

TRANSITION METAL COMPOUND, OLEFIN POLYMERIZATION
CATALYST COMPONENT, OLEFIN POLYMERIZATION CATALYST AND
PROCESS FOR PRODUCING OLEFIN POLYMER

5

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a transition metal compound useful as an olefin polymerization catalyst component, an olefin polymerization catalyst using said transition metal compound and process for producing an olefin polymer using said olefin polymerization catalyst with a high activity.

Description of the Related Art

Many processes for producing an olefin polymer with a metallocene complex have been already reported. For example, a process for producing an olefin polymer with a metallocene complex and an aluminoxane is reported in Japanese Patent Publication (Kokai) No.58-19306. The metallocene complex disclosed therein is a complex having only one transition metal atom in its molecule.

It is disclosed in Japanese Patent Publication (Kokai) No.4-91095 to use a metallocene complex having a structure in which two transition metal atoms are contained in its molecule and two η^5 -cyclopentadienyl groups coordinate on each of the transition metal atoms, as an olefin polymerization catalyst component.

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However, when these metallocene complexes having the structure in which two η^5 -cyclopentadienyl groups coordinate on one transition metal atom are used as the olefin polymerization catalyst component, there are
5 problems that the molecular weight of an olefin polymer obtained is low and the comonomer reaction rate in copolymerization is low, and the more improvement of activity has been desired from an industrial viewpoint.

Although metallocene complexes in which two
10 transition metal atoms are contained in its molecule and only one η^5 -cyclopentadienyl group coordinates on each of transition metal atoms are disclosed in Japanese Patent Publication (Kokai) Nos.3-163088 and 3-188092, they are complexes having a peculiar structure in which
15 excessive anionic ligands against the valence number of a transition metal atom are combined, and its polymerization activity is not confirmed.

Although a metallocene complex in which two transition metal atoms are contained in its molecule and
20 only one η^5 -cyclopentadienyl group coordinates per one transition metal atom is disclosed in Japanese Patent Publication (Kokai) No.7-126315, it is a complex having a structure in which those two η^5 -cyclopentadienyl groups are linked, and there are problems in that the
25 olefin polymerization catalyst using it as a catalyst component has low copolymerizability and the melting point of a copolymer obtained is high, and more

improvement of activity has been desired from an industrial viewpoint.

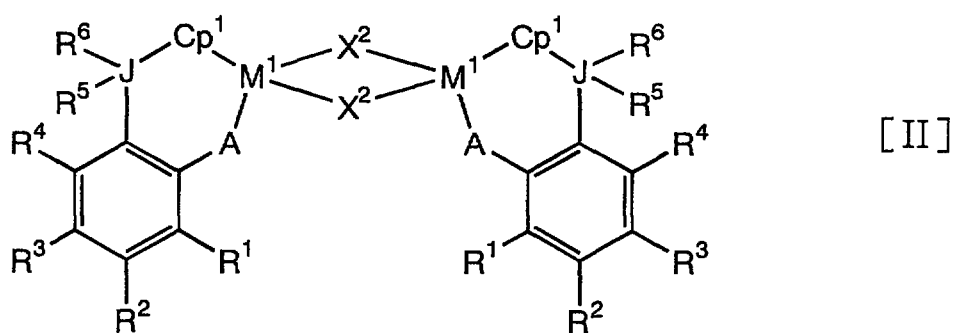
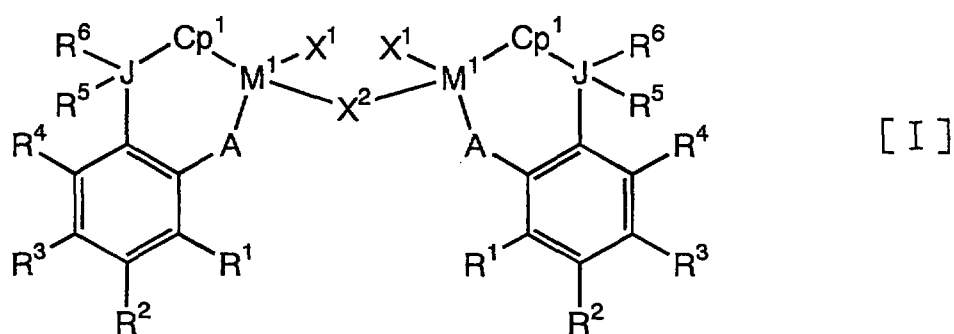
SUMMARY OF THE INVENTION

5 Under these situations, the objects of the present invention are to provide a transition metal compound useful as a highly active olefin polymerization catalyst component at an efficient reaction temperature in the industrial process of important olefin polymerization
10 from an industrial view point, and to provide a highly active olefin polymerization catalyst using said transition metal compound and a process for producing an olefin polymer using said olefin polymerization catalyst.

15 In order to attain the above-mentioned objects, the present inventors have intensively studied a process for producing an olefin polymer using a metallocene transition metal compound, in particular, a mono cyclopentadienyl transition metal compound as one of
20 catalyst components, and have thus completed the present invention.

The present invention relates to a transition metal compound represented by the general formula [I] or [II] described below, an olefin polymerization
25 catalyst component comprising said transition metal compound, an olefin polymerization catalyst prepared by a process comprising contacting a transition metal

compound selected from the group consisting of transition metal compounds represented by the general formulas [I] and [II], and [(B) described below and/or (C)] described below, and a process for producing an olefin polymer with said olefin polymerization catalyst.



(wherein M¹ indicates a transition metal atom of the Group IV of the Periodic Table of the Elements; A indicates an atom of the Group XVI of the Periodic Table of the Elements; J indicates an atom of the Group XIV of the Periodic Table of the Elements; Cp¹ indicates a group having a cyclopentadiene type anion skeleton; each of X¹, R¹, R², R³, R⁴, R⁵ and R⁶ independently indicates a hydrogen atom, a halogen atom, an alkyl group, an

aralkyl group, an aryl group, a substituted silyl group,
an alkoxy group, an aralkyloxy group, an aryloxy group
or a di-substituted amino group; X^2 indicates an atom
of Group XVI of the Periodic Table of the Elements; R^1 ,
5 R^2 , R^3 , R^4 , R^5 and R^6 may be optionally combined with each
other to form a ring; and a plural number of M^1 , A, J,
 Cp^1 , X^1 , X^2 , R^1 , R^2 , R^3 , R^4 , R^5 and R^6 may be respectively
the same or different.)

(B) at least one aluminum compound selected from (B1)
10 to (B3) described below:

(B1) an organoaluminum compound indicated by the
general formula $E^1_a AlZ_{3-a}$;

(B2) a cyclic aluminoxane having a structure
indicated by the general formula $\{-Al(E^2)-O-\}_b$; and

15 (B3) a linear aluminoxane having a structure
indicated by the general formula $E^3\{-Al(E^3)-O-\}_c AlE^3_2$
(wherein each of E^1 , E^2 and E^3 is a hydrocarbon group,
and all of E^1 , all of E^2 and all of E^3 may be the same
or different; Z represents a hydrogen atom or a halogen
20 atom; and all of Z may be the same or different; a
represents a number satisfying an expression of $0 < a$
 ≤ 3 ; b represents an integer of 2 or more; and c
represents an integer of 1 or more).

(C) any one of boron compounds of (C1) to (C3) described
25 below:

(C1) a boron compound represented by the general
formula $BQ^1Q^2Q^3$;

(C2) a boron compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$; and

(C3) a boron compound represented by the general formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$

5 (wherein B is a boron atom in the trivalent valence state; Q^1 to Q^4 are a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a substituted silyl group, an alkoxy group or a di-substituted amino group which may be the same or different; G^+ is an inorganic
10 or organic cation; L is a neutral Lewis base; and $(L-H)^+$ is a Brønsted acid).

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 shows a flow chart for assisting the
15 understanding of the present invention. The flow chart is a typical example of the mode of operation of the present invention, but the present invention is not limited thereto.

20 DETAILED DESCRIPTION OF THE INVENTION

The present invention is further illustrated in detail below.

(A) Transition metal compound:

In the general formula [I] or [II], the transition
25 metal atom represented by M^1 indicates a transition metal element of the Group IV of the Periodic Table of the Elements (Revised edition of IUPAC Inorganic Chemistry

Nomenclature 1989), and examples thereof include a titanium atom, a zirconium atom, a hafnium atom and the like. A titanium atom or a zirconium atom is preferable.

5 Examples of the atom of the Group XVI of the Periodic Table of the Elements indicated as A in the general formula [I] or [II] include an oxygen atom, a sulfur atom, a selenium atom and the like, and an oxygen atom is preferable.

10 Examples of the atom of the Group XIV of the Periodic Table of the Elements indicated as J in the general formula [I] or [II] include a carbon atom, a silicon atom, a germanium atom and the like, and a carbon atom or a silicon atom is preferable.

15 Examples of the group having a cyclopentadiene type anion skeleton indicated as the substituent group, Cp¹, include an η^5 -(substituted)cyclopentadienyl group, an η^5 -(substituted)indenyl group, an η^5 -(substituted)fluorenyl group and the like. Specific examples include an η^5 -cyclopentadienyl group, an η^5 -
20 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-
25 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 -n-
pentylcyclopentadienyl group, an η^5 -
neopentylcyclopentadienyl group, an η^5 -n-
5 hexylcyclopentadienyl group, an η^5 -n-
octylcyclopentadienyl group, an η^5 -
phenylcyclopentadienyl group, an η^5 -
naphthylcyclopentadienyl group, an η^5 -
trimethylsilylcyclopentadienyl group, an η^5 -
10 triethylsilylcyclopentadienyl group, an η^5 -tert-
butyldimethylsilylcyclopentadienyl group, an η^5 -
indenyl group, an η^5 -methylindenyl group, an η^5 -
dimethylindenyl group, an η^5 -ethylindenyl group, an η^5 -
n-propylindenyl group, an η^5 -isopropylindenyl group,
15 an η^5 -n-butylindenyl group, an η^5 -sec-butylindenyl
group, an η^5 -tert-butylindenyl group, an η^5 -n-
pentylindenyl group, an η^5 -neopentylindenyl group,
an η^5 -n-hexylindenyl group, an η^5 -n-octylindenyl
group, an η^5 -n-decylindenyl group, an η^5 -
20 phenylindenyl group, an η^5 -methylphenylindenyl group,
an η^5 -naphthylindenyl group, an η^5 -
trimethylsilylindenyl group, an η^5 -
triethylsilylindenyl group, an η^5 -tert-
butyldimethylsilylindenyl group, an η^5 -
25 tetrahydroindenyl group, an η^5 -fluorenyl group, an η^5 -
methylfluorenyl group, an η^5 -dimethylfluorenyl
group, an η^5 -ethylfluorenyl group, an η^5 -

diethylfluorenyl group, an η^5 -n-propylfluorenyl group,
an η^5 -di-n-propylfluorenyl group, an η^5 -
isopropylfluorenyl group, an η^5 -diisopropylfluorenyl
group, an η^5 -n-butylfluorenyl group, an η^5 -sec-
5 butylfluorenyl group, an η^5 -tert-butylfluorenyl group,
an η^5 -di-n-butylfluorenyl group, an η^5 -di-sec-
butylfluorenyl group, an η^5 -di-tert-butylfluorenyl
group, an η^5 -n-pentylfluorenyl group, an η^5 -
neopentylfluorenyl group, an η^5 -n-hexylfluorenyl
10 group, an η^5 -n-octylfluorenyl group, an η^5 -n-
decylfluorenyl group, an η^5 -n-dodecylfluorenyl group,
an η^5 -phenylfluorenyl group, an η^5 -diphenylfluorenyl
group, an η^5 -methylphenylfluorenyl group, an η^5 -
naphthylfluorenyl group, an η^5 -
15 trimethylsilylfluorenyl group, an η^5 -bis-
trimethylsilylfluorenyl group, an η^5 -
triethylsilylfluorenyl group, an η^5 -tert-
butyldimethylsilylfluorenyl group and the like. An η^5 -
 η^5 -cyclopentadienyl group, an η^5 -
20 methylcyclopentadienyl group, an η^5 -tert-
butylcyclopentadienyl group, an η^5 -
tetramethylcyclopentadienyl group, an η^5 -indenyl
group or an η^5 -fluorenyl group is preferable.

As the halogen atom in the substituent, X^1 , R^1 , R^2 ,
25 R^3 , R^4 , R^5 or R^6 , a fluorine atom, a chlorine atom, a
bromine atom, and an iodine atom are illustrated. A
chlorine atom or a bromine atom is preferable and a

chlorine atom is more preferable.

As the alkyl group in the substituent, X^1 , R^1 , R^2 , R^3 , R^4 , R^5 or R^6 , an alkyl group having 1 to 20 carbon atoms is preferred, and examples include 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, a n-pentyl group, a neopentyl group, a sec-amyl group, a n-hexyl group, a n-octyl group, a n-decyl group, a n-dodecyl group, a n-pentadecyl group, a n-eicosyl group and the like, and a methyl group, an ethyl group, an isopropyl group, a tert-butyl group or a sec-amyl group is more preferable.

All of these alkyl groups may be substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom or an iodine atom. Examples of the alkyl group having 1 to 20 carbon atoms which is substituted with the halogen atom, include 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, pentachloroethyl group, a

bromoethyl group, a dibromoethyl group, a tribromoethyl group, a tetrabromoethyl group, 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, a perbromoeicosyl group and the like.

Further, all of these alkyl groups may be partially substituted with an alkoxy group such as a methoxy group, an ethoxy group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy group or the like, etc.

As the aralkyl group in the substituent, X^1 , R^1 , R^2 , R^3 , R^4 , R^5 or R^6 , an aralkyl group having 7 to 20 carbon atoms is preferable, and examples thereof include 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 (3,5-
dimethylphenyl)methyl group, a (2,3,4-
5 trimethylphenyl)methyl group, a (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-
10 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 group, a (n-propylphenyl)methyl
15 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, a (n-
20 octylphenyl)methyl group, a (n-decylphenyl)methyl
group, a (n-dodecylphenyl)methyl group, a
naphthylmethyl group, an anthracenylmethyl group and
the like, and a benzyl group is more preferable.

All of these aralkyl groups may be partially
25 substituted with a halogen atom such as a fluorine atom,
a chlorine atom, a bromine atom or an iodine atom, an
alkoxy group such as a methoxy group, an ethoxy group

or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy group or the like, etc.

As the aryl group in the substituent, X^1 , R^1 , R^2 ,
5 R^3 , R^4 , R^5 or R^6 , an aryl group having 6 to 20 carbon atoms is preferable, and examples thereof include 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, a 3,4-xylyl group, a 3,5-xylyl group,
10 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 2,3,4,6-tetramethylphenyl group, a 2,3,5,6-tetramethylphenyl group, a pentamethylphenyl group, an ethylphenyl group,
15 a n-propylphenyl group, an isopropylphenyl group, a n-butylphenyl group, a sec-butylphenyl group, a tert-butylphenyl 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, an anthracenyl group and the like, and a phenyl group is more preferable.

All of these aryl groups may be partially
25 substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom, an iodine atom or the like, an alkoxy group such as a methoxy group, an ethoxy

group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy group or the like, etc.

The substituted silyl group in the substituent, X^1 ,
5 R^1 , R^2 , R^3 , R^4 , R^5 or R^6 is a silyl group substituted with
a hydrocarbon group, and examples of the hydrocarbon
group include alkyl groups having 1 to 10 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,
10 a tert-butyl group, an isobutyl group, a n-pentyl group,
a n-hexyl group, a cyclohexyl group and the like, and
aryl groups such as a phenyl group and the like, etc.
Examples of such substituted silyl group having 1 to 20
carbon atoms include mono-substituted silyl groups
15 having 1 to 20 carbon atoms such as a methylsilyl group,
an ethylsilyl group, a phenylsilyl group and the like;
di-substituted silyl groups having 2 to 20 carbon atoms
such as a dimethylsilyl group, a diethylsilyl group, a
diphenylsilyl group and the like; and tri-substituted
20 silyl groups having 3 to 20 carbon atoms such as a
trimethylsilyl group, a 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,
25 a tert-butyl-dimethylsilyl group, a tri-n-pentylsilyl
group, a tri-n-hexylsilyl group, a tricyclohexylsilyl
group, a triphenylsilyl group and the like, and a

trimethylsilyl group, a tert-butyldimethylsilyl group or a triphenylsilyl group is preferable.

5 All of the hydrocarbon groups of these substituted silyl groups may be partially substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom or an iodine atom, an alkoxy group such as a methoxy group, an ethoxy group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy group or the like, etc.

10 As the alkoxy group in the substituent X^1 , R^1 , R^2 , R^3 , R^4 , R^5 or R^6 , an alkoxy group having 1 to 20 carbon atoms is preferable, and examples thereof include a methoxy group, an ethoxy group, a n-propoxy group, an isopropoxy group, a n-butoxy group, a sec-butoxy group, 15 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, a n-eicosoxy group and the like, and a methoxy group, an ethoxy group or a tert-butoxy group is preferable.

20 All of these alkoxy groups may be partially substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom, an iodine atom or the like, an alkoxy group such as a methoxy group, an ethoxy group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a 25 benzyloxy group or the like, etc.

As the aralkyloxy group in the substituent, X^1 ,

R^1 , R^2 , R^3 , R^4 , R^5 or R^6 , an aralkyloxy group having 7 to 20 carbon atoms is preferable, and examples thereof include a benzyloxy group, a (2-methylphenyl)methoxy group, a (3-methylphenyl)methoxy 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 (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 (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 (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, 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, an anthracenylmethoxy group and the like, and a benzyloxy group is more preferable.

All of these aralkyloxy groups may be partially substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom or an iodine atom, an alkoxy group such as a methoxy group, an ethoxy group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy group or the like, etc.

As the aryloxy group in the substituent, X^1 , X^2 , R^1 , R^2 , R^3 , R^4 , R^5 or R^6 , an aryloxy group having 6 to 20 carbon atoms is preferable, and examples thereof include 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, 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, a

n-hexylphenoxy group, a n-octylphenoxy group, a n-decylphenoxy group, a n-tetradecylphenoxy group, a naphthoxy group, an anthracenoxy group and the like.

5 All of these aryloxy groups may be partially substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom or an iodine atom, an alkoxy group such as a methoxy group, an ethoxy group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy
10 group or the like, etc.

The di-substituted amino group in the substituent, X^1 , R^1 , R^2 , R^3 , R^4 , R^5 or R^6 is an amino group substituted with two hydrocarbon groups, and examples of the hydrocarbon group include alkyl groups having 1 to 10
15 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, a cyclohexyl group and the like; aryl groups having 6 to 10 carbon atoms
20 such as a phenyl group and the like; aralkyl groups having 7 to 10 carbon atoms, etc. Examples of such di-substituted amino group substituted with the hydrocarbon group having 1 to 10 carbon atoms include 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
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tert-butyliisopropylamino group, a di-n-hexylamino group, a di-n-octylamino group, a di-n-decylamino group, a diphenylamino group, a bistrimethylsilylamino group, a bis-tert-butyldimethylsilylamino group and the like,
5 and a dimethylamino group or an diethylamino group is preferable.

All of these di-substituted amino groups may be partially substituted with a halogen atom such as a fluorine atom, a chlorine atom, a bromine atom or an
10 iodine atom, an alkoxy group such as a methoxy group, an ethoxy group or the like, an aryloxy group such as a phenoxy group or the like or an aralkyloxy group such as a benzyloxy group or the like, etc.

The substituent, R^1 , R^2 , R^3 , R^4 , R^5 and R^6 may be
15 optionally combined with each other to form a ring.

Each of R^1 is preferably an alkyl group, an aralkyl group, an aryl group or a substituted silyl group, independently.

Each of X^1 is preferably a halogen atom, an alkyl group, an aralkyl group, an alkoxy group, an aryloxy group or a di-substituted amino group, independently.
20 An alkoxy group is more preferable.

Examples of the atom of Group XVI of the Periodic Table of the Elements indicated as X^2 in the general
25 formula [I] or [II] include an oxygen atom, a sulfur atom, a selenium atom and the like, and an oxygen atom is preferable.

Examples of such transition metal compound [I]
include μ -oxobis{isopropylidene(η^5 -
cyclopentadienyl)(2-phenoxy)titanium chloride},
 μ -oxobis{isopropylidene(η^5 -cyclopentadienyl)(2-
5 phenoxy)titanium methoxide},
 μ -oxobis{isopropylidene(η^5 -cyclopentadienyl)(3-
tert-butyl-5-methyl-2-phenoxy)titanium chloride},
 μ -oxobis{isopropylidene(η^5 -cyclopentadienyl)(3-
tert-butyl-5-methyl-2-phenoxy)titanium methoxide},
10 μ -oxobis{isopropylidene(η^5 -methylcyclopentadienyl)
(2-phenoxy)titanium chloride}, μ -
oxobis{isopropylidene(η^5 -methylcyclopentadienyl)
(2-phenoxy)titanium methoxide}, μ -
oxobis{isopropylidene(η^5 -methylcyclopentadienyl)(3-
15 tert-butyl-5-methyl-2-phenoxy)titanium chloride}, μ -
oxobis{isopropylidene(η^5 -
methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-
phenoxy)titanium methoxide}, μ -oxobis{isopropylidene
(η^5 -tetramethylcyclopentadienyl)(2-phenoxy)titanium
20 chloride}, μ -oxobis{isopropylidene(η^5 -
tetramethylcyclopentadienyl)(2-phenoxy)titanium
methoxide}, μ -oxobis{isopropylidene(η^5 -
tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-
2-phenoxy)titanium chloride}, μ -
25 oxobis{isopropylidene(η^5 -
tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-
2-phenoxy)titanium methoxide}, μ -

- oxobis{dimethylsilylene(η^5 -cyclopentadienyl)(2-phenoxy)titanium chloride}, μ -
oxobis{dimethylsilylene(η^5 -cyclopentadienyl)(2-phenoxy)titanium methoxide}, μ -
- 5 oxobis{dimethylsilylene(η^5 -cyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium chloride},
 μ -oxobis{dimethylsilylene(η^5 -cyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide},
 μ -oxobis{dimethylsilylene(η^5 -
- 10 methylcyclopentadienyl)(2-phenoxy)titanium chloride},
 μ -oxobis{dimethylsilylene(η^5 -methylcyclopentadienyl)(2-phenoxy)titanium methoxide}, μ -oxobis{dimethylsilylene(η^5 -methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-
- 15 phenoxy)titanium chloride}, μ -oxobis{dimethylsilylene(η^5 -methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide}, μ -oxobis{dimethylsilylene(η^5 -
- 20 tetramethylcyclopentadienyl)(2-phenoxy)titanium chloride}, μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(2-phenoxy)titanium methoxide}, μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-
- 25 2-phenoxy)titanium chloride}, μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-

2-phenoxy)titanium methoxide} and the like.

Examples of such transition metal compound [II] include di- μ -oxobis{isopropylidene(η^5 -cyclopentadienyl)(2-phenoxy)titanium}, di- μ -
5 oxobis{isopropylidene(η^5 -cyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium}, di- μ -oxobis{isopropylidene(η^5 -methylcyclopentadienyl)(2-phenoxy)titanium}, di- μ -oxobis{isopropylidene(η^5 -methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-
10 phenoxy)titanium}, di- μ -oxobis{isopropylidene(η^5 -tetramethylcyclopentadienyl)(2-phenoxy)titanium}, di- μ -oxobis{isopropylidene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium}, di- μ -oxobis{dimethylsilylene
15 (η^5 -cyclopentadienyl)(2-phenoxy)titanium}, di- μ -oxobis{dimethylsilylene(η^5 -cyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium}, di- μ -oxobis{dimethylsilylene(η^5 -methylcyclopentadienyl)(2-phenoxy)titanium}, di- μ -oxobis{dimethylsilylene
20 (η^5 -methylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium}, di- μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(2-phenoxy)titanium}, di- μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-
25 phenoxy)titanium} and the like.

The transition metal compound represented by the general formula [I] or [II] can be produced, for example,

by reacting a transition metal compound obtained according to the method described in the WO 97/03992 with 0.5-fold by mole or 1-fold by mole of water. Wherein a method of directly reacting a transition metal compound with a required amount of water, a method of charging a transition metal compound in a solvent such as a hydrocarbon containing a required amount of water, or the like, a method of charging a transition metal compound in a solvent such as a dry hydrocarbon or the like and further flowing an inert gas containing a required amount of water, or the like, etc. can be adopted.

(B) Aluminum compound

The aluminum compound (B) used in the present invention is at least one organoaluminum compound selected from (B1) to (B3) described below:

(B1) an organoaluminum compound indicated by the general formula $E^1_a AlZ_{3-a}$;

(B2) a cyclic aluminoxane having a structure indicated by the general formula $\{-Al(E^2)-O-\}_b$; and

(B3) a linear aluminoxane having a structure indicated by the general formula $E^3\{-Al(E^3)-O-\}_c AlE^3$, (wherein each of E^1 , E^2 and E^3 is a hydrocarbon group; all of E^1 , all of E^2 and all of E^3 may be the same or different; Z represents a hydrogen atom or a halogen atom; all of Z may be the same or different; a represents a number satisfying an expression of $0 < a \leq 3$; b

represents an integer of 2 or more; and c represents an integer of 1 or more).

As the hydrocarbon group in E^1 , E^2 or E^3 , a hydrocarbon group having 1 to 8 carbon atoms is preferable and an alkyl group is more preferable.

Specific examples of the organoaluminum compound (B1), indicated by the general formula $E^1_a AlZ_{3-a}$ include trialkylaluminums such as trimethylaluminum, triethylaluminum, tri-n-propylaluminum, triisopropylaluminum, triisobutylaluminum, tri-n-hexylaluminum and the like; dialkylaluminum chlorides such as dimethylaluminum chloride, diethylaluminum chloride, di-n-propylaluminum chloride, diisopropylaluminum chloride, diisobutylaluminum chloride, di-n-hexylaluminum chloride and the like; alkylaluminum dichlorides such as methylaluminum dichloride, ethylaluminum dichloride, n-propylaluminum dichloride, isopropylaluminum dichloride, isobutylaluminum dichloride, n-hexylaluminum dichloride and the like; and dialkylaluminum hydrides such as dimethylaluminum hydride, diethylaluminum hydride, di-n-propylaluminum hydride, diisopropylaluminum hydride, diisobutylaluminum hydride, di-n-hexylaluminum hydride and the like, etc.

Trialkylaluminum is preferable and triethylaluminum or triisobutylaluminum is more preferable.

Specific examples of E^2 and E^3 in the cyclic
aluminoxane(B2) having a structure indicated by the
general formula $\{-Al(E^2)-O-\}_b$ and the linear
aluminoxane(B3) having a structure indicated by the
5 general formula $E^3\{-Al(E^3)-O-\}_cAlE^3$, include alkyl groups
such as a methyl group, an ethyl group, a n-propyl group,
an isopropyl group, a n-butyl group, an isobutyl group,
a n-pentyl group, a neopentyl group and the like. b is
an integer of 2 or more, and c is an integer of 1 or more.
10 Preferably, each of E^2 and E^3 is a methyl group or an
isobutyl group, b is 2 to 40 and c is 1 to 40.

The above-mentioned aluminoxane is prepared by
various methods. The method is not specifically limited,
and the aluminoxane may be prepared according to
15 publicly known processes.

For example, the aluminoxane is prepared by
contacting a solution of a trialkylaluminum (e.g.
trimethylaluminum or the like) dissolved in a suitable
organic solvent (e.g. benzene, an aliphatic hydrocarbon
20 or the like) with water. Further, there is exemplified
a process for preparing the aluminoxane by contacting
a trialkylaluminum (e.g. trimethylaluminum, etc.) with
a metal salt containing crystal water (e.g. copper
sulfate hydrate, etc.).

25 (C) Boron compound

As the boron compound (C) in the present invention,
any one of the boron compound (C1) represented by the

general formula $BQ^1Q^2Q^3$, the boron compound (C2) represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$ and the boron compound (C3) represented by the general formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$ can be used.

5 In the boron compound (C1) represented by the general formula $BQ^1Q^2Q^3$, B represents a boron atom in the trivalent valence state; Q^1 to Q^3 are respectively a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a substituted silyl group, an alkoxy
10 group or a di-substituted amino group and they may be the same or different. Each of Q^1 to Q^3 is preferably a halogen atom, a hydrocarbon group having 1 to 20 carbon atoms, a halogenated hydrocarbon group having 1 to 20 carbon atoms, a substituted silyl group having 1 to 20
15 carbon atoms, an alkoxy group having 1 to 20 carbon atoms or a di-substituted amino group having 2 to 20 carbon atoms, and each of more preferable Q^1 to Q^3 is a halogen atom, a hydrocarbon group having 1 to 20 carbon atoms or a halogenated hydrocarbon group having 1 to 20 carbon
20 atoms. Each of the more preferable Q^1 to Q^4 is a fluorinated hydrocarbon group having 1 to 20 carbon atoms which contains at least one fluorine atom, and in particular, each of Q^1 to Q^4 is preferably a fluorinated aryl group having 6 to 20 carbon atoms which contains
25 at least one fluorine atom.

Specific examples of the compound (C1) include tris(pentafluorophenyl)borane, tris(2,3,5,6-

tetrafluorophenyl)borane, tris(2,3,4,5-tetrafluorophenyl)borane, tris(3,4,5-trifluorophenyl)borane, tris(2,3,4-trifluorophenyl)borane,
5 phenylbis(pentafluorophenyl)borane and the like, and tris(pentafluorophenyl)borane is most preferable.

In the boron compound (C2) represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$, G^+ is an inorganic or organic cation; B is a boron atom in the trivalent valence
10 state; and Q^1 to Q^4 are the same as defined in Q^1 to Q^3 in the above-mentioned (C1).

Specific examples of G^+ as the inorganic cation in the compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$ include a ferrocenium cation, an alkyl-substituted ferrocenium cation, a silver cation and the
15 like, and the G^+ as the organic cation includes a triphenylmethyl cation and the like. G^+ is preferably a carbenium cation, and a triphenylmethyl cation is particularly preferred. As the $(BQ^1Q^2Q^3Q^4)^-$,
20 tetrakis(pentafluorophenyl)borate, tetrakis(2,3,5,6-tetrafluorophenyl)borate, tetrakis(2,3,4,5-tetrafluorophenyl)borate, tetrakis(3,4,5-trifluorophenyl)borate, tetrakis(2,3,4-trifluorophenyl)borate,
25 phenyltris(pentafluorophenyl)borate, tetrakis(3,5-bistrifluoromethylphenyl)borate and the like are mentioned.

These specific combinations include ferrocenium tetrakis(pentafluorophenyl)borate, 1,1'-dimethylferrocenium tetrakis(pentafluorophenyl)borate, silver tetrakis(pentafluorophenyl)borate, 5 triphenylmethyl tetrakis(pentafluorophenyl)borate, triphenylmethyl tetrakis(3,5-bistrifluoromethylphenyl)borate and the like, and triphenylmethyl tetrakis(pentafluorophenyl)borate is most preferable.

Further, in the boron compound (C3) represented 10 by the formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$, L is a neutral Lewis base; $(L-H)^+$ is a Brønsted acid; B is a boron atom in the trivalent valence state; and Q^1 to Q^4 are the same as Q^1 to Q^3 in the above-mentioned Lewis acid (C1).

Specific examples of $(L-H)^+$ as the Brønsted acid in 15 the compound represented by the formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$ include a trialkyl-substituted ammonium, an N,N-dialkylanilinium, a dialkylammonium, a triarylphosphonium and the like, and examples of $(BQ^1Q^2Q^3Q^4)^-$ include those as previously described.

20 These specific combinations include triethylammonium tetrakis(pentafluorophenyl)borate, tripropylammonium tetrakis(pentafluorophenyl)borate, tri(n-butyl)ammonium tetrakis(pentafluorophenyl)borate, tri(n- 25 butyl)ammonium tetrakis(3,5-bistrifluoromethylphenyl)borate, N,N-dimethylanilinium tetrakis(pentafluorophenyl)borate,

N,N-diethylanilinium
tetrakis(pentafluorophenyl)borate, N,N-2,4,6-
pentamethylanilinium tetrakis(pentafluorophenyl)
borate, N,N-dimethylanilinium tetrakis(3,5-
5 bistrifluoromethylphenyl)borate, diisopropylammonium
tetrakis(pentafluorophenyl)borate,
dicyclohexylammonium
tetrakis(pentafluorophenyl)borate,
triphenylphosphonium
10 tetrakis(pentafluorophenyl)borate,
tri(methylphenyl)phosphonium
tetrakis(pentafluorophenyl)borate,
tri(dimethylphenyl)phosphonium
tetrakis(pentafluorophenyl)borate and the like, and
15 tri(n-butyl)ammonium
tetrakis(pentafluorophenyl)borate or N,N-
dimethylanilinium tetrakis(pentafluorophenyl)borate is
most preferable.

[Polymerization of olefin]

20 In the present invention, the olefin
polymerization catalyst is prepared by a process
comprising contacting the transition metal compound(A)
represented by the general formula [I] and/or [II] and
[the above-mentioned(B) and/or the above-mentioned (C)].
25 In case of an olefin polymerization catalyst prepared
by using the transition metal compound (A) and the
above-mentioned(B), the fore-mentioned cyclic

aluminoxane (B2) and/or the linear aluminoxane (B3) is preferable as (B). Further, as another preferable mode of an olefin polymerization catalyst, an olefin polymerization catalyst prepared by using the
5 transition metal compound, (A), the above-mentioned(B) and the above-mentioned (C) is illustrated, and the fore-mentioned (B1) is also easily used as said (B).

In the present invention, the transition metal compound (A) represented by the general formula [I]
10 and/or [II] and the above-mentioned(B), or further the above-mentioned(C) can be charged in an arbitrary order during polymerization to be used, but a reaction product obtained by previously contacting an arbitrary combination of those compounds may be also used.

15 The used amount of respective components is not specifically limited, and it is desirable to usually use the respective components so that the molar ratio of the (B)/transition metal compound (A) is 0.1 to 10000 and preferably 5 to 2000, and the molar ratio of the
20 (C)/transition metal compound (A) is 0.01 to 100 and preferably 0.5 to 10.

When the respective components are used in a solution condition or a condition in which they are suspended or slurried in a solvent, the concentration
25 of the respective components is appropriately selected according to the conditions such as the ability of an apparatus for feeding the respective components in a

polymerization reactor. The respective components are desirably used so that the concentration of the transition metal compound (A) is usually 0.001 to 200 mmol/L, more preferably 0.001 to 100mmol/L and most preferably 0.05 to 50mmol/L; the concentration of (B) is usually 0.01 to 5000 mmol/L converted to Al atom, more preferably 0.1 to 2500mmol/L and most preferably 0.1 to 2000mmol/L; and the concentration of (C) is usually 0.001 to 500 mmol/L, more preferably 0.01 to 250 mmol/L and most preferably 0.05 to 100 mmol/L.

As olefins which can be applied to the polymerization in the present invention, olefins having 2 to 20 carbon atoms such as, particularly, ethylene and an α -olefin having 3 to 20 carbon atoms, diolefins having 4 to 20 carbon atoms and the like can be used, and two or more monomers can also be used, simultaneously. Specific examples of the olefin include straight-chain olefins such as ethylene, propylene, butene-1, pentene-1, hexene-1, heptene-1, octene-1, nonene-1, decene-1 and the like; branched olefins such as 3-methylbutene-1, 3-methylpentene-1, 4-methylpentene-1, 5-methylhexene-1 and the like; vinylcyclohexane, etc., but the present invention should not be limited to the above-mentioned compounds. Specific examples of the combination of monomers in case of conducting copolymerization include ethylene and propylene, ethylene and butene-1, ethylene and hexene-1, ethylene

and octene-1, propylene and butene-1 and the like, but the present invention should not be limited thereto.

The present invention can be effectively applied to the particular preparation of the copolymer of
5 ethylene and an α -olefin such as in particular, propylene, butene-1, 4-methylpentene-1, hexene-1, octene-1 or the like.

Polymerization processes should not be also specifically limited, and there can be a solvent
10 polymerization or slurry polymerization in which an aliphatic hydrocarbon such as butane, pentane, hexane, heptane, octane or the like; an aromatic hydrocarbon such as benzene, toluene or the like; or a halogenated hydrocarbon such as methylene dichloride or the like
15 used as a polymerization medium. Further, high pressure ionic polymerization in which the polymerization of an olefin is conducted without a solvent under which an olefin polymer is melt in a high temperature and high pressure olefin in a supercritical liquid condition, and
20 further, a gas phase polymerization in a gaseous monomer and the like are possible. Further, either of a continuous polymerization and a batch-wise polymerization are possible.

The polymerization temperature can be usually
25 adopted at a range of -50°C to 350°C and preferably 0°C to 300°C , and in particular, a range of 50°C to 300°C is preferable. The polymerization pressure can be adopted

at a range of atmospheric pressure to 350MPa and preferably atmospheric pressure to 300MPa, and in particular, a range of atmospheric pressure to 200MPa is preferable.

5 In general, the polymerization time is appropriately determined according to the kind of a desired polymer and a reaction apparatus, and the conditions are not specifically limited and a range of 1 minute to 20 hours can be adopted. Further, a chain
10 transfer agent such as hydrogen or the like can also be added to adjust the molecular weight of a copolymer in the present invention.

 The process for polymerizing the olefin polymer of the present invention is suitably carried out by a
15 high-pressure ionic polymerization process, in particular.

 Specifically, it is preferably carried out under a pressure of 30MPa or more and at a temperature of 300°C or more. It is more preferably carried out under a
20 pressure of 35 to 350MPa and at a temperature of 135 to 350°C.

 The polymerization form can be carried out in either a batch-wise manner or a continuous manner, but the continuous manner is preferable. As a reactor, a
25 stirring vessel type reactor or a tubular reactor can be used. The polymerization can be performed in a single reaction zone. Alternatively, the polymerization can

also be performed by partitioning one reactor into a plurality of reaction zones or connecting a plurality of reactors in series or parallel. In case of using a plurality of reactors, a combination of a vessel reactor and a vessel reactor or a combination of a vessel reactor and a tubular reactor may be used. In a polymerization process using a plurality of reaction zones or a plurality of reactors, polymers having different characteristics can also be produced by changing the temperature, pressure and gas composition of respective reaction zones or reactors.

EXAMPLE

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

Properties of the polymers in Examples were measured according to methods described below.

(1) Melt index (MFR) was measured at 190°C according to the method defined in JIS K-6760. (Unit: g/10min.)

(2) Density was determined according to JIS K-6760.

Wherein the value of density described as density (without annealing) is a value obtained by measuring without an annealing treatment in JIS K-6760. (Unit: g/cm³)

(3) Melting point of copolymer:

It was measured under the following conditions using

DSC7 manufactured by Perkin-Elmer Co.

Heating: heating to 150°C and maintaining until the change of calorie is stabilized

Cooling: 150 to 10°C (5°C/min.) and maintaining for
5 10 minutes

Measurement: 10 to 160°C (5°C/min.)

(4) Content of α -olefin:

It was determined from the characteristic absorption of ethylene and α -olefin using an infrared
10 spectrometer (FT-IR7300, manufactured by NIPPON BUNKO Inc.) and was represented as a short-chain branch (SCB) number per 1000 carbon atoms.

(5) Weight average molecular weight (M_w), number average molecular weight (M_n) and molecular weight
15 distribution (M_w/M_n):

They were determined under the following conditions using gel permeation chromatograph (150. C, manufactured by Waters Co.).

Column: TSK gel GMH-HT
20 Measurement temperature: set at 145°C

Measurement concentration: 10 mg/10 ml ortho-dichlorobenzene

(6) Intrinsic viscosity ($[\eta]$):

100mg of a copolymer obtained was dissolved in 50ml
25 of tetralin at 135°C and the solution was set in an oil bath maintained at 135°C. Using an Ubbelohde viscometer, the intrinsic viscosity was determined by the falling

speed of the tetralin solution in which said sample was dissolved. (Unit: dl/g)

Reference Example 1

[Synthesis of transition metal compound:

5 dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium dimethoxide)]

In a Schlenk tube, 0.131g (4.1mmol) of methanol was dissolved in 10ml of anhydrous diethyl ether and a diethyl ether solution (3.9ml, 4.1mmol) of
10 methylolithium having a concentration of 1.05mol/L was added dropwise at -78°C thereto. The resulting mixture was heated to 20°C , the formation of lithium methoxide was confirmed by gas generation, and the resulting reaction solution was again cooled to -78°C . Into the
15 reaction solution, 20ml of an anhydrous diethyl ether suspension liquid of 0.919g (2.0mmol) of dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium dichloride which was previously prepared in another Schlenk tube
20 was transferred, and then, the resulting reaction mixture was gradually heated to room temperature to obtain a reaction solution. After concentrating the reaction solution, 20ml of toluene was added and an insoluble product was separated by filtration. The
25 filtrate was concentrated to obtain dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium dimethoxide of yellow

crystals (0.86g, 95%).

$^1\text{H-NMR}$ (270MHz, C_6D_6); δ 7.26 (m, 2H), 4.13(s, 6H), 2.33 (s, 3H), 1.97(s, 6H), 1.89(s, 6H), 1.59(s, 9H), 0.55(s, 6H)

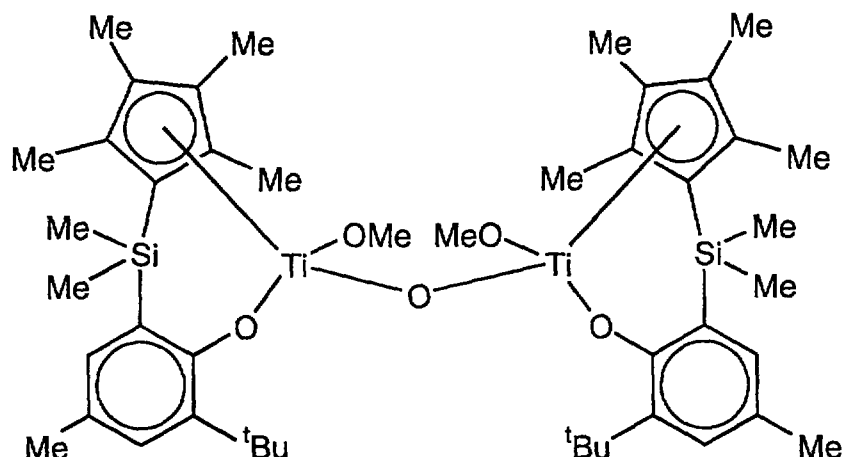
5 Reference Example 2

[Synthesis example of transition metal compound: μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)}(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide (Compound 1)]

10 Under a nitrogen atmosphere, 10.00g of dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium dimethoxide (the compound obtained by the same method as in Reference Example 1) was dissolved in 50ml of heptane, 0.30g of
15 distilled water was added thereto, and the mixture was stirred at the same temperature for 12 hours. The solid produced was separated by filtration, rinsed with 5.0ml of heptane, and then dried under vacuum to obtain
20 μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)}(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide of a yellow solid (5.51g, 56%).

Mass spectrum (m/e) 855. Calculated value: 855

25 $^1\text{H-NMR}$ (C_6D_6); δ 7.25 (d, $J=2.0$ Hz, 2H), 7.16 (d, $J=2.0$ Hz, 2H), 3.99(s, 6H), 2.32(s, 6H), 2.30 (s, 6H), 2.06(s, 6H), 1.86(s, 6H), 1.71(s, 6H), 1.27(s, 18H), 0.83(s, 6H), 0.63(s, 6H)



Reference Example 3

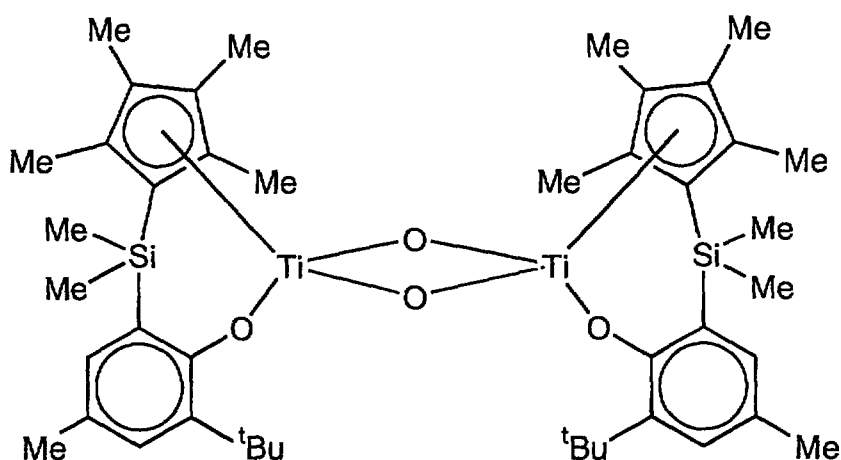
[Synthesis example of transition metal compound: di-
 μ -oxobis{dimethylsilylene(η^5 -tetramethyl
 5 cyclopentadienyl)(3-tert-butyl-5-methyl-2-
 phenoxy)titanium} (Compound 2)]

In a Schlenk tube, 1.50g (3.3mmol) of
 dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-
 tert-butyl-5-methyl-2-phenoxy)titanium dimethoxide
 10 was dissolved in 20ml of toluene, 10ml of water was added
 thereto, and the resulting liquid mixture was stirred
 at 70°C for 1 hour. After concentrating the organic layer
 which was obtained by phase separation, the concentrate
 was recrystallized from 10ml of heptane to obtain di-
 15 μ -oxobis {dimethylsilylene(η^5 -tetramethyl
 cyclopentadienyl)(3-tert-butyl-5-methyl-2-
 phenoxy)titanium} of yellow crystals (0.40g, 33%).
 Mass spectrum (m/e) 808. Calculated value: 808

$^1\text{H-NMR}$ (270MHz, C_6D_6); δ 7.28 (m, 4H), 2.32(s, 12H),
 20 1.97(s, 6H), 1.78(s, 6H), 1.59(s, 6H), 1.53(s, 18H),



0.78(s, 6H), 0.58(s, 6H)



5 Example 1

Using an autoclave type reactor having an inner volume of 1 liter equipped with a stirrer, polymerization was carried out by continuously feeding ethylene and hexene-1 into the reactor. Regarding the polymerization conditions, the total pressure was set to 80MPa and the concentration of hexene-1 based on the total of ethylene and hexene-1 was set to 28.8% by mole. A heptane solution (which was adjusted to be the concentration of Compound 1 of $0.37 \mu\text{mol/g}$, the concentration of triisobutylaluminum of $18.5 \mu\text{mol/g}$ and a molar ratio of Al atom to Ti atom of 25.) in which μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl) (3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide} (Compound 1) and triisobutylaluminum were mixed and a toluene solution

(0.90 μ mol/g) of N,N-dimethylaniliniumtetrakis
(pentafluorophenyl)borate were respectively prepared
in separate vessels. Each of the solutions was
continuously fed in the reactor at a feeding rate of 100
5 g/hour and 140 g/hour. The polymerization reaction
temperature was set at 222°C, and a molar ratio of boron
atom to Ti atom was set to 3.4. As a result, an
ethylene-hexene-1 copolymer having MFR of 8.39, a
density (without annealing) of 0.883 g/cm³, SCB of 36.0,
10 a weight average molecular weight (Mw) of 62000 and a
molecular weight distribution (Mw/Mn) of 1.9 was
produced at a rate of 74 ton per 1 mole of Ti atom.
Comparative Example 1

Using an autoclave type reactor having an inner
15 volume of 1 liter equipped with a stirrer,
polymerization was carried out by continuously feeding
ethylene and hexene-1 into the reactor. The total
pressure was set to 80MPa and the concentration of
hexene-1 based on the total of ethylene and hexene-1 was
20 set to 34% by mole. A hexane solution (0.7 μ mol/g) of
dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-
tert-butyl-5-methyl-2-phenoxy)titanium dichloride, a
heptane solution of triisobutylaluminum (33 μ mol/g) and
further a toluene solution (1.2 μ mol/g) of N,N-
25 dimethylaniliniumtetrakis(pentafluorophenyl)borate
were respectively prepared in separate vessels and
continuously fed into the reactor at feeding rates of

290 g/hour, 350g/hour and 580 g/hour, respectively. The polymerization reaction temperature was set at 215°C, and a molar ratio of boron atom to Ti atom was set to 3.3. As a result, an ethylene-hexene-1 copolymer having
5 MFR of 4.2, a density (without annealing) of 0.881g/cm³, a melting point of 67.3°C, SCB of 40.4, Mw of 66000 and Mw/Mn of 1.8 was produced in a rate of 14 ton per 1 mole of Ti atom.

Example 2

10 After replacing the atmosphere of an autoclave type reactor having an inner volume of 0.4 liter equipped with a stirrer with argon, 185ml of cyclohexane as a solvent and 15ml of hexene-1 as an α -olefin were charged and the reactor was heated to 180°C. After the elevation
15 of temperature, ethylene was fed while adjusting at an ethylene pressure of 2.5Mpa. After the system was stabilized, 0.2mmol of triisobutylaluminum, 0.5ml (namely, 0.5 μ mol of Compound 1 and 25 μ mol of triisobutylaluminum) of a heptane solution (which was
20 adjusted to be the concentration of Compound 1 of 1 μ mol/ml, the concentration of triisobutylaluminum of 50 μ mol/ml and a molar ratio of Al atom to Ti atom of 25.) in which μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-
25 2-phenoxy)titanium methoxide} (Compound 1) and triisobutylaluminum were mixed, were charged and successively, 1.5 μ mol of N,N-

dimethylaniliniumtetrakis(pentafluorophenyl)borate was charged as a slurry in heptane. Polymerization was carried out for 2 minutes. As a result of the polymerization, 2.53g of an ethylene-hexene-1 copolymer having $[\eta]$ of 0.85 dl/g, SCB of 31.4 and melting points of 78.6°C and 90.8°C was obtained. Polymerization activity per 1 mole of Ti atom was 2.53×10^6 g-polymer/mol-Ti atom per 2 minutes.

Example 3

After replacing the atmosphere of an autoclave type reactor having an inner volume of 0.4 liter equipped with a stirrer with argon, 185ml of cyclohexane as a solvent and 15ml of hexene-1 as an α -olefin were charged and the reactor was heated to 180°C. After the elevation of temperature, ethylene was fed while adjusting at an ethylene pressure of 2.5Mpa. After the inner of system was stabilized, 0.2mmol of triisobutylaluminum, 0.5ml (namely, 0.5 μ mol of Compound 1 and 25 μ mol of triisobutylaluminum) of a heptane solution (which was adjusted to be the concentration of Compound 1 of 1 μ mol/ml, the concentration of triisobutylaluminum of 50 μ mol/ml and a molar ratio of Al atom to Ti atom of 25.) in which μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-2-phenoxy)titanium methoxide} (Compound 1) and triisobutylaluminum were mixed, were charged and successively, 3 μ mol of N,N-dimethylanilinium

tetrakis(pentafluorophenyl)borate was charged as a slurry in heptane (a slurry concentration of $1 \mu\text{mol/ml}$). Polymerization was carried out for 2 minutes. As a result of the polymerization, 5.33g of an ethylene-hexene-1 copolymer having $[\eta]$ of 0.67 dl/g, SCB of 35.0, melting points of 74.2°C and 88.6°C , Mw of 43000 and Mw/Mn of 2.7 was obtained. Polymerization activity per 1 mole of Ti atom was 5.33×10^6 g-polymer/mol-Ti atom per 2 minutes.

Example 4

10 After replacing the atmosphere of an autoclave type reactor having an inner volume of 0.4 liter equipped with a stirrer with argon, 185ml of cyclohexane as a solvent and 15ml of hexene-1 as an α -olefin were charged and the reactor was heated to 180°C . After the elevation
15 of temperature, ethylene was fed while adjusting at an ethylene pressure of 2.5Mpa. After the system was stabilized, 0.2mmol of triisobutylaluminum, 0.5ml (namely, $0.5 \mu\text{mol}$ of Compound 2 and $25 \mu\text{mol}$ of triisobutylaluminum) of a heptane solution (which was
20 adjusted to be the concentration of Compound 2 of $1 \mu\text{mol/ml}$, the concentration of triisobutylaluminum of $50 \mu\text{mol/ml}$ and a molar ratio of Al atom to Ti atom of 25.) in which di- μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-
25 2-phenoxy)titanium} (Compound 2) and triisobutylaluminum were mixed, were charged and successively, $1.5 \mu\text{mol}$ of N,N-dimethylanilinium

tetrakis(pentafluorophenyl)borate was charged as a slurry in heptane (a slurry concentration of $1 \mu\text{mol/ml}$). Polymerization was carried out for 2 minutes. As a result of the polymerization, 2.55g of an ethylene-hexene-1
5 copolymer having $[\eta]$ of 0.84 dl/g, SCB of 30.7 and melting points of 80.2°C and 93.0°C was obtained. Polymerization activity per 1 mole of Ti atom was 2.55×10^6 g-polymer/mol-Ti atom per 2 minutes.

Example 5

10 After replacing the atmosphere of an autoclave type reactor having an inner volume of 0.4 liter equipped with a stirrer with argon, 185ml of cyclohexane as a solvent and 15ml of hexene-1 as an α -olefin were charged and the reactor was heated to 180°C. After the elevation
15 of temperature, ethylene was fed while adjusting at an ethylene pressure of 2.5Mpa. After the system was stabilized, 0.2mmol of triisobutylaluminum, 0.5ml (namely, $0.5 \mu\text{mol}$ of Compound 2 and $25 \mu\text{mol}$ of triisobutylaluminum) of a heptane solution (which was
20 adjusted to be the concentration of Compound 2 of $1 \mu\text{mol/ml}$, the concentration of triisobutylaluminum of $50 \mu\text{mol/ml}$ and a molar ratio of Al atom to Ti atom of 25.) in which di- μ -oxobis{dimethylsilylene(η^5 -tetramethylcyclopentadienyl)(3-tert-butyl-5-methyl-
25 2-phenoxy)titanium} (Compound 2) and triisobutylaluminum were mixed, were charged and successively, $3 \mu\text{mol}$ of N,N-dimethylanilinium

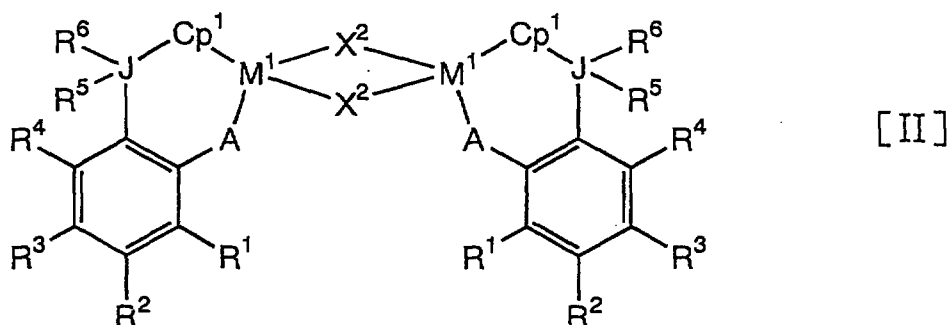
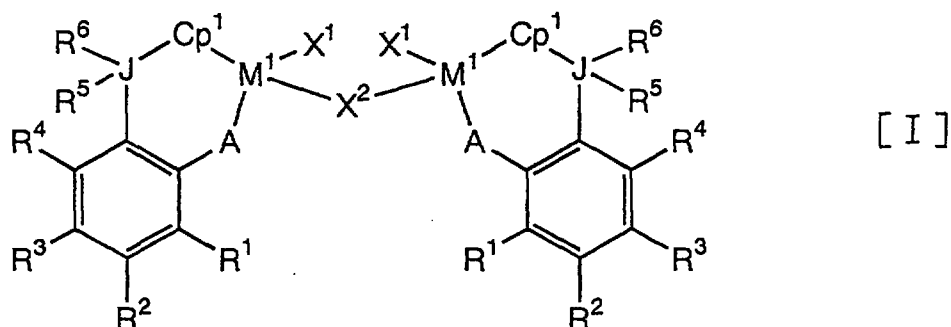
tetrakis(pentafluorophenyl)borate was charged as a slurry in heptane (a slurry concentration of 1 μ mol/ml). Polymerization was carried out for 2 minutes. As a result of the polymerization, 3.92g of an ethylene-hexene-1
5 copolymer having $[\eta]$ of 0.73 dl/g, SCB of 33.0, melting points of 78.9°C and 91.5°C, Mw of 48000 and Mw/Mn of 2.5 was obtained. Polymerization activity per 1 mole of Ti atom was 3.92×10^6 g-polymer/mol-Ti atom per 2 minutes.

10 As described above in detail, according to the present invention, a transition metal compound useful as a highly active olefin polymerization catalyst component at an efficient reaction temperature in the industrial process of an olefin polymerization, and a
15 highly active olefin polymerization catalyst using said transition metal compound and a process for producing an olefin polymer using said olefin polymerization catalyst are provided. Further, the transition metal compound of the present invention is also effective as
20 an olefin polymerization catalyst component having a high comonomer reaction rate in copolymerization and providing an olefin polymer with a high molecular weight, and has a remarkable value for utilization.



Claims

1. A transition metal compound represented by the general
 5 formula [I] or [II] described below:



- 10 (wherein M¹ is a transition metal atom of Group IV of the
 Periodic Table of the Elements; A is an atom of the Group
 XVI of the Periodic Table of the Elements; and J is an atom
 of the Group XIV of the Periodic Table of the Elements,
 respectively. Cp¹ is a group having a cyclopentadiene type
 15 anion skeleton. Each of X¹, R¹, R², R³, R⁴, R⁵ and R⁶
 independently is a hydrogen atom, a halogen atom, an alkyl
 group, an aralkyl group, an aryl group, a substituted silyl
 group, an alkoxy group, an aralkyloxy group, an aryloxy group



or a di-substituted amino group. X^2 indicates an atom of the Group XVI of the Periodic Table of the Elements. R^1 , R^2 , R^3 , R^4 , R^5 and R^6 may be arbitrarily combined with each other to form a ring. A plural number of M^1 , A, J, Cp^1 , X^1 , X^2 , R^1 , R^2 , R^3 , R^4 , R^5 and R^6 may be respectively the same or different.)

2. A transition metal compound according to claim 1, wherein A in the general formula [I] or [II] is an oxygen atom.

3. A transition metal compound according to claim 1 or 2, wherein X^2 in the general formula [I] or [II] is an oxygen atom.

4. A transition metal compound according to any one of claims 1 to 3, wherein each of R^1 in the general formula [I] or [II] is an alkyl group, an aralkyl group, an aryl group or a substituted silyl group, independently.

5. A transition metal compound according to any one of claims 1 to 4, wherein each of X^1 in the general formula [I] is a halogen atom, an alkyl group, an aralkyl group, an alkoxy group, an aryloxy group or a di-substituted amino group, independently.

6. An olefin polymerization catalyst component comprising said transition metal compound according to any one of claims 1 to 5.

7. An olefin polymerization catalyst obtained by a process comprising contacting the transition metal compound according to any one of claims 1 to 5 and (B) described below and/or (C) described below:



(B) one or more of organoaluminum compounds selected from (B1) to (B3) described below:

(B1) an organoaluminum compound indicated by the general formula $E^1_a AlZ_{3-a}$;

5 (B2) a cyclic aluminoxane having a structure indicated by the general formula $\{-Al(E^2)-O-\}_b$; and

(B3) a linear aluminoxane having a structure indicated by the general formula $E^3\{-Al(E^3)-O-\}_c AlE^3$,

(wherein each of E^1 , E^2 and E^3 is a hydrocarbon group, and
10 all of E^1 , all of E^2 and all of E^3 may be the same or different.
 Z represents a hydrogen atom or a halogen atom, and all of Z may be the same or different. a represents a number satisfying an equation of $0 < a \leq 3$, b represents an integer of 2 or more, and c represents an integer of 1 or
15 more).

(C) any one of boron compounds of (C1) to (C3) described below:

(C1) a boron compound represented by the general formula $BQ^1Q^2Q^3$;

20 (C2) a boron compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$; and

(C3) a boron compound represented by the general formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$

(wherein B is a boron atom in the trivalent valence state,
25 Q^1 to Q^4 are a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a substituted silyl group, an alkoxy group or a di-substituted amino group and they may be the same or



different. G^+ is an inorganic or organic cation, L is a neutral Lewis base, and $(L-H)^+$ is a Brønsted acid).

8. An olefin polymerization catalyst according to claim 7, wherein (B) is triethylaluminum,
5 triisobutylaluminum or methylaluminoxane.

9. An olefin polymerization catalyst according to claim 7 or 8, wherein (C) is dimethylaniliniumtetrakis(pentafluorophenyl) borate or triphenylmethyl tetrakis(pentafluorophenyl) borate.

10. An olefin polymerization catalyst obtained by a process comprising contacting the transition metal compound according to any one of claims 1 to 5, (B) according to claim 7 and (C) according to claim 7.

11. An olefin polymerization catalyst obtained by a
15 process comprising contacting the transition metal compound according to any one of claims 1 to 5, (B2) according to claim 7 and/or (B3) according to claim 7.

12. A process for producing an olefin polymer comprising polymerizing an olefin with the olefin polymerization
20 catalyst according to any one of claims 7 to 11.

13. A process for producing an olefin polymer according to claim 12, wherein the olefin polymer is a copolymer of ethylene and an α -olefin.

14. A process for producing an olefin polymer according
25 to claim 12 or 13, wherein the polymerization is carried out by a high-pressure ionic polymerization process.

15. A process for producing an olefin polymer according



to claim 12 or 13, wherein the polymerization is carried out under a pressure of 30MPa or more at a temperature of 130°C or more.