoxy group; or an aralkyloxy group such as a benzyloxy group.

 Examples of the hydrocarbon seleno group in X^4 to X^7 ,
20 R^{11} to R^{16} , R^{21} to R^{26} , R^{31} to R^{36} , R^{61} to R^{66} and R^{71} to R^{76} of the formulas [8] to [10] are an alkylseleno group, an aralkylseleno group and an arylseleno group.

 Examples of the alkylseleno group are a methylseleno group, an ethylseleno group, a n-propylseleno group, an
25 isopropylseleno group, a n-butylseleno group, a sec-butylseleno group, a tert-butylseleno group, a n-pentylseleno group, a neopentylseleno group, a n-hexylseleno group, a n-octylseleno group, a n-dodecylseleno group, a n-pentadecylseleno group and a n-eicosylseleno group.

30 The alkylseleno group is preferably an alkylseleno group

(3-methylphenyl)methylseleno group, a
(4-methylphenyl)methylseleno group, a
(2,3-dimethylphenyl)methylseleno group, a
(2,4-dimethylphenyl)methylseleno group, a
10 (2,5-dimethylphenyl)methylseleno group, a
(2,6-dimethylphenyl)methylseleno group, a
(3,4-dimethylphenyl)methylseleno group, a
(3,5-dimethylphenyl)methylseleno group, a
(2,3,4-trimethylphenyl)methylseleno group, a
15 (2,3,5-trimethylphenyl)methylseleno group, a
(2,3,6-trimethylphenyl)methylseleno group, a
(2,4,5-trimethylphenyl)methylseleno group, a
(2,4,6-trimethylphenyl)methylseleno group, a
(3,4,5-trimethylphenyl)methylseleno group, a
20 (2,3,4,5-tetramethylphenyl)methylseleno group, a
(2,3,4,6-tetramethylphenyl)methylseleno group, a
(2,3,5,6-tetramethylphenyl)methylseleno group, a
(pentamethylphenyl)methylseleno group, an
(ethylphenyl)methylseleno group, a
25 (n-propylphenyl)methylseleno group, an
(isopropylphenyl)methylseleno group, a
(n-butylphenyl)methylseleno group, a
(sec-butylphenyl)methylseleno group, a
(tert-butylphenyl)methylseleno group, a
30 (n-hexylphenyl)methylseleno group, a

benzylseleno group.

Examples of the arylseleno group are a phenylseleno group,
a 2-methylphenylseleno group, a 3-methylphenylseleno group,
a 4-methylphenylseleno group, a 2,3-dimethylphenylseleno
10 group, a 2,4-dimethylphenylseleno group, a
2,5-dimethylphenylseleno group, a 2,6-dimethylphenylseleno
group, a 3,4-dimethylphenylseleno group, a
3,5-dimethylphenylseleno group, a
2-tert-butyl-3-methylphenylseleno group, a
15 2-tert-butyl-4-methylphenylseleno group, a
2-tert-butyl-5-methylphenylseleno group, a
2-tert-butyl-6-methylphenylseleno group, a
2,3,4-trimethylphenylseleno group, a
2,3,5-trimethylphenylseleno group, a
20 2,3,6-trimethylphenylseleno group, a
2,4,5-trimethylphenylseleno group, a
2,4,6-trimethylphenylseleno group, a
2-tert-butyl-3,4-dimethylphenylseleno group, a
2-tert-butyl-3,5-dimethylphenylseleno group, a
25 2-tert-butyl-3,6-dimethylphenylseleno group, a
2,6-di-tert-butyl-3-methylphenylseleno group, a
2-tert-butyl-4,5-dimethylphenylseleno group, a
2,6-di-tert-butyl-4-methylphenylseleno group, a
3,4,5-trimethylphenylseleno group, a
30 2,3,4,5-tetramethylphenylseleno group, a

2,6-di-tert-butyl-3,5-dimethylphenylseleno group, a pentamethylphenylseleno group, an ethylphenylseleno group, a n-propylphenylseleno group, an isopropylphenylseleno group, a n-butylphenylseleno group, a sec-butylphenylseleno group, a tert-butylphenylseleno group, a n-pentylphenylseleno group, a neopentylphenylseleno group, a n-hexylphenylseleno group, a n-octylphenylseleno group, a n-decylphenylseleno group, a n-tetradecylphenylseleno group, a naphthylseleno group and an anthracenylseleno group.

The arylseleno group is preferably an alkylseleno group having 6 to 20 carbon atoms.

These alkylseleno, aralkylseleno and arylseleno groups above-mentioned may be respectively substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; an aryloxy group such as a phenoxy group; or an aralkyloxy group such as a benzyloxy group.

X^4 to X^7 in the formulas [8] to [10] are preferably independently a halogen atom, an alkyl group, an aralkyl group, an alkoxy group, an aryloxy group or a di-substituted amino group, and more preferably a halogen atom, an alkyl group, an alkoxy group or an aryloxy group.

Further, R^{11} to R^{14} , R^{21} to R^{24} , R^{31} to R^{34} , R^{61} to R^{64} and R^{71} to R^{74} in the formula [8] to [10] are preferably independently a hydrogen atom, a halogen atom, an alkyl group, an aralkyl

Furthermore, R^{15} , R^{16} , R^{25} , R^{26} , R^{35} , R^{36} , R^{65} , R^{66} , R^{75} and R^{76} are preferably independently a hydrogen atom, an alkyl group, an aralkyl group, an aryl group, a substituted silyl group, an alkoxy group, an aralkyloxy group or an aryloxy group.

10 Moreover, X^8 to X^{10} in the formulas [9] and [10] are an atom of the Group 16 of the periodic table of the elements such as an oxygen atom, a sulfur atom and a selenium atom, and are preferably an oxygen atom or a sulfur atom, and more preferably an oxygen atom.

15 Furthermore, A^1 to A^5 in the formulas [8] to [10] are an atom of the Group 16 of the periodic table of the elements such as an oxygen atom, a sulfur atom and a selenium atom, and are preferably an oxygen atom.

20 Moreover, J^1 to J^5 in the formulas [8] to [10] are an atom of the Group 14 of the periodic table of the elements such as a carbon atom, a silicon atom and a germanium atom, and are preferably a carbon atom or a silicon atom.

Examples of the metal compound represented by the formula [8] are methylene(η^5 -cyclopentadienyl)
25 (3,5-dimethyl-2-phenoxy)titanium dichloride (herein-after, " η^5 -" is sometimes omitted),
methylene(cyclopentadienyl)(3-tert-butyl-2-phenoxy)
titanium dichloride,
methylene(cyclopentadienyl)(3-tert-butyl-5-methyl-2-
30 phenoxy)titanium dichloride,

phenoxy)titanium dichloride,
methylene(cyclopentadienyl)(3-tert-butyl-5-methoxy-2-
phenoxy)titanium dichloride,
methylene(cyclopentadienyl)(3-tert-butyl-5-chloro-2-
10 phenoxy)titanium dichloride,
methylene(tetramethylcyclopentadienyl)(3,5-dimethyl-2-
phenoxy)titanium dichloride,
methylene(tetramethylcyclopentadienyl)(3-tert-butyl-2-
phenoxy)titanium dichloride,
15 methylene(tetramethylcyclopentadienyl)(3-tert-butyl-5-
methyl-2-phenoxy)titanium dichloride,
methylene(tetramethylcyclopentadienyl)(3-phenyl-2-
phenoxy)titanium dichloride,
methylene(tetramethylcyclopentadienyl)(3-tert-butyl
20 dimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
methylene(tetramethylcyclopentadienyl)
(3-trimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
methylene(tetramethylcyclopentadienyl)
(3-tert-butyl-5-methoxy-2-phenoxy)titanium dichloride,
25 methylene(tetramethylcyclopentadienyl)
(3-tert-butyl-5-chloro-2-phenoxy)titanium dichloride,
isopropylidene(cyclopentadienyl)(3,5-dimethyl-2-phenoxy)
titanium dichloride,
isopropylidene(cyclopentadienyl)(3-tert-butyl-2-phenoxy)
30 titanium dichloride,

silyl-5-methyl-2-phenoxy)titanium dichloride,
isopropylidene(cyclopentadienyl)(3-trimethylsilyl-5-
methyl-2-phenoxy)titanium dichloride,
isopropylidene(cyclopentadienyl)(3-tert-butyl-5-methoxy-
10 2-phenoxy)titanium dichloride,
isopropylidene(cyclopentadienyl)(3-tert-butyl-5-chloro-2-
phenoxy)titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)(3,5-dimethyl-
2-phenoxy)titanium dichloride,
15 isopropylidene(tetramethylcyclopentadienyl)(3-tert-butyl-
2-phenoxy)titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)(3-tert-butyl-
5-methyl-2-phenoxy)titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)(3-phenyl-2-
20 phenoxy)titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)(3-tert-butyl
dimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)
(3-trimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
25 isopropylidene(tetramethylcyclopentadienyl)(3-tert-butyl-
5-methoxy-2-phenoxy)titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)(3-tert-butyl-
5-chloro-2-phenoxy)titanium dichloride,
diphenylmethylenecyclopentadienyl)(3,5-dimethyl-2-
30 phenoxy)titanium dichloride,

titanium dichloride,
diphenylmethylene(cyclopentadienyl)(3-tert-butyl-5-methoxy-2-phenoxy)titanium dichloride,
diphenylmethylene(cyclopentadienyl)(3-trimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
10 diphenylmethylene(cyclopentadienyl)(3-tert-butyl-5-methoxy-2-phenoxy)titanium dichloride,
diphenylmethylene(cyclopentadienyl)(3-tert-butyl-5-chloro-2-phenoxy)titanium dichloride,
15 diphenylmethylene(tetramethylcyclopentadienyl)(3,5-dimethyl-2-phenoxy)titanium dichloride,
diphenylmethylene(tetramethylcyclopentadienyl)(3-tert-butyl-2-phenoxy)titanium dichloride,
diphenylmethylene(tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium dichloride,
20 diphenylmethylene(tetramethylcyclopentadienyl)(3-phenyl-2-phenoxy)titanium dichloride,
diphenylmethylene(tetramethylcyclopentadienyl)(3-tert-butyl-5-methoxy-2-phenoxy)titanium dichloride,
25 diphenylmethylene(tetramethylcyclopentadienyl)(3-trimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
diphenylmethylene(tetramethylcyclopentadienyl)(3-tert-butyl-5-methoxy-2-phenoxy)titanium dichloride, and
diphenylmethylene(tetramethylcyclopentadienyl)(3-tert-butyl-5-chloro-2-phenoxy)titanium dichloride; and compounds
30

"(η^5 -tert-butylcyclopentadienyl)",
"(η^5 -trimethylsilylcyclopentadienyl)",
"(η^5 -tert-butyl dimethylsilylcyclopentadienyl)",
"(η^5 -indenyl)", "(η^5 -phenylindenyl)" or "(η^5 -fluorenyl)".

10 Further, compounds in which "dichloride" in the
above-mentioned compounds is replaced with "dimethyl",
"dibenzyl", "dimethoxide", "diphenoxide",
"bis(dimethylamino)" or "bis(diethylamino)" are also
exemplified.

15 Moreover, examples of the metal compound represented
by the formula [8] are dimethylsilylene (η^5 -cyclopentadienyl)
(2-phenoxy)titanium dichloride, dimethylsilylene
(η^5 -cyclopentadienyl)(3-methyl-2-phenoxy)titanium
dichloride, dimethylsilylene(η^5 -cyclopentadienyl)
20 (3,5-dimethyl-2-phenoxy)titanium dichloride,
dimethylsilylene(η^5 -cyclopentadienyl)
(3-tert-butyl-2-phenoxy)titanium dichloride,
dimethylsilylene(η^5 -cyclopentadienyl)(3-tert-butyl-5-
methyl-2-phenoxy)titanium dichloride, dimethylsilylene
25 (η^5 -cyclopentadienyl)(3,5-di-tert-butyl-2-phenoxy)
titanium dichloride, dimethylsilylene(η^5 -cyclopentadienyl)
(5-methyl-3-phenyl-2-phenoxy)titanium dichloride,
dimethylsilylene(η^5 -cyclopentadienyl)(3-tert-
butyldimethylsilyl-5-methyl-2-phenoxy)titanium dichloride,
30 dimethylsilylene(η^5 -cyclopentadienyl)(5-methyl-3-

- (3,5-diamyl-2-phenoxy)titanium dichloride, dimethylsilylene
 (η^5 -cyclopentadienyl)(1-naphtoxy-2-yl)titanium dichloride,
 dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(2-
 phenoxy)titanium dichloride, dimethylsilylene
- 10 (η^5 -tetramethylcyclopentadienyl)(3-methyl-2-phenoxy)
 titanium dichloride, dimethylsilylene
 (η^5 -tetramethylcyclopentadienyl)(3,5-dimethyl-2-phenoxy)
 titanium dichloride, dimethylsilylene
 (η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-2-phenoxy)
- 15 titanium dichloride, dimethylsilylene
 (η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-
 phenoxy)titanium dichloride, dimethylsilylene
 (η^5 -tetramethylcyclopentadienyl)(3,5-di-tert-butyl-2-
 phenoxy)titanium dichloride, dimethylsilylene
- 20 (η^5 -tetramethylcyclopentadienyl)(5-methyl-3-phenyl-2-
 phenoxy)titanium dichloride, dimethylsilylene
 (η -tetramethylcyclopentadienyl)(3-tert-butyl dimethylsilyl
 -5-methyl-2-phenoxy)titanium dichloride, dimethylsilylene
 (η -tetramethylcyclopentadienyl)(5-methyl-3-trimethylsilyl
 -2-phenoxy)titanium dichloride, dimethylsilylene
- 25 (η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methoxy
 -2-phenoxy)titanium dichloride, dimethylsilylene
 (η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-chloro-2-
 phenoxy)titanium dichloride, dimethylsilylene
- 30 (η^5 -tetramethylcyclopentadienyl)(3,5-diamyl-2-phenoxy)

"(η^5 -dimethylcyclopentadienyl)",
 "(η^5 -trimethylcyclopentadienyl)",
 "(η^5 -n-butylcyclopentadienyl)",
 "(η^5 -tert-butylcyclopentadienyl)",
 10 "(η^5 -trimethylsilylcyclopentadienyl)",
 "(η^5 -tert-butyldimethylsilylcyclopentadienyl)",
 "(η^5 -indenyl)", "(η^5 -phenylindenyl)" or "(η^5 -fluorenyl)";
 compounds in which "(2-phenoxy)" in the above-mentioned
 compounds is replaced with with "3-phenyl-2-phenoxy",
 15 "3-trimethylsilyl-2-phenoxy" or
 "3-tert-butyldimethylsilyl-2-phenoxy"; and compounds in
 which "dimethylsilylene" in the above-mentioned compounds is
 replaced with "diethylsilylene", "diphenylsilylene" or
 "dimethoxysilylene". Further, compounds in which "dichloride"
 20 in the above-mentioned compounds is replaced with "dimethyl",
 "dibenzyl", "dimethoxide", "diphenoxide",
 "bis(dimethylamino)" or "bis(diethylamino)" are also
 exemplified. Furthermore, compounds in which "titanium" in
 the above-mentioned compounds is replaced with "zirconium"
 25 or "hafnium" are exemplified.

Moreover, in the metal compound represented by the
 formula [9], specific examples of the μ -oxo type compound are
 μ -oxobis(isopropylidene(cyclopentadienyl)
 (2-phenoxy)titanium chloride},
 30 μ -oxobis(isopropylidene(cyclopentadienyl)(2-phenoxy)

(methylcyclopentadienyl)(2-phenoxy)titanium chloride},
 μ -oxobis{isopropylidene (methylcyclopentadienyl)
(2-phenoxy)titanium methoxide}, μ -oxobis{isopropylidene
(methylcyclopentadienyl) (3-tert-butyl-5-methyl-2-
10 phenoxy)titanium chloride}, μ -oxobis{isopropylidene
(methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)
titanium methoxide}, μ -oxobis{isopropylidene
(tetramethylcyclopentadienyl) (2-phenoxy)titanium chloride},
 μ -oxobis{isopropylidene(tetramethylcyclopentadienyl)(2-
15 phenoxy)titanium methoxide}, μ -oxobis{isopropylidene
(tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-
phenoxy)titanium chloride}, and μ -oxobis{isopropylidene
(tetramethylcyclopentadienyl) (3-tert-butyl-5-methyl-2-
phenoxy)titanium methoxide}; and compounds in which " η
20 ⁵-cyclopentadienyl)" in the above-mentioned compounds is
replaced with " $(\eta^5$ -dimethylcyclopentadienyl)",
" $(\eta^5$ -trimethylcyclopentadienyl)",
" $(\eta^5$ -n-butylcyclopentadienyl)",
" $(\eta^5$ -tert-butylcyclopentadienyl)",
25 " $(\eta^5$ -trimethylsilylcyclopentadienyl)",
" $(\eta^5$ -tert-butyl dimethylsilylcyclopentadienyl)",
" $(\eta^5$ -indenyl)", " $(\eta^5$ -methylindenyl)" or " $(\eta^5$ -fluorenyl)".
Further, compounds in which "(2-phenoxy)" in the
above-mentioned compounds is replaced with " (3-methyl-2-
30 phenoxy)", "(3,5-dimethyl-2-phenoxy)", "(3,5-di-tert-butyl

in which "titanium" in the above-mentioned compounds is replaced with "zirconium" or "hafnium" are exemplified.

Moreover, in the metal compound represented by the formula [10], specific examples of the μ -oxo type compound

are di- μ -oxobis[isopropylidene

(cyclopentadienyl) (2-phenoxy)titanium], di- μ -oxobis

[isopropylidene(cyclopentadienyl)(3-tert-butyl-5-methyl-2

-phenoxy)titanium], di- μ -oxobis[isopropylidene

(methylcyclopentadienyl)(2-phenoxy)titanium], di- μ -oxobis

[isopropylidene(methylcyclopentadienyl)(3-tert-butyl-5-

methyl-2-phenoxy)titanium], di- μ -oxobis[isopropylidene

(tetramethylcyclopentadienyl)(2-phenoxy)titanium], di- μ

-oxobis[isopropylidene (tetramethylcyclopentadienyl)

(3-tert-butyl-5-methyl-2-phenoxy)titanium], di- μ -oxobis

[dimethylsilylene(cyclopentadienyl)(2-phenoxy)titanium],

di- μ -oxobis[dimethylsilylene(cyclopentadienyl) (3-tert-

butyl-5-methyl-2-phenoxy)titanium], di- μ -oxobis

[dimethylsilylene(methylcyclopentadienyl)(2-phenoxy)

titanium], di- μ -oxobis[dimethylsilylene

(methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)

titanium], di- μ -oxobis[dimethylsilylene

(tetramethylcyclopentadienyl)(2-phenoxy)titanium], and di-

μ -oxobis[dimethylsilylene(tetramethylcyclopentadienyl)(3-

tert-butyl-5-methyl-2-phenoxy)titanium]; and compounds in

which "(η^5 -cyclopentadienyl)" in the above-mentioned compounds

"(η^5 -tert-butyldimethylsilylcyclopentadienyl)",
"(η^5 -indenyl)", "(η^5 -methylindenyl)" or "(η^5 -fluorenyl)".
Further, compounds in which "(2-phenoxy) in the above-mentioned
compounds is replaced with "(3-methyl-2-phenoxy)",

10 "(3,5-dimethyl-2-phenoxy)",
"(3,5-di-tert-butyl-2-phenoxy)",
"(3-phenyl-5-methyl-2-phenoxy)" or
"(3-trimethylsilyl-5-methyl-2-phenoxy)". Furthermore,
compounds in which "titanium" in the above-mentioned compounds
15 is replaced with "zirconium" or "hafnium" are exemplified.

The above-mentioned metal compounds as the compound (B)
may be used singly, or may be used in combination of two or
more thereof.

The compound (B) is preferably a metal compound
20 represented by the formula [4], more preferably a metal compound
in which M^2 in the formula [4] is the Group 4 atom in the periodic
table, and further preferably a metal compound, which contains
at least one group having a cyclopentadienyl type anion skeleton
as L^2 in the formula [4].

25 As the organoaluminum compound (C) used for the catalyst
for addition polymerization according to the present invention,
known organoaluminum compounds can be used. Preferred is an
organoaluminum compound represented by the following formula
[11]:

hydrocarbonoxy group, and when two or more Y's exist, they may be the same or different.

R^6 in the formula [11] is preferably a hydrocarbon group having 1 to 24 carbon atoms, and more preferably an alkyl group having 1 to 24 carbon atoms. Examples thereof are a methyl group, an ethyl group, a n-propyl group, a n-butyl group, an isobutyl group, a n-hexyl group, a 2-methylhexyl group and a n-octyl group. More preferred is an ethyl group, a n-butyl group, an isobutyl group, a n-hexyl group or a n-octyl group.

Examples of the halogen atom as Y in the formula [11] are a fluorine atom, a chlorine atom, a bromine atom and an iodine atom, and preferred is a chlorine atom.

The hydrocarbonoxy group as Y in the formula [11] is preferably an alkoxy group, an aralkyloxy group or an aryloxy group.

Examples of the alkoxy group as Y in the formula [11] are a methoxy group, an ethoxy group, a n-propoxy group, an isopropoxy group, a n-butoxy group, a sec-butoxy group, a tert-butoxy group, a n-pentoxy group, a neopentoxy group, a n-hexoxy group, a n-octoxy group, a n-dodecoxy group, a n-pentadecoxy group and a n-icosoxy group.

Each of those alkoxy groups may be substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; or an aryloxy group such as a phenoxy

are a phenoxy group, a 2-methylphenoxy group, a 3-methylphenoxy group, a 4-methylphenoxy group, a 2,3-dimethylphenoxy group, a 2,4-dimethylphenoxy group, a 2,5-dimethylphenoxy group, a 2,6-dimethylphenoxy group, a 3,4-dimethylphenoxy group, a 3,5-dimethylphenoxy group, a 2,3,4-trimethylphenoxy group, a 2,3,5-trimethylphenoxy group, a 2,3,6-trimethylphenoxy group, a 2,4,5-trimethylphenoxy group, a 2,4,6-trimethylphenoxy group, a 3,4,5-trimethylphenoxy group, a 2,3,4,5-tetramethylphenoxy group, a 2,3,4,6-tetramethylphenoxy group, 2,3,5,6-tetramethylphenoxy group, a pentamethylphenoxy group, an ethylphenoxy group, a n-propylphenoxy group, an isopropylphenoxy group, a n-butylphenoxy group, a sec-butylphenoxy group, a tert-butylphenoxy group, a n-hexylphenoxy group, a n-octylphenoxy group, a n-decylphenoxy group, a n-tetradecylphenoxy group, a naphthoxy group and an anthrathenoxy group.

Each of those aryloxy groups may be substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; an alkoxy group such as a methoxy group and an ethoxy group; or an aryloxy group such as a phenoxy group.

The aryloxy group as Y in the formula [11] is preferably an aryloxy group having 6 to 24 carbon atoms.

Examples of the aralkyloxy group as Y in the formula

(2,6-dimethylphenyl)methoxy group, a
(3,4-dimethylphenyl)methoxy group, a
(3,5-dimethylphenyl)methoxy group, a
(2,3,4-trimethylphenyl)methoxy group, a
10 (2,3,5-trimethylphenyl)methoxy group, a
(2,3,6-trimethylphenyl)methoxy group, a
(2,4,5-trimethylphenyl)methoxy group, a
(2,4,6-trimethylphenyl)methoxy group, a
(3,4,5-trimethylphenyl)methoxy group, a
15 (2,3,4,5-tetramethylphenyl)methoxy group, a
(2,3,4,6-tetramethylphenyl)methoxy group, a
(2,3,5,6-tetramethylphenyl)methoxy group, a
(pentamethylphenyl)methoxy group, an (ethylphenyl)methoxy
group, a (n-propylphenyl)methoxy group, an
20 (isopropylphenyl)methoxy group, a (n-butylphenyl)methoxy
group, a (sec-butylphenyl)methoxy group, a
(tert-butylphenyl)methoxy group, a (n-hexylphenyl)methoxy
group, a (n-octylphenyl)methoxy group, a
(n-decylphenyl)methoxy group, a
25 (n-tetradecylphenyl)methoxy group, a naphthylmethoxy group
and an anthrathenylmethoxy group.

Each of those aralkyloxy groups may be substituted with
a halogen atom such as a fluorine atom, a chlorine atom, a
bromine atom and an iodine atom; an alkoxy group such as a
30 methoxy group and an ethoxy group; or an aryloxy group such

the formula [11] are a trialkylaluminum such as trimethylaluminum, triethylaluminum, tri-n-propylaluminum, tri-n-butylaluminum, triisobutylaluminum, tri-n-hexylaluminum and tri-n-octylaluminum; a

10 dialkylaluminum chloride such as dimethylaluminum chloride, diethylaluminum chloride, di-n-propylaluminum chloride, di-n-butylaluminum chloride, diisobutylaluminum chloride and di-n-hexylaluminum chloride; an alkylaluminum dichloride such as methylaluminum dichloride, ethylaluminum dichloride,

15 n-propylaluminum dichloride, n-butylaluminum dichloride, isobutylaluminum dichloride and n-hexylaluminum dichloride; a dialkylaluminum hydride such as dimethylaluminum hydride, diethylaluminum hydride, di-n-propylaluminum hydride, di-n-butylaluminum hydride, diisobutylaluminum hydride and

20 di-n-hexylaluminum hydride; an alkyl(dialkoxy)aluminum such as methyl(dimethoxy)aluminum, methyl(diethoxy)aluminum and methyl(di-tert-butoxy)aluminum; a dialkyl(alkoxy)aluminum such as dimethyl(methoxy)aluminum, dimethyl(ethoxy)aluminum and dimethyl(tert-butoxy)aluminum; an

25 alkyl(diaryloxy)aluminum such as methyl(diphenoxy)aluminum, methylbis(2,6-diisopropylphenoxy)aluminum and methylbis(2,6-diphenylphenoxy)aluminum; and a dialkyl(aryloxy)aluminum such as dimethyl(phenoxy)aluminum, dimethyl(2,6-diisopropylphenoxy)aluminum and

30 dimethyl(2,6-diphenylphenoxy)aluminum.

These organoaluminum compounds may be used alone, or in combination of two or more thereof.

The ratio (molar ratio) of the amount of the respective catalyst components used in the present invention is not particularly limited. The molar ratio of the component (A) to the component (B) is usually in a range of (A) : (B) = from 1 : 1 to 10000 : 1, preferably from 1 : 1 to 5000 : 1, and further preferably from 1 : 1 to 1000 : 1. The amount of the component (C) is usually in a range of (B) : (C) = from 0.1 : 1 to 1 : 10000, and preferably from 1 : 1 to 1 : 1000.

As the catalyst for addition polymerization of the present invention, a reaction product obtained by preliminarily contacting the component (A) and the component (B), optionally, further the component (C) may be also used, and they may be also used by being separately charged in a polymerization vessel. The arbitrary two components among them may be also previously contacted, and further, another component may be also contacted.

Examples of the addition polymerizable monomer in the present invention are an olefin, a diolefin, a cyclic olefin, an alkenyl aromatic hydrocarbon and a polar monomer, each of which has 2 to 100 carbon atoms. A combination of two or more thereof may be used.

Examples thereof are an olefin such as ethylene, propylene, 1-butene, 1-pentene, 4-methyl-1-pentene-1,

5-ethylidene-2-norbornene, dicyclopentadiene,
5-vinyl-2-norbornene, 5-methyl-2-norbornene, norbornadiene,
5-methylene-2-norbornene, 1,5-cyclooctadiene,
5,8-endomethylenehexahydronaphthalene, 1,3-butadiene,
10 isoprene, 1,3-hexadiene, 1,3-octadiene, 1,3-cyclooctadiene
and 1,3-cyclohexadiene; a cyclic olefin such as norbornene,
5-methylnorbornene, 5-ethylnorbornene, 5-butylnorbornene,
5-phenylnorbornene, 5-benzylnorbornene, tetracyclododecene,
tricyclodecene, tricycloundecene, pentacyclopentadecene,
15 pentacyclohexadecene, 8-methyltetracyclododecene,
8-ethyltetracyclododecene, 5-acetylnorbornene,
5-acetyloxynorbornene, 5-methoxycarbonylnorbornene,
5-ethoxycarbonylnorbornene,
5-methyl-5-methoxycarbonylnorbornene, 5-cyanonorbornene,
20 8-methoxycarbonyltetracyclododecene,
8-methyl-8-tetracyclododecene and
8-cyanotetracyclododecene; an alkenyl aromatic hydrocarbon
such as an alkenylbenzene (e.g. styrene, 2-phenylpropylene,
2-phenylbutene and 3-phenylpropylene), an alkylstyrene (e.g.
25 p-methylstyrene, m-methylstyrene, o-methylstyrene,
p-ethylstyrene, m-ethylstyrene, o-ethylstyrene,
2,4-dimethylstyrene, 2,5-dimethylstyrene,
3,4-dimethylstyrene, 3,5-dimethylstyrene,
3-methyl-5-ethylstyrene, p-tert-butylstyrene and
30 p-sec-butylstyrene), a bis(alkenyl)benzene (e.g.

acid), and metal salts thereof (e.g. salts of sodium, potassium, lithium, zinc, magnesium and calcium), an α, β -unsaturated carboxylic acid ester (e.g. methyl acrylate, ethyl acrylate, n-propyl acrylate, isopropyl acrylate, tert-butyl acrylate, 2-ethylhexyl acrylate, methyl methacrylate, ethyl methacrylate, n-propyl methacrylate, isopropyl methacrylate, n-butyl methacrylate and isobutyl methacrylate), an unsaturated dicarboxylic acid (e.g. maleic acid and itaconic acid), a vinyl ester (e.g. vinyl acetate, vinyl propionate, vinyl capronate, vinyl caprate, vinyl laurate, vinyl stearate and vinyl trifluoroacetate), an unsaturated carboxylic acid glycidylate (e.g. acrylic acid glycidylate, methacrylic acid glycidylate and itaconic acid monoglycidylate), and a cyclic ether (e.g. ethylene oxide, propylene oxide, 1-hexene oxide, cyclohexene oxide, styrene oxide and tetrahydrofuran).

The catalyst for addition polymerization of the present invention can be applied to homopolymerization or copolymerization of these monomers. Examples of a combination of monomers constituting the copolymer are ethylene and propylene; ethylene and 1-butene; ethylene and 1-hexene; and propylene and 1-butene.

The catalyst for olefin polymerization according to the present invention is particularly preferable as a catalyst for olefin polymerization, and is preferably used for a process for producing an olefin polymer. The olefin polymer is

A polymerization method is not particularly limited. For example, there can be exemplified a solvent polymerization method and a slurry polymerization method, in which an aliphatic hydrocarbon (e.g. butane, pentane, hexane, heptane and octane),
10 an aromatic hydrocarbon (e.g. benzene and toluene) or a halogenated hydrocarbon (e.g. methylene dichloride) is used as a solvent; a bulk polymerization method, in which polymerization is carried out in a liquid monomer; a gas phase polymerization method, in which polymerization is carried out
15 in a gaseous monomer; and a high-pressure polymerization method, in which polymerization is carried out in a supercritical liquid condition at a high temperature under a high pressure. As a polymerization type, either of a batch-wise type and a continuous type is possible.

20 A method of feeding the respective components in a reactor is not particularly limited. Examples thereof are a method of feeding them in a solid condition; and a method of feeding them in a condition of a solution, a suspension or a slurry, using a hydrocarbon solvent, from which components
25 deactivating catalyst components such as moisture and oxygen are completely removed,

When the respective components are used as a solution, the concentration of the component (A) and the component (C) are usually from 0.0001 to 100 mmol/L, and preferably from
30 0.01 to 10 mmol/L, converted to a metal atom, respectively.

20 to 300°C. The polymerization pressure is usually from 0.1 to 350 MPa, preferably from 0.1 to 300 MPa, and more preferably from 0.1 to 200 MPa. In general, the polymerization time can be appropriately determined according to the kind of a desired polymer and a reaction apparatus, and a range of from 1 minute to 20 hours can be adopted.

In order to control a molecular weight of an addition polymer, a chain transfer agent such as hydrogen may be added.

Examples

The present invention is further illustrated in detail according to Examples and Comparative Examples below, but the present invention is not limited thereto.

The measurement values of respective items in Examples were measured according to methods described below.

(1) Content of α -olefin unit in copolymer (short chain branch degree : SCB)

The content of an α -olefin unit in an obtained polymer was determined from an IR absorption spectrum, wherein the measurement and calculation were carried out by using characteristic absorptions derived from the α -olefin, according to a method described in "Die Makromolekulare Chemie, 177, 449 (1976) McRae, M. A., Madams, W. F.", and the IR absorption spectrum was obtained by a measurement using an

an Ubbelohde viscometer.

(3) Molecular weight and molecular weight distribution

They were determined under the under-mentioned
10 conditions according to a gel permeation chromatography (GPC).
A calibration curve was prepared using standard polystyrenes.
Molecular weight distribution was evaluated by a ratio, (M_w/M_n) ,
of a weight average molecular weight (M_w) to a number average
molecular weight (M_n):

15 equipment: 150C type, manufactured by Milipore Waters
Co., Ltd.,

column: TSK-GEL GMH-HT, $7.5 \times 600 \times 2$ columns,

measurement temperature: 140°C ,

solvent: o-dichlorobenzene, and

20 measurement concentration: 5 mg/5 ml.

(4) Melt flow rate (MFR) (g/10 min)

According to a method prescribed in JIS K7210-1995, it
was measured at 190°C under a load of 21.18 N (2.16 kg). As
25 a sample, a polymer containing 1000 ppm of an antioxidant was
used.

Example 1

(1) Preparation of bismuth compound

30 Into a 300 ml four-necked flask purged with argon, 9.88

reaction was carried out (i) for 4 hours under a toluene-refluxing condition, (ii) for 18 hour at room temperature, (iii) for 7 hours under a toluene-refluxing condition, and (iv) for 17 hour at room temperature. A formed yellow needle-like crystal was filtered, and dried under vacuum at room temperature, thereby obtaining 12.6 g of a yellow crystal (hereinafter, referred to as "compound A").

Next, into a 100ml four-necked flask purged with argon, 0.967 g (1.14 mmol) of the compound A and 30 ml of toluene were charged. Thereto, 0.243 g (1.13 mmol) of diphenylsilanediol and 10 ml of toluene were charged at room temperature. The mixture was stirred for 6 hours under a refluxing condition. By allowing the mixture to stand without stirring, a white precipitation was formed, and the supernatant liquid was a yellow clear liquid. A white crystal was obtained by distilling out volatile components under vacuum, and drying.

(2) Production of addition polymer

After drying under vacuum an autoclave reactor having an inner volume of 400ml equipped with a stirrer, and replacing the atmosphere thereof with argon, 190 ml of hexane as a solvent and 10 ml of 1-hexene as a comonomer were charged, and the reactor was heated to 70 °C. Then, ethylene was fed while adjusting at an ethylene pressure of 0.6 MPa. After the system was stabilized, 0.25 ml (250 μ mol) of triisobutylaluminum (1

feeding ethylene to keep the constant total pressure. As a result, 2.06 g of an ethylene-1-hexene copolymer was obtained. The polymerization activity, SCB, Mw and Mw/Mn were 4.1×10^6 g/mol-Zr/hour, 15.5, 92000 and 2.5, respectively.

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Comparative Example 1

Example 1 was repeated except that 43.3 mg of the white crystal used in Example 1 (2) was changed to 49.8 mg (113 μ mol) of triphenyl bismuth. As a result, only a trace of an ethylene-1-hexene copolymer was obtained.

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Comparative Example 2

Example 1 was repeated except that 43.3 mg of the white crystal used in Example 1 (2) was changed to 60.9 mg (71.6 μ mol) of the compound A prepared in Example 1 (1). As a result, only a trace of an ethylene-1-hexene copolymer was obtained.

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Comparative Example 3

(1) Preparation of bismuth compound

Into a 100 ml four-necked flask purged with argon, 1.06 g (1.25 mmol) of the compound A prepared in Example 1 (1) and 30 ml of toluene were charged. Thereto, 0.125 g (0.578 mmol) of diphenylsilanediol and 10 ml of toluene were charged at room temperature. The mixture was stirred for three hours under a refluxing condition. By allowing the mixture to stand

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(2) Production of addition polymer

Example 1 (2) was repeated except that 43.3 mg of the white crystal used therein was changed to 5 ml of the slurry obtained in the above (1). As a result, only a trace of an
10 ethylene-1-hxene copolymer was obtained.

Example 2

(1)

Into a 100 ml four-necked flask purged with nitrogen,
15 17.5 ml of toluene and 12.5 ml (25.0 mmol) of a toluene solution (2.00 mol/liter) of triethylaluminum were charged, and the mixture was cooled at 5 °C. Thereto, 3.5 ml (33.3 mmol) of 1,1,1,3,3,3-hexafluoro-2-propanol was added dropwise over 0.25 hour. Thereafter, the mixture was stirred for 1.5 hours
20 at 5 °C. Then, 5.3 g (24.5 mmol) of diphenylsilanediol was added thereto. Thereafter, the mixture was stirred for 1 hour at 5 °C, for 1 hour at 40 °C, and for 2 hours at 80 °C, respectively, thereby obtaining a deep green-colored slurry solution, whose concentration was 0.75 mol/liter in terms of an aluminum atom
25 based on the amount added.

(2) Polymerization

A 3 liter-inner volume autoclave reactor equipped with a stirrer was dried under reduced pressure, and the atmosphere
30 thereof was replaced with argon, and then made vacuum. 1000

0.9 ml of a hexane solution (concentration = 1 mmol/ml) of triisobutylaluminum was charged. Next, 0.25 ml of a toluene solution (concentration = 2 μ mol/ml) of racemi-ethylenebis(1-indenyl)zirconium diphenoxide was charged, and successively, 0.6 ml of the slurry solution obtained in the above-mentioned Example 2 (1) was charged. The polymerization was carried out at 70 °C for 20 minutes under feeding ethylene to keep the constant total pressure. After deashing and washing with a hydrochloric acid/methanol solution, and then drying under vacuum, 49 g of an olefin polymer was obtained. The polymerization activity, SCB and MFR were 2.9×10^8 g/mol-Zr/hour, 17.1 and 4.7, respectively.

to 8 mol, and the amount of the component (c) contacted is from 0.5 to 8 mol, per 1 mol of the component (a), respectively:

(a) a compound represented by the following formula [1]



(b) a compound represented by the following formula [2]



(c) a compound represented by the following formula [3],



20 wherein M^1 is a metal atom of the Groups 12 to 15 in the periodic table or a boron atom; r is a valence of M^1 ; L^1 is a hydrogen atom, a halogen atom, a hydrocarbon group or a hydrocarbon oxy group, and when two or more L^1 's exist, they may be the same or different from one another; T is a non-metal
25 atom of the Group 15 or 16 in the periodic table; s is a valence of T ; R^1 is an electron-withdrawing group or an electron-withdrawing group-containing group, and when two or more R^1 's exist, they may be the same or different from one another; n is the number of from 2 to 4; J is a non-metal atom
30 of the Group 14 in the periodic table; and R^2 is a hydrocarbon

3. The metal compound according to Claim 1, wherein R^1 is a halogenated hydrocarbon group.

10 4. The metal compound according to Claim 1, wherein the component (b) is a fluorinated phenol.

5. The metal compound according to Claim 1, wherein the component (b) is pentafluorophenol.

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6. The metal compound according to Claim 1, wherein the component (b) is a fluorinated alcohol.

20 7. The metal compound according to Claim 1, wherein the component (b) is 1,1,1,3,3,3-hexafluoro-2-propanol.

8. The metal compound according to Claim 1, wherein M^1 is a bismuth atom.

25 9. The metal compound according to Claim 1, wherein M^1 is an aluminum atom.

10. The metal compound according to Claim 1, wherein J is a silicon atom.

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for addition polymerization according to Claim 11 with a compound (B) of a metal selected from the group consisting of metals of Groups 3 to 11 and lanthanide series, and optionally an organoaluminum compound (C).

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13. The catalyst for addition polymerization according to Claim 12, wherein the compound (B) is a metallocene compound.

14. The catalyst for addition polymerization according to Claim 12, wherein the compound (B) is a transition metal compound, which contains at least one group having a cyclopentadienyl type anion skeleton.

15. A process for producing an addition polymer comprising the step of polymerizing an addition polymerizable monomer in the presence of the catalyst for addition polymerization according to Claim 12.

16. The process for producing an addition polymer according to Claim 15, wherein the addition polymerizable monomer is an olefin.

17. The process for producing an addition polymer according to Claim 15, wherein the addition polymerizable monomer is a combination of ethylene and an α -olefin.