

The present invention relates to a metal compound; 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.

Background of the Invention

Since olefin polymers such as polypropylene and 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 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.

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 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 0.6 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 r is a valence of Bi; 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 T; R^1 is an
20 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 2 or 3; J is an atom of the Group 13 in the periodic table; and R^2 is a hydrocarbon group, and when two or more R^2 's exist, they may be the same or different from one another.

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

Further, the present invention is a catalyst for addition polymerization obtained by a process comprising the step of
30 contacting the above-mentioned catalyst component for addition

producing an addition polymer comprising the step of polymerizing an addition polymerizable monomer in the presence of the above-mentioned catalyst for addition polymerization.

10 Detailed Description of the Invention

In the above formula [1], r , a valence of Bi , is 3 or 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 isobutyl group, a *n*-pentyl group, a neopentyl group, a *n*-hexyl group, a *n*-octyl group, a *n*-decyl group, a *n*-dodecyl group, a *n*-pentadecyl group and a *n*-eicosyl group.

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 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 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
10 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, perchlorohexyl group, a perchlorooctyl
15 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.

20 The alkyl group as L^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 n-butyl group, a tert-butyl
group or an isobutyl group.

Examples of the aryl group as L^1 are a phenyl group, a
25 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,
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
30 group, a 2,3,4,5-tetramethylphenyl group, a

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.

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

 Examples of the aralkyl group as L^1 are a benzyl group, a (2-methylphenyl)methyl group, a (3-methylphenyl)methyl
15 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
20 (3,4-dimethylphenyl)methyl group, a (3,5-dimethylphenyl)methyl group, a (2,3,4-trimethylphenyl)methyl group, a (2,3,5-trimethylphenyl)methyl group, a (2,3,6-trimethylphenyl)methyl group, a
25 (3,4,5-trimethylphenyl)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
30 (pentamethylphenyl)methyl group, an (ethylphenyl)methyl

a (n-octylphenyl)methyl group, a (n-decylphenyl)methyl group, a (tetradecylphenyl)methyl group, a naphthylmethyl group and an anthracenylmethyl group.

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

15 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, a n-octyloxy group, a n-decyloxy group, a n-dodecyloxy group, a n-pentadecyloxy group and a n-eicosyl oxy group.

20 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, an isobutoxy group, a neopentoxyl group or a tert-pentyloxy group.

25 Specific examples of the aryloxy group as L^1 are a phenoxy group, a 2-tolyloxy group, a 3-tolyloxy group, a 4-tolyloxy group, a 2,3-xylyloxy group, a 2,4-xylylphenoxy group, a 2,5-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

5 isopropylphenoxy group, a n-butylphenoxy group, a
sec-butylphenoxy group, a tert-butylphenoxy group, an
isobutylphenoxy group, a n-pentylphenoxy group, a
neopentylphenoxy group, a n-hexylphenoxy group, a
n-octylphenoxy group, a n-decylphenoxy group, a
10 n-tetradecylphenoxy group, a naphthoxy group and an
anthrathenoxy group.

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

15 These alkyl, aryl, aralkyl, alkoxy and aryloxy groups
above-mentioned as L^1 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.

20 As L^1 in the above formula [1], preferred is a halogen
atom, an alkyl group, an aryl group, an alkoxy group or an
aryloxy group, more preferred is a halogen atom, an aryl group,
an alkoxy group or an aryloxy group, and particularly preferable
is an aryl group.

25 Examples of the compound (a) represented by the formula
[1] 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

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,
10 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,
15 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,
20 tri(n-butylphenoxy) bismuth, tri(sec-butylphenoxy) bismuth,
tri(tert-butylphenoxy) bismuth, tri(isobutylphenoxy) bismuth,
tri(n-pentylphenoxy) bismuth, tri(neopentylphenoxy) bismuth,
tri(n-hexylphenoxy) bismuth, tri(n-octylphenoxy) bismuth,
tri(n-decylphenoxy) bismuth, tri(n-dodecylphenoxy) bismuth,
25 tri(n-tetradecylethylphenoxy) bismuth, trinaphtyloxy 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
30 and pentaethoxy bismuth; and a pentaaryloxy bismuths such as

a trialkoxy bismuth and a triaryloxy bismuth, and particularly preferably a triaryl bismuth such as triphenyl bismuth.

Examples of the non-metal atom of T of the Group 15 are a nitrogen atom and a phosphorous atom, and examples of the
10 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
15 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,
20 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
25 electron-withdrawing group are a halogenated hydrocarbon group such as a halogenated alkyl group and a halogenated aryl group; a cyanated hydrocarbon group such as a cyanated aryl group; a nitrated hydrocarbon group such as a nitrated aryl groups; a hydrocarbonoxy carbonyl group such as an alkoxycarbonyl group,

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
10 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
15 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
1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl group, a
20 1,1-bis(trichloromethyl)-2,2,2-trichloroethyl group, a
1,1-bis(tribromomethyl)-2,2,2-tribromoethyl group, and a
1,1-bis(triiodomethyl)-2,2,2-triiodoethyl group.

Examples of the halogenated aryl group as R^1 are aryl
groups in which a hydrogen atom of an aromatic ring in the
25 group is substituted with a halogen such as a 2-fluorophenyl
group, a 3-fluorophenyl group, a 4-fluorophenyl group, a
2-chlorophenyl group, a 3-chlorophenyl group, a 4-chlorophenyl
group, a 2-bromophenyl group, a 3-bromophenyl group, a
4-bromophenyl group, a 2-iodophenyl group, a 3-iodophenyl group,
30 a 4-iodophenyl group, a 2,6-difluorophenyl group, a

a 2,4,6-tribromophenyl group, a 2,4,6-triiodophenyl group, 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 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 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.

Examples of the alkoxycarbonyl group as R^1 are a methoxycarbonyl group, an ethoxycarbonyl group, a n-propoxycarbonyl group, an isopropoxycarbonyl group and a trifluoromethoxycarbonyl group.

An example of the aralkyloxycarbonyl group as R^1 is a benzyloxycarbonyl group.

Examples of the aryloxycarbonyl group as R^1 are a phenoxycarbonyl group and a pentafluorophenoxycarbonyl group.

Examples of the acyloxycarbonyl group as R^1 are a

preferably a fluoroalkyl group or a fluoroaryl group;
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
10 2,2,2-trifluoro-1-trifluoromethylethyl group, a
1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl group, a
2-fluorophenyl group, a 3-fluorophenyl group, a 4-fluorophenyl
group, a 2,4-difluorophenyl group, a 2,6-difluorophenyl group,
a 3,4-difluorophenyl group, a 3,5-difluorophenyl group, a
15 2,4,6-trifluorophenyl group, a 3,4,5-trifluorophenyl group,
a 2,3,5,6-tetrafluorophenyl group, a pentafluorophenyl group,
a 2,3,5,6-tetrafluoro-4-trifluoromethylphenyl group, a
2,3,5,6-tetrafluoro-4-pentafluorophenylphenyl group, a
perfluoro-1-naphthyl group, or a perfluoro-2-naphthyl group;
20 and most preferably a trifluoromethyl group, a
2,2,2-trifluoro-1-trifluoromethylethyl group, a
1,1-bis(trifluoromethyl)-2,2,2-trifluoroethyl group, a
3,5-difluorophenyl group, a 3,4,5-trifluorophenyl group, or
a pentafluorophenyl group.

25 When the compound (b) represented by the above formula
[2] is an amine, examples thereof are di(fluoromethyl)amine,
di(chloromethyl)amine, di(bromomethyl)amine,
di(iodomethyl)amine, bis(difluoromethyl)amine,
bis(dichloromethyl)amine, bis(dibromomethyl)amine,
30 bis(diiodomethyl)amine, bis(trifluoromethyl)amine,

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,
10 bis(2,2,2-trifluoro-1-trifluoromethylethyl)amine,
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,
15 bis(1,1-bis(trichloromethyl)-2,2,2-trichloroethyl)amine,
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,
20 bis(3-chlorophenyl)amine, bis(4-chlorophenyl)amine,
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,
25 bis(2,6-dichlorophenyl)amine, bis(3,5-dichlorophenyl)amine,
bis(2,6-dibromophenyl)amine, bis(3,5-dibromophenyl)amine,
bis(2,6-diiodophenyl)amine, bis(3,5-diiodophenyl)amine,
bis(2,4,6-trifluorophenyl)amine,
bis(2,4,6-trichlorophenyl)amine,
30 bis(2,4,6-tribromophenyl)amine,

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,

10 bis(2-cyanophenyl)amine, bis(3-cyanophenyl)amine,
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
15 with a phosphorus atom in the above-mentioned amine compounds.

When the compound (b) is an alcohol, examples thereof
are fluoromethanol, chloromethanol, bromomethanol,
iodomethanol, difluoromethanol, dichloromethanol,
dibromomethanol, diiodomethanol, trifluoromethanol,
20 trichloromethanol, tribromomethanol, triiodomethanol,
2,2,2-trifluoroethanol, 2,2,2-trichloroethanol,
2,2,2-tribromoethanol, 2,2,2-triiodoethanol,
2,2,3,3,3-pentafluoropropanol,
2,2,3,3,3-pentachloropropanol,
25 2,2,3,3,3-pentabromopropanol, 2,2,3,3,3-pentaiodopropanol,
2,2,2-trifluoro-1-trifluoromethylethanol,
2,2,2-trichloro-1-trichloromethylethanol,
2,2,2-tribromo-1-tribromomethylethanol,
2,2,2-triiodo-1-triiodomethylethanol,
30 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethanol,

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,
2-chlorophenol, 3-chlorophenol, 4-chlorophenol,
10 2-bromophenol, 3-bromophenol, 4-bromophenol, 2-iodophenol,
3-iodophenol, 4-iodophenol, 2,6-difluorophenol,
3,5-difluorophenol, 2,6-dichlorophenol, 3,5-dichlorophenol,
2,6-dibromophenol, 3,5-dibromophenol, 2,6-diiodophenol,
3,5-diiodophenol, 2,4,6-trifluorophenol,
15 3,4,5-trifluorophenol, 2,4,6-trichlorophenol,
2,4,6-tribromophenol, 2,4,6-triiodophenol,
pentafluorophenol, pentachlorophenol, pentabromophenol,
pentaiodophenol, 2-(trifluoromethyl)phenol,
3-(trifluoromethyl)phenol, 4-(trifluoromethyl)phenol,
20 2,6-bis(trifluoromethyl)phenol,
3,5-bis(trifluoromethyl)phenol, 2-cyanophenol,
3-cyanophenol, 4-cyanophenol, 2-nitrophenol, 3-nitrophenol
and 4-nitrophenol.

When the compound (b) is a thiophenol compound, examples
25 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
thereof are 2-fluorobenzoic acid, 3-fluorobenzoic acid,
30 4-fluorobenzoic acid, 2,3-difluorobenzoic acid,

acid; and a preferable sulfonic acid thereof is trifluoromethanesulfonic acid.

A more preferable compound (b) is bis(trifluoromethyl)amine, bis(pentafluorophenyl) amine, trifluoromethanol, 2,2,2-trifluoro-1-trifluoromethylethanol, 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethanol, 4-fluorophenol, 2,6-difluorophenol, 2,4,6-trifluorophenol, 3,4,5-trifluorophenol, pentafluorophenol, 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 or 1,1-bis(trifluoromethyl)-2,2,2-trifluoroethanol.

Examples of J in the above formula [3] are a boron atom, an aluminum atom, a gallium atom, an indium atom and a thallium atom. J is preferably a boron atom or an aluminum atom, and particularly preferably a boron atom.

In the above formula [3], n is 2 or 3, and preferably 2.

Examples of the hydrocarbon group as R^2 in the above formula [3] are the hydrocarbon groups mentioned above as L^1 in the above formula [1], and the halogenated hydrocarbon groups mentioned above as R^1 in the above formula [2]. Preferred is an alkyl group or an aryl group; and more preferred is a methyl

group, a 2,3-xylyl group, 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,
10 a 3,4,5-trimethylphenyl group, a 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 n-hexylphenyl
group, a n-octylphenyl group, a n-decylphenyl group, a
15 n-dodecylphenyl group, a n-tetradecylphenyl group, a naphthyl
group, an anthracenyl group, a 2-fluorophenyl group, a
3-fluorophenyl group, a 4-fluorophenyl group, a
2,4-difluorophenyl group, a 2,6-difluorophenyl group, a
3,4-difluorophenyl group, a 3,5-difluorophenyl group, a
20 2,4,6-trifluorophenyl group, a 2,3,5,6-tetrafluorophenyl
group, or a pentafluorophenyl group. Further preferred is 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-hexyl group, a n-octyl group, a n-dodecyl
25 group, a phenyl group, a 2-tolyl group, a 2,4,6-trimethylphenyl
group, a n-propylphenyl group, a n-butylphenyl group, a
tert-butylphenyl group, a n-pentylphenyl group, a
n-hexylphenyl group, a n-octylphenyl group, a n-decylphenyl
group, a n-dodecylphenyl group, a naphthyl group, an
30 anthracenyl group, a 2-fluorophenyl group, a 3-fluorophenyl

Examples of the compound (c) represented by the formula

[3] are methylboric acid, ethylboric acid, n-propylboric acid, isopropylboric acid, n-butylboric acid, sec-butylboric acid, tert-butylboric acid, isobutylboric acid, n-pentylboric acid, n-hexylboric acid, n-heptylboric acid, n-octylboric acid, n-decylboric acid, n-dodecylboric acid, phenylboric acid, 2-tolylboric acid, 3-tolylboric acid, 4-tolylboric acid, 2,3-xylylboric acid, 2,4-xylylboric acid, 2,5-xylylboric acid, 2,6-xylylboric acid, 3,4-xylylboric acid, 3,5-xylylboric acid, 2,3,4-trimethylphenylboric acid, 2,3,5-trimethylphenylboric acid, 2,3,6-trimethylphenylboric acid, 2,4,6-trimethylphenylboric acid, 3,4,5-trimethylphenylboric acid, n-propylphenylboric acid, isopropylphenylboric acid, n-butylphenylboric acid, sec-butylphenylboric acid, tert-butylphenylboric acid, Isobutylphenylboric acid, n-pentylphenylboric acid, n-hexylphenylboric acid, n-octylphenylboric acid, n-decylphenylboric acid, n-dodecylphenylboric acid, n-tetradecylphenylboric acid, naphthylboric acid, anthracenylboric acid, 2-fluorophenylboric acid, 3-fluorophenylboric acid, 4-fluorophenylboric acid, 2,4-difluorophenylboric acid, 2,6-difluorophenylboric acid, 3,4-difluorophenylboric acid, 3,5-difluorophenylboric acid, 2,4,6-trifluorophenylboric acid, 2,3,5,6-tetrafluorophenylboric acid, and pentafluorophenylboric acid.

2,4,6-trimethylphenylboric acid, n-propylphenylboric acid,
n-butylphenylboric acid, tert-butylphenylboric acid,
n-pentylphenylboric acid, n-hexylphenylboric acid,
n-octylphenylboric acid, n-decylphenylboric acid,
10 n-dodecylphenylboric acid, naphthylboric acid,
anthracenylboric acid, 2-fluorophenylboric acid,
3-fluorophenylboric acid, 4-fluorophenylboric acid,
2,4-difluorophenylboric acid, 2,6-difluorophenylboric acid,
3,4-difluorophenylboric acid, 3,5-difluorophenylboric acid,
15 2,4,6-trifluorophenylboric acid, or pentafluorophenylboric
acid. Particularly preferred is methylboric acid, phenylboric
acid, or pentafluorophenylboric acid.

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

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

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

25 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
(a) and (b), or by contacting (b) with a contact product obtained
30 by contacting (a) and (c). Further, there may be carried out

or a method comprising the steps of:

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

(2) purifying the contact product to obtain a purified
10 contact product, and

(3) contacting the purified contact product with the remaining compound.

The contact treatment of the above-mentioned compounds (a) to (c) is preferably carried out under an inert gas atmosphere.
15 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
20 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)
25 to (c). Examples of the solvent are butane, pentane, 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,
30 chlorobenzene, bromobenzene, o-dichlorobenzene, dimethyl

0.1 to 8 mol, more preferably from 1 to 6 mol, further preferably from 2 to 4 mol, and particularly preferably from 2.5 to 3.5 mol, per one mol of the compound (a).

10 The compound (c) is used in an amount of preferably from 0.6 to 8 mol, more preferably from 0.7 to 6 mol, further preferably from 0.8 to 4 mol, and particularly preferably from 0.9 to 1.2 mol, per one mol of the compound (a).

15 As a result of the contact treatment, at least one of 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, pentafluorophenol and pentafluorophenylboric acid, respectively, an example of a process for producing the metal
20 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 bismuth to a toluene solution of triphenyl bismuth,

25 (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,

(4) concentrating the solution,

30 (5) filtering a precipitated solid component,

The metal compound (hereinafter, referred to as "compound (A)") according to the present invention can preferably be used as a catalyst component of a catalyst for addition polymerization. Examples of the catalyst for addition polymerization using said catalyst component are (1) a catalyst obtained by a process comprising the step of contacting the 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 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 is a metal atom of the Groups 3 to 12 or Lanthanide Series of the Periodic Table of the Elements; 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,

Examples of M are a scandium atom, an yttrium atom, a titanium atom, a zirconium atom, a hafnium atom, a vanadium atom, a niobium atom, a tantalum atom, a chromium atom, an iron atom, a ruthenium atom, a cobalt atom, a rhodium atom, a nickel atom, a palladium atom, a samarium atom and an ytterbium atom. M^2 is preferably a metal atom of Groups 3 to 11, and 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 -6-tert-butylindenyl group, an η
5-7-tert-butylindenyl group, an η^5 -2,3-dimethylindenyl group,
an η^5 -4,7-dimethylindenyl group, an η
5-2,4,7-trimethylindenyl group, an η
10 5-2-methyl-4-isopropylindenyl group, an η^5 -4,5-benzindenyl
group, an η^5 -2-methyl-4,5-benzindenyl 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
15 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 L^2 are an oxygen atom, a sulfur atom, a nitrogen
20 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
25 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.

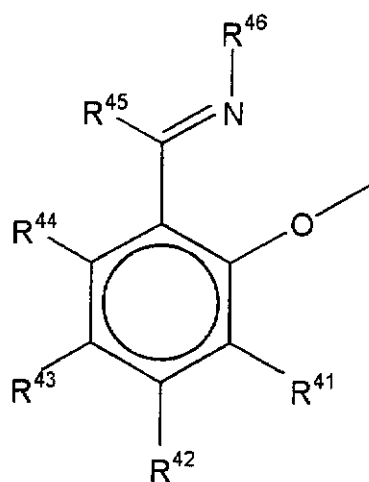
Examples of the group containing a hetero-atom are
a methoxy group, an ethoxy group, a n- or iso-propoxy group,
30 a n-, sec-, iso- or tert-butoxy group, a phenoxy group, a

a 4-tert-butyl-4-methylphenoxy group, a
2,6-di-tert-butylphenoxy group, a 4-methoxyphenoxy group, a
2,6-dimethoxyphenoxy group, a 3,5-dimethoxyphenoxy group, a
2-chlorophenoxy group, a 4-nitrosophenoxy group, a
10 4-nitrophenoxy group, a 2-aminophenoxy group, a 3-aminophenoxy
group, a 4-aminothiophenoxy group, a 2,3,6-trichlorophenoxy
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
15 isopropylamino group, a tert-butylamino group, a pyrrolyl group,
a dimethylphosphino group, a 2-(2-oxy-1-propyl)phenoxy group,
a catecholato group, a 2-hydroxyphenoxy group, a
resorcinolate group, a 3-hydroxyphenoxy group, a
4-isopropyl-catecholato group, a
20 2-hydroxy-4isopropyl-phenoxy group, a 3-methoxycatecholato
group, a 2-hydroxy-3-methoxyphenoxy 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
25 4,4',6,6'-tetra-tert-butyl-2,2'-methylenediphenoxy group,
and a 4,4',6,6'-tetramethyl-2,2'-isobutylidenediphenoxy
group.

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

Examples of R^3 in the formula [5] are a hydrogen atom, 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 tert-butyl group, a cyclohexyl group, a phenyl group, a 1-naphtyl group and a benzyl group.

A still further example of the hetero atom-containing group is a group represented by the following formula [6]:



[6]

wherein respective R^{41} to R^{46} 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.

Examples of R^{41} to R^{46} in the above formula [6] are a hydrogen atom, a fluorine atom, a chlorine atom, a bromine atom, an

group, a benzyl group, a methyl group, a triethylsilyl group, a diphenylmethylsilyl group, a 1-methyl-1-phenylethyl group, a 1,1-dimethyl propyl group, a 2-chlorophenyl group and a pentafluorophenyl group.

10 The above-mentioned chelating ligand as L^2 means a ligand having plural coordinating positions. Examples thereof are acetylacetonate, diimine, oxazoline, bisoxazoline, terpyridine, acylhydrazone, diethylenetriamine, triethylenetetramine, porphyrin, crown ether and cryptate.

15 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
20 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
25 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
30 group), a diphenylmethylene group, a dimethylsilylene group,

group, an aryl group and an alkenyl group.

Examples of the alkyl group as X^8 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 isobutyl group, a n-pentyl group, a neopentyl group, an amyl group, a n-hexyl group, a n-octyl group, a n-decyl group, a n-dodecyl group, a n-pentdecyl group and a n-eicosyl 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,

(2,6-dimethylphenyl)methyl group, a
(3,4-dimethylphenyl)methyl group, a
(3,5-dimethylphenyl)methyl group, a
(2,3,4-trimethylphenyl)methyl group, a
10 (2,3,5-trimethylphenyl)methyl group, a
(2,3,6-trimethylphenyl)methyl group, a
(3,4,5-trimethylphenyl)methyl group, a
(2,4,6-trimethylphenyl)methyl group, a
(2,3,4,5-tetramethylphenyl)methyl group, a
15 (2,3,4,6-tetramethylphenyl)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,
20 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
25 an anthracenylmethyl group.

Each of these aralkyl 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; an aryloxy group such as
30 a phenoxy group; or an aralkyloxy group such as a benzyloxy

group, 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
10 group, a 2,3,4,5-tetramethylphenyl group, a
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
15 tert-butylphenyl group, an isobutylphenyl group, a
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.

20 Each of these aryl 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; an aryloxy group such as a phenoxy group;
or an aralkyloxy group such as a benzyloxy group.

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

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
30 3 to 20 carbon atoms, and more preferably an ally group or

7 to 20 carbon atoms. Examples thereof are hydrocarbonoxy groups as above-exemplified as L^1 , a (2-methylphenyl)methoxy group, a (3-methylphenyl)methoxy group, a (4-methylphenyl)methoxy group, a (2,3-dimethylphenyl)methoxy group, a

10 (2,4-dimethylphenyl)methoxy group, a (2,5-dimethylphenyl)methoxy group, a (2,6-dimethylphenyl)methoxy group, a (3,4-dimethylphenyl)methoxy group, a (3,5-dimethylphenyl)methoxy group, a
15 (2,3,4-trimethylphenyl)methoxy group, a (2,3,5-trimethylphenyl)methoxy group and a benzyloxy group. 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
20 benzyloxy group; further preferred is a methoxy group, a phenoxy group, a 2,6-di(tert-butyl)phenoxy group or a 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 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.

30 In the formula [4], respective numbers of a and b depend

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

dichloride, dimethylsilylene(methylcyclopentadienyl)
(indenyl)titanium dichloride,
dimethylsilylene(n-butylcyclopentadienyl)(indenyl)
titanium dichloride,
10 dimethylsilylene(tetramethylcyclopentadienyl)
(indenyl)titanium dichloride,
dimethylsilylene(cyclopentadienyl)(fluorenyl) titanium
dichloride,
dimethylsilylene(methylcyclopentadienyl)(fluorenyl)
15 titanium dichloride,
dimethylsilylene(n-butylcyclopentadienyl)(fluorenyl)
titanium dichloride,
dimethylsilylene(tetramethylcyclopentadienyl) (fluorenyl)
titanium dichloride, and
20 dimethylsilylene(indenyl)(fluorenyl)titanium dichloride;
and compounds obtained by changing "dimethylsilylene" in the
above compounds to "diethylsilylene", "diphenylsilylene" or
"dimethoxysilylene".

Further examples of the metal compound represented by
25 the formula [4], wherein M is a titanium atom, are
bis(cyclopentadienyl)titanium dichloride,
bis(methylcyclopentadienyl)titanium dichloride,
bis(n-butylcyclopentadienyl)titanium dichloride,
bis(dimethylcyclopentadienyl)titanium dichloride,
30 bis(ethylmethylcyclopentadienyl)titanium dichloride,

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

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

(fluorenyl)titanium dichloride, ethylene
(tetramethylpentadienyl)(fluorenyl)titanium dichloride,
ethylene(indenyl)(fluorenyl)titanium dichloride,
isopropylidenebis(cyclopentadienyl) titanium dichloride,
10 isopropylidenebis(2-methylcyclopentadienyl)titanium
dichloride,
isopropylidenebis(3-methylcyclopentadienyl)titanium
dichloride,
isopropylidenebis(2-n-butylcyclopentadienyl)titanium
15 dichloride,
isopropylidenebis(3-n-butylcyclopentadienyl)titanium
dichloride,
isopropylidenebis(2,3-dimethylcyclopentadienyl) titanium
dichloride,
20 isopropylidenebis(2,4-dimethylcyclopentadienyl) titanium
dichloride,
isopropylidenebis(2,5-dimethylcyclopentadienyl) titanium
dichloride,
isopropylidenebis(3,4-dimethylcyclopentadienyl) titanium
25 dichloride,
isopropylidenebis(2,3-ethylmethylcyclopentadienyl)
titanium dichloride,
isopropylidenebis(2,4-ethylmethylcyclopentadienyl)
titanium dichloride,
30 isopropylidenebis(2,5-ethylmethylcyclopentadienyl)

isopropylidenebis(2,3,5-trimethylcyclopentadienyl)
titanium dichloride,
isopropylidenebis(tetramethylcyclopentadienyl) titanium
dichloride, isopropylidenebis(indenyl) titanium dichloride,
10 isopropylidenebis(4,5,6,7-tetrahydroindenyl)titanium
dichloride, isopropylidenebis(2-phenylindenyl)titanium
dichloride, isopropylidenebis(fluorenyl)titanium dichloride,
isopropylidene(cyclopentadienyl)
(tetramethylcyclopentadienyl)titanium dichloride,
15 isopropylidene(cyclopentadienyl)(indenyl)titanium
dichloride, isopropylidene(methylcyclopentadienyl)
(indenyl)titanium dichloride,
isopropylidene(n-butylcyclopentadienyl)(indenyl) titanium
dichloride, isopropylidene(tetramethylcyclopentadienyl)
20 (indenyl)titanium dichloride, isopropylidene
(cyclopentadienyl)(fluorenyl)titanium dichloride,
isopropylidene(methylcyclopentadienyl)(fluorenyl) titanium
dichloride,
isopropylidene(n-butylcyclopentadienyl)(fluorenyl)
25 titanium dichloride,
isopropylidene(tetramethylcyclopentadienyl)
(fluorenyl)titanium dichloride, isopropylidene
(indenyl)(fluorenyl)titanium dichloride,
cyclopentadienyl(dimethylamido)titanium dichloride,
30 cyclopentadienyl(phenoxy)titanium dichloride,

dichloride,
pentamethylcyclopentadienyl(2,6-diisopropylphenyl)
titanium dichloride,
pentamethylcyclopentadienyl(2,6-di-tert-butylphenyl)
10 titanium dichloride, indenyl(2,6-diisopropylphenyl)titanium
dichloride, fluorenyl (2,6-diisopropylphenyl)titanium
dichloride,
(tert-butylamido)tetramethylcyclopentadienyl-1,2-
ethanediyltitanium dichloride,
15 (methylamido)tetramethylcyclopentadienyl-1,2-
ethanediyltitanium dichloride,
(ethylamido)tetramethylcyclopentadienyl-1,2-
ethanediyltitanium dichloride,
(tert-butylamido)tetramethylcyclopentadienyl
20 dimethylsilanetitanium
dichloride, (benzylamido)tetramethylcyclopentadienyl
dimethylsilanetitanium dichloride,
(phenylphosphido)tetramethylcyclopentadienyl
dimethylsilanetitanium dichloride,
25 (tert-butylamido)indenyl-1,2-ethanediyltitanium dichloride,
(tert-butylamido)tetrahydroindenyl-1,2-ethanediyl titanium
dichloride,
(tert-butylamido)fluorenyl-1,2-ethanediyltitanium
dichloride, (tert-butylamido)indenyl dimethylsilanetitanium
30 dichloride,

titanium(III) dichloride,
(dimethylaminoethyl)tetramethylcyclopentadienyl
titanium(III) dichloride,
(dimethylaminopropyl)tetramethylcyclopentadienyl-titanium
10 (III) dichloride,
(N-pyrrolidinyethyl)tetramethylcyclopentadienyl-titanium
dichloride,
(B-dimethylaminoborabenzene)cyclopentadienylzirconium
dichloride,
15 cyclopentadienyl(9-mesitylboraanthracenyl)zirconium
dichloride,
2,2'-thiobis(4-methyl-6-tert-butylphenoxy)titanium
dichloride,
2,2'-thiobis[4-methyl-6-(1-methylethyl)phenoxy] titanium
20 dichloride, 2,2'-thiobis[4,6-dimethylphenoxy]titanium
dichloride,
2,2'-methylenebis(4-methyl-6-tert-butylphenoxy) titanium
dichloride,
2,2'-ethylenebis(4-methyl-6-tert-butylphenoxy) titanium
25 dichloride, 2,2'-sulfinylbis(4-methyl-6-tert-butylphenoxy)
titanium dichloride,
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
30 dichloride,

dichloride,

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

[bis(2,6-di-tert-butylphenyl)-1,3-propanediamido]

10 titanium dichloride,

[bis(triisopropylsilyl)naphthalenediamido]titanium
dichloride,

[bis(trimethylsilyl)naphthalenediamido]titanium dichloride,

[bis(tert-butyldimethylsilyl)naphthalenediamido] titanium

15 dichloride,

[bis(tert-butyldimethylsilyl)naphthalenediamido]titanium
dibromide, cyclopentadienyttitanium trichloride,

pentamethylcyclopentadienyttitanium trichloride,

[hydrotris(3,5-dimethylpyrazolyl)borate]titanium

20 trichloride,

[hydrotris(3,5-diethylpyrazolyl)borate]titanium
trichloride,

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

trichloride, [tris(3,5-dimethylpyrazolyl)methyl]titanium

25 trichloride, [tris(3,5-diethylpyrazolyl)methyl]titanium

trichloride and

[tris(3,5-di-tert-butylpyrazolyl)methyl]titanium

trichloride.

Still further examples of the metal compound represented
30 by the formula [4], wherein M is a titanium atom, are compounds

"di-tert-butoxide", "diphenoxide" or
"di(2,6-di-tert-butylphenoxide", and compounds in which
"trichloride" in the above-mentioned compounds is changed to
"trifluoride", "tribromide", "triiodide", "trimethyl",
10 "triethyl", "triisopropyl", "triphenyl", "tribenzyl",
"trimethoxide", "triethoxide", "tri-n-propoxide",
"triisopropoxide", "tri-n-butoxide", "triisobutoxide",
"tri-tert-butoxide", "triphenoxide" or
"tri(2,6-di-tert-butylphenoxide".

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

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

2,2'-methylenebis[(4R)-4-isopropyl-5,5-diphenyloxazoline]

nickel dibromide,

2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(2-

methylphenyl)oxazoline]nickel dibromide,

10 2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(3-methylphenyl
)oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(4-

methylphenyl)oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(2-

15 methoxyphenyl)oxazoline]nickel dibromide,

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

methoxyphenyl)oxazoline]nickel dibromide,

2,2'-methylenebis[(4R)-4-isopropyl-5,5-di-(4-

methoxyphenyl)oxazoline]nickel dibromide,

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

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

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

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

2,2'-methylenebis[(4R)-4-isobutyl-5,5-dimethyloxazoline]
nickel dibromide,

30 2,2'-methylenebis[(4R)-4-isobutyl-5,5-diethyloxazoline]

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

2,2'-methylenebis[(4R)-4-tert-butyl-5,5-
diisopropylloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-
diphenylloxazoline]nickel dibromide,
10 2,2'-methylenebis[(4R)-4-tert-butyl-5,5-
dicyclohexylloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(2-
methylphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(3-
15 methylphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(4-
methylphenyl)oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(2-
methoxyphenyl)oxazoline]nickel dibromide,
20 2,2'-methylenebis[(4R)-4-tert-butyl-5,5-di-(3-
methoxyphenyl)oxazoline]nickel dibromide,
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'-
25 cyclobutane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-
cyclopentane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-
cyclohexane}]nickel dibromide,
30 2,2'-methylenebis[spiro{(4R)-4-tert-butyloxazoline-5,1'-

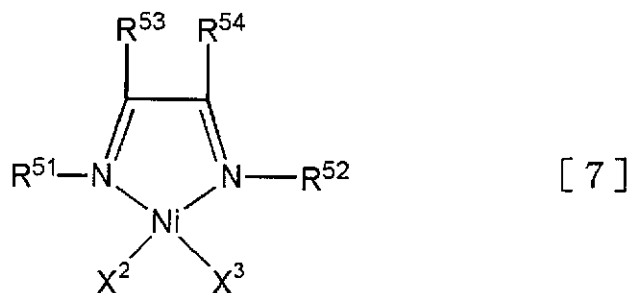
2,2'-methylenebis[(4R)-4-phenyl-5,5-di-n-propyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-diisopropyloxazoline]
nickel dibromide, 2,2'-methylenebis[(4R)-4-phenyl-5,5-
10 dicyclohexyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-phenyl-5,5-diphenyl]oxazoline]
nickel dibromide,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

nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-di-n-propyloxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-diisopropyloxazoline]
10 nickel dibromide, 2,2'-methylenebis[(4R)-4-benzyl-5,5-
dicyclohexyloxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-diphenyl]oxazoline]
nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(2-methylphenyl)
15 oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(3-methylphenyl)
oxazoline]nickel dibromide,
2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(4-methylphenyl)
oxazoline]nickel dibromide,
20 2,2'-methylenebis[(4R)-4-benzyl-5,5-di-(2-methoxyphenyl)
oxazoline]nickel dibromide,
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)
25 oxazoline]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-
cyclobutane}]nickel dibromide,
2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-
cyclopentane}]nickel dibromide,
30 2,2'-methylenebis[spiro{(4R)-4-benzyloxazoline-5,1'-

[hydrotris(3,5-diethylpyrazolyl)borate]nickel bromide, and
[hydrotris(3,5-di-tert-butylpyrazolyl)borate]nickel
bromide.

Still further examples of the metal compound represented
10 by the formula [4], wherein M is a nickel atom, are compounds
in which "dibromide" in the above-mentioned compounds is
changed to "difluoride", "dichloride", "diiodide", "dimethyl",
"diethyl", "diisopropyl", "diphenyl", "dibenzyl",
"dimethoxide", "diethoxide", "di-n-propoxide",
15 "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 is a nickel atom, is a compound
20 represented by the following formula [7]:



wherein each of R^{51} and R^{52} is a 2,6-diisopropylphenyl group;
25 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

group, an isopropoxy group, a n-butoxy group, an isobutoxy or a phenoxy group.

Further examples of the metal compound represented by the formula [4] are compounds in which a "nickel atom" in the above-mentioned nickel compounds is changed to a "palladium atom", a "cobalt atom", a "rhodium atom" or a "ruthenium atom".

Examples of the metal compound represented by the formula [4], wherein M 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,

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 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", "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

(cyclopentadienyl)(2-phenoxy)titanium chloride],
 μ -oxobis[isopropylidene(cyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride],
 μ -oxobis[isopropylidene(methylcyclopentadienyl)
10 (2-phenoxy)titanium chloride],
 μ -oxobis[isopropylidene(methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride],
 μ -oxobis[isopropylidene(tetramethylcyclopentadienyl)
(2-phenoxy)titanium chloride],
15 μ -oxobis[isopropylidene (tetramethylcyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide],
 μ -oxobis [dimethylsilylene(cyclopentadienyl)
(2-phenoxy)titanium methoxide],
 μ -oxobis[dimethylsilylene(cyclopentadienyl)
20 (3-tert-butyl-5-methyl-2-phenoxy)titanium chloride],
 μ -oxobis[dimethylsilylene(methylcyclopentadienyl)
(2-phenoxy)titanium chloride],
 μ -oxobis[dimethylsilylene(methylcyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride],
25 μ -oxobis[dimethylsilylene(tetramethylcyclopentadienyl)
(2-phenoxy)titanium chloride], and
 μ -oxobis[dimethylsilylene(tetramethylcyclopentadienyl)
(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride].

Further examples are compounds obtained by changing "chloride"
30 in these compounds to "fluoride", "bromide", "iodide", "methyl",

the metal compound represented by the formula [4] are

di- μ -oxobis[isopropylidene(cyclopentadienyl)

(2-phenoxy)titanium],

di- μ -oxobis[isopropylidene(cyclopentadienyl)

10 (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],

15 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)

20 (2-phenoxy)titanium],

di- μ -oxobis[dimethylsilylene(cyclopentadienyl)

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

di- μ -oxobis[dimethylsilylene(methylcyclopentadienyl)

(2-phenoxy)titanium],

25 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)

30 (3-tert-butyl-5-methyl-2-phenoxy)titanium].

nickel, bis(1,5-cyclooctadiene)nickel,
dichloro(1,5-cyclooctadiene) nickel,
dichlorobis(acetonitrile)nickel,
dichlorobis(benzonitrile)nickel, carbonyl
10 tris(triphenylphosphine)nickel,
dichlorobis(triethylphosphine)nickel, di-acetobis
(triphenylphosphine)nickel,
tetrakis(triphenylphosphine)nickel, dichloro[1,2- bis
(diphenylphosphino)ethane]nickel,
15 bis[1,2-bis(diphenylphosphino)ethane]nickel,
dichloro[1,3-bis(diphenylphosphino)propane]nickel,
bis[1,3-bis(diphenylphosphino)propane]nickel, tetraamine
nickel nitrate, tetrakis(acetonitrile)nickel
tetrafluoroborate and nickel phthalocyanine.

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

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

at least one group having a cyclopentadienyl type anion skeleton as L^2 in the formula [3].

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 [8]:



wherein d is a number satisfying $0 < d \leq 3$; R^6 is a hydrocarbon group, and when two or more R^6 groups exist, these may be the same or different; Y is a hydrogen atom, a halogen atom or an hydrocarbonoxy group, and when two or more Y 's exist, they may be the same or different.

R^6 in the formula [8] 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 [8] are a fluorine atom, a chlorine atom, a bromine atom and an iodine atom, and preferred is a chlorine atom.

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.

10 The alkoxy group as Y in the formula [8] is preferably an alkoxy group having 1 to 24 carbon atoms, and more preferably a methoxy group, an ethoxy group or a tert-butoxy group.

 Examples of the aryloxy group as Y in the formula [8] are a phenoxy group, a 2-methylphenoxy group, a 3-methylphenoxy group, a 4-methylphenoxy group, a 2,3-dimethylphenoxy group, 15 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, 20 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, 25 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 30 anthrathenoxy group.

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

30 The aralkyloxy group as Y in the formula [8] is

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.

Examples of the organoaluminum compound represented by the formula [8] are a trialkylaluminum such as trimethylaluminum, triethylaluminum, tri-n-propylaluminum, tri-n-butylaluminum, triisobutylaluminum, tri-n-hexylaluminum and tri-n-octylaluminum; a 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, 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 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 alkyl(diaryloxy)aluminum such as methyl(diphenoxy)aluminum,

Among them, preferred is a trialkylaluminum, further preferred is trimethylaluminum, triethylaluminum, tri-n-butylaluminum, triisobutylaluminum or tri-n-hexylaluminum, and particularly preferred is triisobutylaluminum or tri-n-hexylaluminum.

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,

5-methyl-1-hexene, 1-hexene, 1-heptene, 1-octene, 1-nonene,
1-decene and vinylcyclohexane; a diolefin such as 1,5-hexadiene,
1,4-hexadiene, 1,4-pentadiene, 1,7-octadiene, 1,8-nonadiene,
1,9-decadiene, 4-methyl-1,4-hexadiene,
10 5-methyl-1,4-hexadiene, 7-methyl-1,6-octadiene,
5-ethylidene-2-norbornene, dicyclopentadiene,
5-vinyl-2-norbornene, 5-methyl-2-norbornene, norbornadiene,
5-methylene-2-norbornene, 1,5-cyclooctadiene,
5,8-endomethylenhexahydronaphthalene, 1,3-butadiene,
15 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,
tricyclododecene, tricycloundecene, pentacyclopentadecene,
20 pentacyclohexadecene, 8-methyltetracyclododecene,
8-ethyltetracyclododecene, 5-acetylnorbornene,
5-acetyloxynorbornene, 5-methoxycarbonylnorbornene,
5-ethoxycarbonylnorbornene,
5-methyl-5-methoxycarbonylnorbornene, 5-cyanonorbornene,
25 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.
30 p-methylstyrene, m-methylstyrene, o-methylstyrene,

divinylbenzene) and an alkenylnaphthalene (e.g.

1-vinylnaphthalene); and a polar monomer such as an α, β -unsaturated carboxylic acid (e.g. acrylic acid, methacrylic acid, fumaric acid, maleic anhydride, itaconic acid, itaconic anhydride and bicyclo(2,2,1)-5-heptene-2,3-dicarboxylic 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

particularly preferably copolymers of ethylene with an α -olefin. Among them, preferred is a copolymer of ethylene with an α -olefin having a polyethylene crystal structure. The α -olefin has preferably 3 to 8 carbon atoms, and examples thereof
10 are 1-butene, 1-hexene and 1-octene.

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),
15 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
20 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.

25 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
30 deactivating catalyst components such as moisture and oxygen

The concentration of the component (B) is usually from 0.0001 to 100 mmol/L, and preferably from 0.01 to 10 mmol/L, converted to a metal atom.

10 The polymerization temperature is usually from -100 to 350°C, preferably from -20 to 300°C, and more preferably from 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
15 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.

20 Examples

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

25 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)

30 The content of an α -olefin unit in an obtained polymer was determined from an IR absorption spectrum, wherein the

infrared spectrometer (FT-IR7300, manufactured by NIPPON BUNKO Inc.).

(2) Intrinsic viscosity ($[\eta]$)

10 It was measured at 135°C in a tetralin solution using an Ubbelohde viscometer.

(3) Molecular weight and molecular weight distribution

15 They were determined under the under-mentioned 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):

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

 column: TSK-GEL GMH-HT, 7.5 × 600 × 2 columns,

 measurement temperature: 140°C,

 solvent: o-dichlorobenzene, and

25 measurement concentration: 5 mg/5 ml.

Example 1

(1) Preparation of bismuth compound

30 Into a 300 ml four-necked flask purged with argon, 9.88 g (22.4 mmol) of triphenyl bismuth and 100 ml of toluene were

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.

Next, into a 100ml four-necked flask purged with argon, 0.978 g (1.15 mmol) of said yellow crystal and 30 ml of toluene were charged. Thereto, 0.250 g (1.18 mmol) of pentafluorophenylboric acid and 10 ml of toluene were charged at room temperature. The mixture was stirred for 3 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 mmol/ml, toluene solution) was charged, successively, 0.5 ml

result, 1.97 g of an ethylene-1-hxene copolymer was obtained. The polymerization activity, SCB, Mw and Mw/Mn were 3.9×10^6 g/mol-Zr/hour, 16.4, 66000 and 2.1, respectively.

10 Comparative Example 1

Example 1 was repeated except that 73.9 mg of the white crystal used in Example 1 (2) was changed to 49.8 mg (113 μ mol) of tripheny bismuth. As a result, only a trace of an ethylene-1-hxene copolymer was obtained.

15

Comparative Example 2

Example 1 was repeated except that 73.9 mg of the white crystal used in Example 1 (2) was changed to 60.9 mg (71.6 μ mol) of the yellow crystal prepared in Example 1 (1). As a
20 result, only a trace of an ethylene-1-hxene copolymer was obtained.

Comparative Example 3

(1) Preparation of bismuth compound

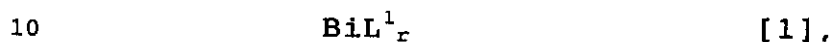
25 Into a 100 ml four-necked flask purged with argon, 0.957 g (1.13 mmol) of the yellow crystal prepared in Example 1 (1) and 30 ml of toluene were charged. Thereto, 0.120 g (0.568 mmol) of pentafluorophenylboronic acid and 10 ml of toluene were charged at room temperature. The mixture was stirred for
30 three hours under a refluxing condition to obtain a toluene

(2) Production of addition polymer

Example 1 (2) was repeated except that 73.9 mg of the white crystal used therein was changed to 5 ml of the solution obtained in the above (1). As a result, only a trace of an
10 ethylene-1-hxene copolymer was obtained.

to 8 mol, and the amount of the component (c) contacted is from 0.6 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]



15

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



20 wherein r is a valence of Bi; 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 T; R^1 is an
25 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 2 or 3; J is an atom of the Group 13 in the periodic table; and R^2 is a hydrocarbon group, and when two or more R^2 's exist, they may
30 be the same or different from one another.

is a halogenated hydrocarbon group.

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

10

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

6. The metal compound according to Claim 1, wherein Bi
15 has a valence of 3.

7. The metal compound according to Claim 1, wherein J
is a boron atom.

8. A catalyst component for addition polymerization
20 comprising a metal compound according to Claim 1.

9. A catalyst for addition polymerization obtained by
a process comprising the step of contacting a catalyst component
25 for addition polymerization according to Claim 8 with a compound
(B) of a metal selected from the group consisting of metals
of Groups 3 to 12 and lanthanide series, and optionally an
organoaluminum compound (C).

10. The catalyst for addition polymerization according
30

polymerization according to Claim 9.

12. The process for producing an addition polymer
according to Claim 11, wherein the addition polymerizable
10 monomer is an olefin.

13. The process for producing an addition polymer
according to Claim 11, wherein the addition polymerizable
monomer is a combination of ethylene and an α -olefin.

15