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CATALYST FOR ADDITION POLYMERIZATION AND PROCESS FOR PRODUCING AN ADDITION POLYMER

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a catalyst for addition polymerization, and a process for producing an addition polymer with the catalyst.

Description of the Related Art

10 In the field of single-site catalysts, there have been already a lot of reports regarding a process for producing an addition polymer such as an olefin polymer using a transition metal compound such as a metallocene complex. For example, JP58019309A reports a process for producing an olefin polymer
15 using a metallocene complex and aluminoxane.

 Regarding a process for producing an addition polymer using a transition metal compound called non-metallocene, there have been done wide researches on from the early transition metal to the late transition metal, however, in general, there are
20 a lot of studies regarding combinations of ligands as described above in the range of Groups III to VI metals and Groups VIII to X metals, while there are few research regarding application to a catalyst addition polymerization of Group VII metals.

 Oligopyrazole ligands combining a plurality of pyrazoles
25 have very long been studied as a metal ligand, and as a metal complex of Group VII, there is a report of a {bis[hydrotris(pyrazolyl)borate]manganese} complex by S.

Trofimenko, et al., J. Am. Chem. Soc., 88, 1842 (1966), and also thereafter, Moro-oka, et al., J. Am. Chem. Soc., 113, 7757 (1991) have progressed studies mainly in the field of biological inorganic chemistry such as findings of the ability of a
5 mono-nuclear oligo(pyrazolyl)borate-manganese complex as an oxygen carrier, and the like, however, there is no study regarding application to a catalytic reaction.

Sangyo Kagaku Gijutsu Kenkyu Kaihatsu (Industrial Scientific Technology Research and Development), third
10 Dokusoteki Koseino Zairyo Sosei Gijutsu Symposium (Original High Performance Material Creation Technology Symposium), preprints, pp. 125 to 126, describes an example of polymerization of ethylene and propylene using $Mn(acac)_3$ and Mn-salen complex. This literature discloses that a catalyst prepared by using the
15 complex shows no polymerization activity on propylene, but that propylene is polymerized by supporting on magnesium it though the activity thereof is extremely low.

Therefore, the above-mentioned Mn compounds have little polymerization activity of addition polymerizable monomers, and
20 further, could not provide a stereoregular α -olefin polymer.

SUMMARY OF THE INVENTION

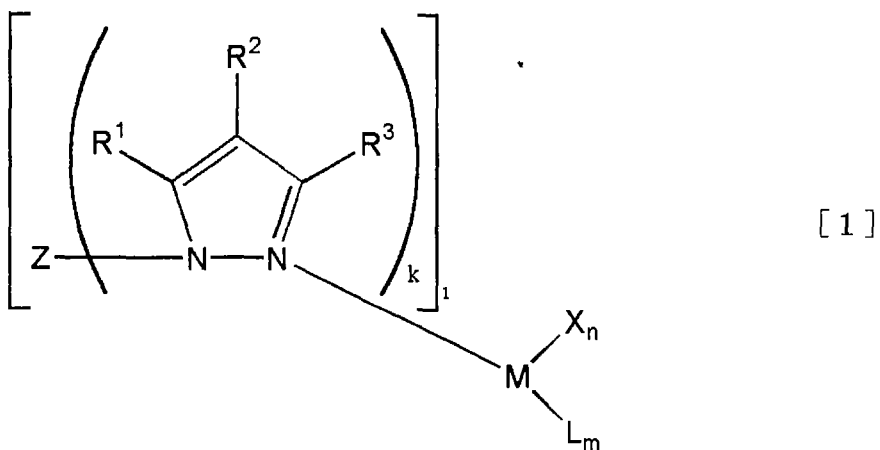
Under such conditions, an object of the present invention is to provide a catalyst for addition polymerization having high
25 activity, and an efficient producing process of an addition polymer with the catalyst.

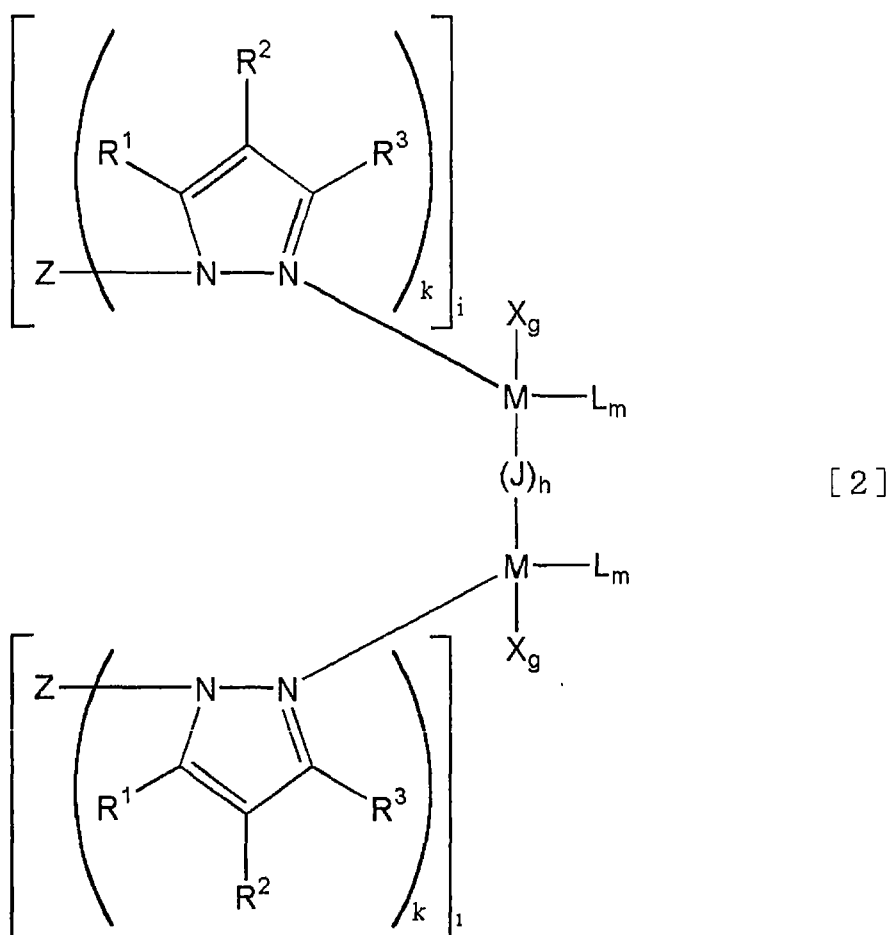
Another object of the present invention is to provide a

producing process of a stereoregular α -olefin polymer with the catalyst.

Other objects and advantages of the present invention will be apparent from the following description.

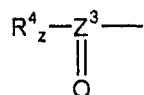
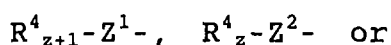
- 5 Namely, the present invention relates to a catalyst for addition polymerization obtained by a process comprising contacting a transition metal compound(A) represented by the following general formula [1] or [2] with an aluminum compound(B) described below and/or a boron compound(C) described below:





(in the general formulae [1] and [2], M represents a transition metal atom of Group 7; Xs represent each independently a hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, alkoxy group, aralkyloxy group, aryloxy group, acyloxy group, acyl group, di-substituted amino group, substituted pyrazolyl group, isocyanate group, thiocyanate group, nitrosyl group, azide group, cyano group, hydroxyl group, perhalide ion, nitrate ion, hexa-halogenated phosphorus ion or tetra-substituted boron ion; L represents a neutral ligand connected with M via a lone pair or π electron; n represents

an integer of 0 to 7 so selected that the compound is neutral;
 g represents an integer of 0 to 6 so selected that the compound
 is neutral; m represents an integer of 0 to 5; R^1 to R^3 represent
 each independently a hydrogen atom, halogen atom, alkyl group,
 5 aralkyl group, aryl group or substituted silyl group and all
 of R^1 to R^3 may be the same or different; Z represents a group
 of



10 (wherein, Z^1 represents an atom of Groups 13 to 15; Z^2 represents
 an atom of Groups 13 to 15 and Z^3 represents an atom of Group
 15; R^4 in each case represents a hydrogen atom, halogen atom,
 alkyl group, aralkyl group, substituted silyl group, alkoxy group,
 aralkyloxy group, aryloxy group, di-substituted amino group or
 15 substituted pyrazolyl group.); k represents an integer of 1 to
 3 and the sum of k and z is 3; J in the general formula [2] is
 a bridging group connecting two Ms; and h represents an integer
 of 1 to 3 showing the number of bridging connecting two M's.),

(B): one or more aluminum compounds selected from the
 20 following (B1) to (B3),

(B1): organoaluminum compounds of the general formula
 $E^1_aAlZ_{3-a}$,

(B2): cyclic aluminoxanes having a structure of the
 general formula $\{-Al(E^2)-O-\}_b$,

25 (B3): linear aluminoxanes having a structure of the

general formula $E^3\{-Al(E^3)-O-\}_cAlE^3_2$,

(wherein, each of E^1 , E^2 and E^3 represents a hydrocarbon group, and all of E^1 's, all of E^2 's and all of E^3 's may be the same or different.

Z represents a hydrogen atom or halogen atom, all of Z s may be
 5 the same or different. a represents a number satisfying $0 < a \leq 3$, b represents an integer of 2 or more, and c represents an integer of 1 or more.), and

(C): one or more boron compounds selected from the following
 (C1) to (C3),

10 (C1): boron compounds of the general formula $BQ^1Q^2Q^3$,

(C2): boron compounds of the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$,

(C3): boron compounds of the general formula

$(L-H)^+(BQ^1Q^2Q^3Q^4)^-$,

(wherein, B represents a boron atom of tri-valent state, Q^1 to
 15 Q^4 represent a halogen atom, hydrocarbon group, halogenated hydrocarbon group, substituted silyl group, alkoxy group or di-substituted amino group, and they may be the same or different. G^+ represents an inorganic or organic cation, L represents a neutral Lewis base, and $(L-H)^+$ represents a
 20 Brønsted acid.).

Further, the present invention relates to a process for producing an addition polymer, which comprises polymerizing an addition polymerizable monomer with said catalyst.

The present invention will be described further in detail
 25 below.

BRIEF EXPLANATION OF DRAWINGS

Fig. 1 shows a result of X-ray structure analysis of a single crystal of the compound obtained in Reference Example 1.

Fig. 2 shows a result of X-ray structure analysis of a single crystal of the compound obtained in Reference Example 2.

DETAILED DESCRIPTION OF THE INVENTION

(A) Transition metal compound

10 M in a transition metal compound of the above-mentioned general formula [1] or [2] represents a transition metal atom of Group 7 of the Periodic Table of Elements (IUPAC Inorganic Chemistry Nomenclature, revision 1989), and preferably a manganese atom, technetium atom or rhenium atom, particularly
15 preferably a manganese atom.

X's in the above-mentioned general formula [1] or [2] represent each independently a hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, alkoxy group, aralkyloxy group, aryloxy group, acyloxy group, acyl group, 20 di-substituted amino group, substituted pyrazolyl group, isocyanate group, thiocyanate group, nitrosyl group, azide group, cyano group, hydroxyl group, perhalide ion, nitrate ion, hexa-halogenated phosphorus ion or tetra-substituted boron ion, and all of X's may be the same or different.

25 The halogen atom as X includes a fluorine atom, chlorine atom, bromine atom and iodine atom are listed, and a chlorine atom is preferable.

The alkyl group as X preferably includes alkyl groups having 1 to 20 carbon atoms, and examples thereof include a methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, sec-butyl group, tert-butyl group, n-pentyl group, neopentyl group, amyl group, n-hexyl group, n-octyl group, n-decyl group, n-dodecyl group, n-pentadecyl group, n-eicosyl group, cyclopentyl group, cyclohexyl group, adamantyl group and the like, more preferably, a methyl group, ethyl group, isopropyl group, tert-butyl group, cyclohexyl group and adamantyl group.

Any of these alkyl groups may be substituted with a halogen atom such as a fluorine atom, chlorine atom, bromine atom, iodine atom or the like. Examples of the alkyl group having 1 to 20 carbon atoms substituted with a halogen atom include a fluoromethyl group, difluoromethyl group, trifluoromethyl group, chloromethyl group, dichloromethyl group, trichloromethyl group, bromomethyl group, dibromomethyl group, tribromomethyl group, iodomethyl group, diiodomethyl group, triiodomethyl group, fluoroethyl group, difluoroethyl group, trifluoroethyl group, tetrafluoroethyl group, pentafluoroethyl group, chloroethyl group, dichloroethyl group, trichloroethyl group, tetrachloroethyl group, pentachloroethyl group, bromoethyl group, dibromoethyl group, tribromoethyl group, tetrabromoethyl group, pentabromoethyl group, perfluoropropyl group, perfluorobutyl group, perfluoropentyl group, perfluorohexyl group, perfluorooctyl group, perfluorododecyl group, perfluoropentadecyl group, perfluoroeicosyl group, perchloropropyl group, perchlorobutyl group, perchloropentyl

group, perchlorohexyl group, perchlorooctyl group,
 perchlorododecyl group, perchloropentadecyl group,
 perchloroeicosyl group, perbromopropyl group, perbromobutyl
 group, perbromopentyl group, perbromohexyl group,
 5 perbromooctyl group, perbromododecyl group, perbromopentadecyl
 group, perbromoeicosyl group, perbromocyclopentyl group,
 perbromocyclohexyl group, perbromoadamantyl group and the like.

Any of these alkyl groups may be partially substituted
 with an alkoxy group such as a methoxy group, ethoxy group or
 10 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.

The aralkyl group as X preferably includes aralkyl groups
 having 7 to 20 carbon atoms, and examples thereof include a benzyl
 group, (2-methylphenyl)methyl group, (3-methylphenyl)methyl
 15 group, (4-methylphenyl)methyl group,
 (2,3-dimethylphenyl)methyl group, (2,4-dimethylphenyl)methyl
 group, (2,5-dimethylphenyl)methyl group,
 (2,6-dimethylphenyl)methyl group, (3,4-dimethylphenyl)methyl
 group, (3,5-dimethylphenyl)methyl group,
 20 (2,3,4-trimethylphenyl)methyl group,
 (2,3,5-trimethylphenyl)methyl group,
 (2,3,6-trimethylphenyl)methyl group,
 (3,4,5-trimethylphenyl)methyl group,
 (2,4,6-trimethylphenyl)methyl group,
 25 (2,3,4,5-tetramethylphenyl)methyl group,
 (2,3,4,6-tetramethylphenyl)methyl group,
 (2,3,5,6-tetramethylphenyl)methyl group,

(pentamethylphenyl)methyl group, (ethylphenyl)methyl group, (n-propylphenyl)methyl group, (isopropylphenyl)methyl group, (n-butylphenyl)methyl group, (sec-butylphenyl)methyl group, (tert-butylphenyl)methyl group, (n-pentylphenyl)methyl group, (neopentylphenyl)methyl group, (n-hexylphenyl)methyl group, (n-octylphenyl)methyl group, (n-decylphenyl)methyl group, (n-tetradecylphenyl)methyl group, naphthylmethyl group, anthracenylmethyl group and the like, and preferable is a benzyl group.

Any of these aralkyl groups may be partially substituted with a halogen atom such as a fluorine atom, chlorine atom, bromine atom, iodine atom or the like, an alkoxy group such as a methoxy group, 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 and or like.

The aryl group as X preferably includes aryl groups having 6 to 20 carbon atoms, and examples thereof include a phenyl group, 2-tolyl group, 3-tolyl group, 4-tolyl group, 2,3-xylyl group, 2,4-xylyl group, 2,5-xylyl group, 2,6-xylyl group, 3,4-xylyl group, 3,5-xylyl group, 2,3,4-trimethylphenyl group, 2,3,5-trimethylphenyl group, 2,3,6-trimethylphenyl group, 2,4,6-trimethylphenyl group, 3,4,5-trimethylphenyl group, 2,3,4,5-tetramethylphenyl group, 2,3,4,6-tetramethylphenyl group, 2,3,5,6-tetramethylphenyl group, pentamethylphenyl group, ethylphenyl group, n-propylphenyl group, isopropylphenyl group, n-butylphenyl group, sec-butylphenyl group, tert-butylphenyl group, n-pentylphenyl group,

neopentylphenyl group, n-hexylphenyl group, n-octylphenyl group, n-decylphenyl group, n-dodecylphenyl group, n-tetradecylphenyl group, naphthyl group, anthracenyl group and the like, and preferable is a phenyl group.

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

 The substituted silyl group as X includes 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, ethyl group, n-propyl group,
15 isopropyl group, n-butyl group, sec-butyl group, tert-butyl group, isobutyl group, n-pentyl group, n-hexyl group, cyclohexyl group and the like, aryl groups such as a phenyl group and the like, and other groups.

 Examples of the substituted silyl group having 1 to 20
20 carbon atoms include mono-substituted silyl groups having 1 to 20 carbon atoms such as a methylsilyl group, ethylsilyl group, phenylsilyl group and the like, di-substituted silyl groups having 2 to 20 carbon atoms such as a dimethylsilyl group, diethylsilyl group, diphenylsilyl group and the like,
25 tri-substituted silyl groups having 3 to 20 carbon atoms such as a trimethylsilyl group, triethylsilyl group, tri-n-propylsilyl group, triisopropylsilyl group,

tri-n-butylsilyl group, tri-sec-butylsilyl group,
 tri-tert-butylsilyl group, tri-isobutylsilyl group,
 tert-butyl-dimethylsilyl group, tri-n-pentylsilyl group,
 tri-n-hexylsilyl group, tricyclohexylsilyl group,
 5 triphenylsilyl group and the like, etc., and preferable is a
 trimethylsilyl group, tert-butyldimethylsilyl group or
 triphenylsilyl group.

Any of these silyl groups may be partially substituted
 with a halogen atom such as a fluorine atom, chlorine atom, bromine
 10 atom, iodine atom or the like, an alkoxy group such as a methoxy
 group, 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.

Examples of the alkoxy group as X include a methoxy group,
 15 ethoxy group, n-propoxy group, isopropoxy group, n-butoxy group,
 sec-butoxy group, t-butoxy group, n-pentoxy group, neopentoxy
 group, n-hexoxy group, n-octoxy group, n-dodesoxy group,
 n-pentadesoxy group, n-icosoxy group and the like, and preferable
 are methoxy group, ethoxy group and t-butoxy group.

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

25 Examples of the aralkyloxy group as X include a benzyloxy
 group, (2-methyphenyl)methoxy group, (3-methyphenyl)methoxy
 group, (4-methyphenyl)methoxy group,

(2,3-dimethylphenyl)methoxy group,
 (2,4-dimethylphenyl)methoxy group,
 (2,5-dimethylphenyl)methoxy group,
 (2,6-dimethylphenyl)methoxy group,
 5 (3,4-dimethylphenyl)methoxy group,
 (3,5-dimethylphenyl)methoxy group,
 (2,3,4-trimethylphenyl)methoxy group,
 (2,3,5-trimethylphenyl)methoxy group,
 (2,3,6-trimethylphenyl)methoxy group,
 10 (2,4,5-trimethylphenyl)methoxy group,
 (2,4,6-trimethylphenyl)methoxy group,
 (3,4,5-trimethylphenyl)methoxy group,
 (2,3,4,5-tetramethylphenyl)methoxy group,
 (2,3,4,6-tetramethylphenyl)methoxy group,
 15 (2,3,5,6-tetramethylphenyl)methoxy group,
 (pentamethylphenyl)methoxy group, (ethylphenyl)methoxyl group,
 (n-propylphenyl)methoxyl group, (isopropylphenyl)methoxy
 group, (n-butylphenyl)methoxy group, (sec-butylphenyl)methoxy
 group, (tert-butylphenyl)methoxy group, (n-hexylphenyl)methoxy
 20 group, (n-octylphenyl)methoxy group, (n-decylphenyl)methoxy
 group, (n-tetradecylphenyl)methoxy group, naphthylmethoxy
 group, anthracenylmethoxy group and the like, and preferable
 is a benzyloxy group.

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

group or the like, or an aralkyloxy group or the like.

Examples of the aryloxy group as X include aryloxy groups having 6 to 20 carbon atoms such as a phenoxy group, 2-methylphenoxy group, 3-methylphenoxy group, 4-methylphenoxy group, 2,3-dimethylphenoxy group, 2,4-dimethylphenoxy group, 2,5-dimethylphenoxy group, 2,6-dimethylphenoxy group, 3,4-dimethylphenoxy group, 3,5-dimethylphenoxy group, 2,3,4-trimethylphenoxy group, 2,3,5-trimethylphenoxy group, 2,3,6-trimethylphenoxy group, 2,4,5-trimethylphenoxy group, 2,4,6-trimethylphenoxy group, 3,4,5-trimethylphenoxy group, 2,3,4,5-tetramethylphenoxy group, 2,3,4,6-tetramethylphenoxy group, 2,3,5,6-tetramethylphenoxy group, pentamethylphenoxy group, ethylphenoxy group, n-propylphenoxy group, isopropylphenoxy group, n-butylphenoxy group, sec-butylphenoxy group, tert-butylphenoxy group, n-hexylphenoxy group, n-octylphenoxy group, n-decylphenoxy group, n-tetradecylphenoxy group, naphthoxy group, anthracenoxy group and the like, etc.

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

Examples of the acyloxy group as X include an acetoxy group, ethylcarbonyloxy group, n-propylcarbonyloxy group, isopropylcarbonyloxy group, n-butylcarbonyloxy group, sec-butylcarbonyloxy group, isobutylcarbonyloxy group,

tert-butylcarbonyloxy group, trifluoroacetoxy group, benzoyloxy group and the like.

Examples of the acyl group as X include a formyl group, acetyl group, propionyl group, butyryl group, isobutyryl group, 5 valeryl group, isovaleryl group, cyclohexanecarbonyl group, benzoyl group and the like.

The di-substituted amino group as X is an amino group substituted with two hydrocarbon groups, and examples of the hydrocarbon group here include alkyl groups having 1 to 10 carbon 10 atoms such as a methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, sec-butyl group, tert-butyl group, isobutyl group, n-pentyl group, n-hexyl group, cyclohexyl group and the like, aryl groups such as a phenyl group and the like, and other groups. Examples of the di-substituted amino 15 group having 1 to 10 carbon atoms include a dimethylamino group, diethylamino group, di-n-propylamino group, diisopropylamino group, di-n-butylamino group, di-sec-butylamino group, di-tert-butylamino group, di-isobutylamino group, tert-butylisopropylamino group, di-n-hexylamino group, 20 di-n-octylamino group, di-n-decylamino group, diphenylamino group, bistrimethylsilylamino group, bis-tert-butyl dimethylsilylamino group and the like, and preferable are a dimethylamino group and diethylamino group.

Examples of the substituted pyrazolyl group as X include 25 a pyrazolyl group, 3-methylpyrazolyl group, 4-methylpyrazolyl group, 3-ethylpyrazolyl group, 3-n-propylpyrazolyl group, 3-isopropylpyrazolyl group, 3-n-butylpyrazolyl group,

3-sec-butylpyrazolyl group, 3-isobutylpyrazolyl group,
 3-tert-butylpyrazolyl group, 3-phenylpyrazolyl group,
 3-p-tolylpyrazolyl group, 3-cumylpyrazolyl group,
 3-(trifluoromethyl)pyrazolyl group,
 5 3-(pentafluoroethyl)pyrazolyl group, 3-cyclohexylpyrazolyl
 group, 3-adamantylpyrazolyl group, 4-chloropyrazolyl group,
 4-bromopyrazolyl group, 4-iodopyrazolyl group,
 3,5-dimethylpyrazolyl group, 3,5-diethylpyrazolyl group,
 3,5-di-n-propylpyrazolyl group, 3,5-diisopropylpyrazolyl
 10 group, 3,5-di-n-butylpyrazolyl group,
 3,5-di-sec-butylpyrazolyl group, 3,5-diisobutylpyrazolyl
 group, 3,5-di-tert-butylpyrazolyl group,
 3,5-diphenylpyrazolyl group, 5-methyl-3-isopropylpyrazolyl
 group, 3-tert-butyl-5-methylpyrazolyl group,
 15 5-methyl-3-phenylpyrazolyl group,
 5-methyl-3-p-tolylpyrazolyl group, 3-cumyl-5-methylpyrazolyl
 group, 3-adamantyl-5-methylpyrazolyl group, imidazolyl group,
 7-methylimidazolyl group, 7-isopropylimidazolyl group,
 7-tert-butylimidazolyl group and the like.

20 Further, the group as X includes an isocyanate group,
 thioisocyanate group, nitrosyl group, azide group, cyano group,
 and hydroxyl group.

X may also be a free anion, and the above-mentioned halogen
 atom, acyloxy group and hydroxyl group may exist as corresponding
 25 anions, respectively. For example, F^- , Cl^- , Br^- , I^- , acetate
 ion, propionate ion, n-butyronate ion, isobutyronate ion,
 n-pentyronate ion, sec-pentyronate ion, isopentyronate ion,

tert-pentylonate ion, trifluoroacetate ion, benzoate ion, OH⁻ and the like are mentioned. Additionally, as the free anion, a perhalide ion, nitrate ion, hexa-halogenated phosphorus ion and tetra-substituted boron ion are listed. As the per-halide
 5 ion, for example, ClO₄⁻ is mentioned. As the hexa-halogenated phosphorus ion, for example, PF₆⁻ is mentioned. As the tetra-substituted boron ion, for example, BPh₄⁻ and BF₄⁻ are listed.

X's in the above-mentioned general formula [1] or [2]
 10 represent each independently a halogen atom, alkyl group, aralkyl group, alkoxy group, aralkyloxy group, hydroxyl group, perhalide ion, nitrate ion, hexa-halogenated phosphorus ion or tetra-substituted boron ion, further preferably, each independently a halogen atom, alkyl group, alkoxy group,
 15 aralkyloxy group, nitrate ion, hexa-halogenated phosphorus ion or tetra-substituted boron ion, particularly preferably, each independently a halogen atom, alkyl group, nitrate ion or tetra-substituted boron ion.

In the above-mentioned general formulae [1] and [2], n
 20 and g are the number of X's and represent an integer of 0 to 7 and 0 to 6, respectively, so selected that the compound is neutral.

In the above-mentioned general formulae [1] and [2], L
 represents a neutral ligand connected with M via a lone pair
 25 or π electron.

The neutral ligand connected with M via a lone pair is a neutral ligand connected with M via a coordinate bond, and

examples thereof include ethers such as diethyl ether, tetrahydrofuran and dimethoxyethane, amines such as triethylamine, N,N,N',N'-tetramethylethylenediamine, pyridines such as pyridine, 2,6-dimethylpyridine and quinoline, 5 pyrazole, substituted pyrazoles such as 3-methylpyrazole, 4-methylpyrazole, 5-methylpyrazole, 3-ethylpyrazole, 3-n-propylpyrazole, 3-isopropylpyrazole, 3-n-butylpyrazole, 3-sec-butylpyrazole, 3-isobutylpyrazole, 3-tert-butylpyrazole, 3-phenylpyrazole, 3-p-tolylpyrazole, 10 3-cumylpyrazole, 3-(trifluoromethyl)pyrazole, 3-(pentafluoroethyl)pyrazole, 3-cyclohexylpyrazole, 3-adamantylpyrazole, 4-chloropyrazole, 4-bromopyrazole, 4-iodopyrazole, 3,5-dimethylpyrazole, 3,5-diethylpyrazole, 3,5-di-n-propylpyrazole, 3,5-diisopropylpyrazole, 15 3,5-di-n-butylpyrazole, 3,5-di-sec-butylpyrazole, 3,5-diisobutylpyrazole, 3,5-di-tert-butylpyrazole, 3,5-diphenylpyrazole, 5-methyl-3-isopropylpyrazole, 3-tert-butyl-5-methylpyrazole, 5-methyl-3-phenylpyrazole, 5-methyl-3-p-tolylpyrazole, 3-cumyl-5-methylpyrazole, 20 3-adamantyl-5-methylpyrazole, imidazole, 7-methylimidazole, 7-isopropylimidazole and 7-tert-butylimidazole, phosphines such as trimethylphosphine, triethylphosphine, triphenylphosphine, dimethylphenylphosphine, methyldiphenylphosphine, 1,2-bis(dimethylphosphino)ethane, 25 1,2-bis(diethylphosphino)ethane, 1,2-bis(diphenylphosphino)ethane and 1,3-bis(diphenylphosphino)propane, nitriles such as

acetonitrile and benzonitrile, or endo-on type nitrogen molecule and carbon monoxide, and preferable are tetrahydrofuran, N,N,N',N'-tetramethylethylenediamine, pyridine, dimethylphenylphosphine, 1,2-bis(dimethylphosphino)ethane, 1,2-bis(diethylphosphino)ethane, 1,2-bis(diphenylphosphino)ethane, 1,3-bis(diphenylphosphino)propane, acetonitrile and carbon monoxide.

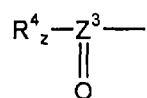
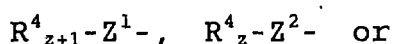
The neutral ligand connected with M via a π electron is a neutral ligand connected with M via a multiple bonding orbital, and examples thereof include olefins such as ethylene, propylene and the like, dienes such as butadiene, 2,4-hexadiene and 1,4-diphenylbutadiene, ketones such as acetone and benzophenone, side-on type nitrogen molecule, and the like, and preferable are olefins and dienes, more preferable are ethylene, butadiene, 2,4-hexadiene and 1,4-diphenylbutadiene.

In the above-mentioned general formulae [1] and [2], m represents the number of neutral ligands L and is an integer of 0 to 5. m is preferably 0 to 3, further preferably 0 or 1.

In the above-mentioned general formulae [1] and [2], R^1 , R^2 and R^3 represent a hydrogen atom, halogen atom, alkyl group, aralkyl group, aryl group or substituted silyl group, and all of R^1 , R^2 and R^3 may be the same or different. The halogen atom, alkyl group, aralkyl group, aryl group and substituted silyl group herein referred to are the same as described already as X. In the above-mentioned general formulae [1] and [2], R^1 , R^2 and R^3 represent preferably, each independently a hydrogen

atom, fluorine atom, chlorine atom, bromine atom, methyl group, ethyl group, isopropyl group, tert-butyl group, cyclohexyl group, adamantyl group, benzyl group, phenyl group or 4-tolyl group, further preferably, each independently a hydrogen atom, fluorine atom, chlorine atom, methyl group, isopropyl group, tert-butyl group, cyclohexyl group, adamantyl group or phenyl group, particularly preferably, each independently a hydrogen atom, chlorine atom, methyl group, isopropyl group, tert-butyl group or adamantyl group.

In the above-mentioned general formulae [1] and [2], Z represents a group of



(wherein, Z^1 represents an atom of Groups 13 to 15 of the Periodic Table of the Elements, Z^2 represents an atom of Groups 13 to 15 of the Periodic Table of the Elements, and Z^3 represents an atom of Group 15 of the Periodic Table of the Elements. R^4 in each case represents a hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, alkoxy group, aralkyloxy group, aryloxy group, di-substituted amino group or substituted pyrazolyl group.);

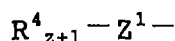
Here, the atom of Group 13 includes a boron atom, aluminum atom and the like, the atom of Group 14 includes a carbon atom, silicon atom and the like, and the atom of the Group 15 includes a nitrogen atom, phosphorus atom and the like. Z^1 represents

preferably an atom of the Group 13 or 14, further preferably a boron atom or carbon atom. Z^2 represents preferably a boron atom or phosphorus atom, further preferably a phosphorus atom. Z^3 represents preferably a nitrogen atom or phosphorus atom,
 5 further preferably a phosphorus atom.

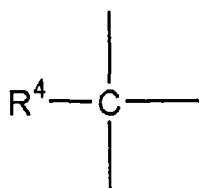
The halogen atom, alkyl group, aralkyl group, substituted silyl group, di-substituted amino group and substituted pyrazolyl group represented by R^4 are the same as described already as X. The above-mentioned R^4 represents preferably a
 10 hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, alkoxy group, aralkyloxy group, aryloxy group or substituted pyrazolyl group, further preferably a hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, di-substituted amino group or
 15 substituted pyrazolyl group, particularly preferably a hydrogen atom, alkyl group, aralkyl group or substituted pyrazolyl group.

In the above-mentioned general formula [1] or [2], k represents an integer of 1 to 3, and the sum of k and z is 3. k represents preferably 2 or 3, further preferably 3.

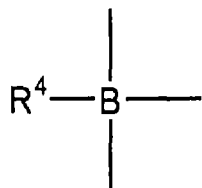
20 In the above-mentioned general formula [1] or [2], Z represents preferably a group of



, and among them, groups of

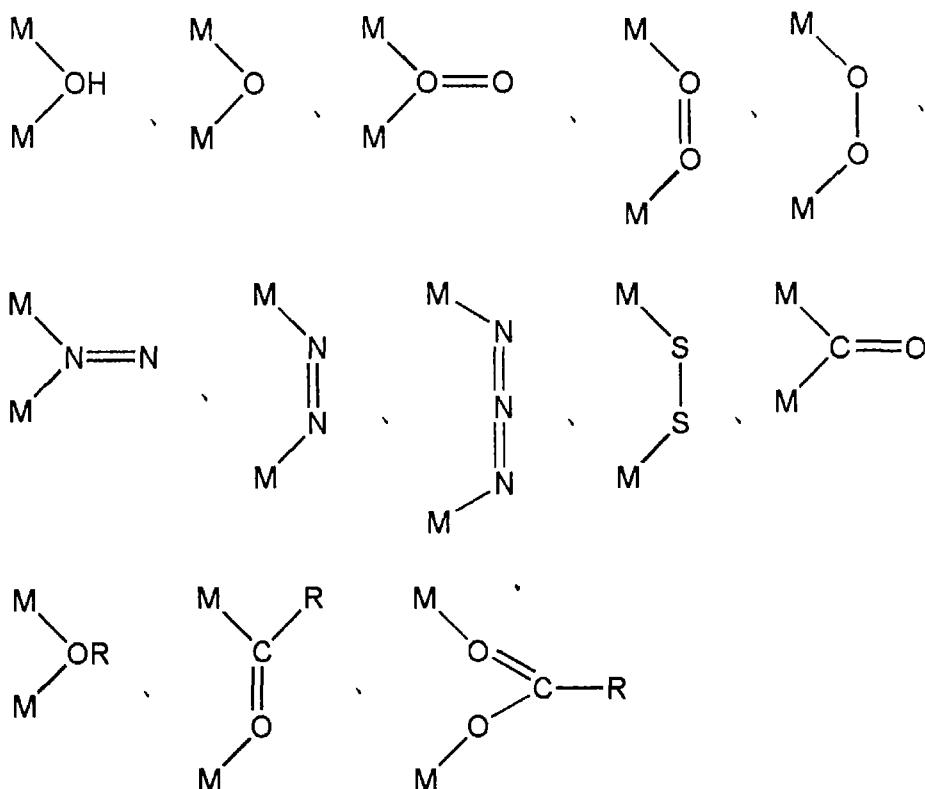


or



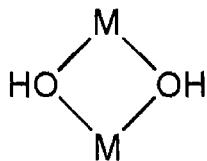
are preferable, and k in these cases is 3 and R⁴ represents particularly preferably a hydrogen atom, alkyl group, aralkyl group or substituted pyrazolyl group.

- 5 In the above-mentioned general formula [2], J is a bridging group connecting two M's. Examples of the bridging group herein referred to include a hydroxyl group, oxygen atom, molecular oxygen molecule, peroxy group, molecular nitrogen molecule, azide, disulfide, carbon monoxide, alkoxy group, aralkyloxy
- 10 group, aryloxy group, acyl group, acyloxy group and the like. Bonding forms with these M's exemplified for understanding are as follows:



(wherein, R represents an alkyl group, aralkyl group or aryl group.) and the like. J represents preferably a hydroxyl group, oxygen atom, molecular oxygen molecule, peroxo group, alkoxy group, aryloxy group, acyloxy group, azide group or carbon monoxide, further preferably a hydroxyl group, oxygen atom, peroxo group, alkoxy group, aryloxy group or acyloxo group.

In the above-mentioned general formula [2], h is a number representing the number of cross-linking connecting two Ms, and represents an integer of 1 to 3. The cross-linking group Q is a hydroxyl group, and examples of bonding forms when h is 2 include the following form.



In the above-mentioned general formula [1], it is preferable that $k \times i + m + n \leq 6$, and in the general formula [2], it is preferable that $g + h + k \times i + m \leq 6$.

5 Specific examples of the compound of the above-mentioned general formula [1] include

chloro[hydrotris(1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-methyl-1'-pyrazolyl)borate]manganese,
 chloro[hydrotris(4-methyl-1-pyrazolyl)borate]manganese,
 10 chloro[hydrotris(3-ethyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-n-propyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-isopropyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-n-butyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-sec-butyl-1-pyrazolyl)borate]manganese,
 15 chloro[hydrotris(3-isobutyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-tert-butyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-phenyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-p-tolyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-cumyl-1-pyrazolyl)borate]manganese,
 20 chloro{hydrotris[3-(trifluoromethyl)-1-pyrazolyl]borate}man-
 ganese, chloro{hydrotris[3-(pentafluoroethyl)-
 -1-pyrazolyl]borate}manganese, chloro[hydrotris
 (3-cyclohexyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3-adamantyl-1-pyrazolyl)borate]manganese,
 25 chloro[hydrotris(4-chloro-1-pyrazolyl)borate]manganese,

chloro[hydrotris(4-bromo-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(4-iodo-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3,5-dimethyl-1-pyrazolyl)borate]manganese,
 chloro[hydrotris(3,5-diethyl-1-pyrazolyl)borate] manganese,
 5 chloro[hydrotris(3,5-di-n-propyl-1-pyrazolyl)
 borate]manganese,
 chloro[hydrotris(3,5-diisopropyl-1-pyrazolyl)borate]mangane
 se, chloro[hydrotris(3,5-di-n-butyl-1-pyrazolyl)borate]
 manganese, chloro[hydrotris(3,5-di-sec-butyl-1-pyrazolyl)
 10 borate]manganese,
 chloro[hydrotris(3,5-diisobutyl-1-pyrazolyl)borate]manganes
 e, chloro[hydrotris(3,5-di-tert-butyl-1-pyrazolyl)
 borate]manganese, chloro[hydrotris(3,5-diphenyl-1
 -pyrazolyl)borate]manganese,
 15 chloro[hydrotris(5-methyl-3-isopropyl-1-pyrazolyl)borate]ma
 nganese,
 chloro[hydrotris(3-tert-butyl-5-methyl-1-pyrazolyl)borate]m
 anganese,
 chloro[hydrotris(5-methyl-3-phenyl-1-pyrazolyl)borate]manga
 20 nese,
 chloro[hydrotris(5-methyl-3-p-tolyl-1-pyrazolyl)borate]mang
 anese,
 chloro[hydrotris(3-cumyl-5-methyl-1-pyrazolyl)borate]mangan
 ese,
 25 chloro[hydrotris(3-adamantyl-5-methyl-1-pyrazolyl)borate]ma
 nganese, chloro[hydrotris(1-imidazolyl)borate]manganese,
 chloro[hydrotris(7-methyl-1-imidazolyl)borate]manganese,

chloro[hydrotris(7-isopropyl-1-imidazolyl)borate]manganese,
 chloro[hydrotris(7-tert-butyl-1-imidazolyl)borate]
 manganese and the like, and
 transition metal compounds such as compounds in which manganese
 5 in these compounds is changed to technetium or rhenium, compounds
 in which chlorine in these compounds is changed to fluorine,
 bromine, iodine, methyl, benzyl, methoxy or phenoxy, compounds
 in which hydrogen in these compounds is changed to methyl, ethyl,
 n-propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl,
 10 phenyl, p-tolyl, cumyl, pyrazolyl, 3-methylpyrazolyl,
 4-methylpyrazolyl, 3-ethylpyrazolyl, 3-n-propylpyrazolyl,
 3-isopropylpyrazolyl, 3-n-butylpyrazolyl,
 3-sec-butylpyrazolyl, 3-isobutylpyrazolyl,
 3-tert-butylpyrazolyl, 3-phenylpyrazolyl, 3-p-tolylpyrazolyl,
 15 3-cumylpyrazolyl, 3-(trifluoromethyl)pyrazolyl,
 3-(pentafluoroethyl)pyrazolyl, 3-cyclohexylpyrazolyl,
 3-adamantylpyrazolyl, 4-chloropyrazolyl, 4-bromopyrazolyl,
 4-iodopyrazolyl, 3,5-dimethylpyrazolyl, 3,5-diethylpyrazolyl,
 3,5-di-n-propylpyrazolyl, 3,5-diisopropylpyrazolyl,
 20 3,5-di-n-butylpyrazolyl, 3,5-di-sec-butylpyrazolyl,
 3,5-diisobutylpyrazolyl, 3,5-di-tert-butylpyrazolyl,
 3,5-diphenylpyrazolyl, 5-methyl-3-isopropylpyrazolyl,
 3-tert-butyl-5-methylpyrazolyl, 5-methyl-3-phenylpyrazolyl,
 5-methyl-3-para-tolylpyrazolyl, 3-cumyl-5-methylpyrazolyl,
 25 3-adamantyl-5-methylpyrazolyl, imidazolyl,
 7-methylimidazolyl, 7-isopropylimidazolyl or
 7-tert-butylimidazolyl, and compounds in which borate in these

compounds is changed to aluminate.

Specific examples of the compound of the above-mentioned general formula [1] include also

- chloro[dihydrobis(1-pyrazolyl)borate]manganese,
- 5 chloro[dihydrobis(3-methyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(4-methyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3-ethyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3-n-propyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3-isopropyl-1-pyrazolyl)borate]manganese,
- 10 chloro[dihydrobis(3-n-butyl-1-pyrazolyl)borate] manganese,
- chloro[dihydrobis(3-sec-butyl-1-pyrazolyl) borate]manganese,
- chloro[dihydrobis(3-isobutyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3-tert-butyl-1-pyrazolyl)borate]manganese,
- chloro[v(3-phenyl-1-pyrazolyl)borate]manganese,
- 15 chloro[dihydrobis(3-p-tolyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3-cumyl-1-pyrazolyl)borate]manganese,
- chloro{dihydrobis[3-(trifluoromethyl)-1-pyrazolyl]borate}ma
nganese,
- chloro{dihydrobis[3-(pentafluoroethyl)-1-pyrazolyl]borate}m
anganese,
- 20 chloro[dihydrobis(3-cyclohexyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3-adamantyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(4-chloro-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(4-bromo-1-pyrazolyl)borate]manganese,
- 25 chloro[dihydrobis(4-iodo-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3,5-dimethyl-1-pyrazolyl)borate]manganese,
- chloro[dihydrobis(3,5-diethyl-1-pyrazolyl)borate]manganese,

chloro[dihydrobis(3,5-di-n-propyl-1-pyrazolyl)borate]mangan
ese,
chloro[dihydrobis(3,5-diisopropyl-1-pyrazolyl)borate]mangan
ese,
5 chloro[dihydrobis(3,5-di-n-butyl-1-pyrazolyl)borate]mangane
se,
chloro[dihydrobis(3,5-di-sec-butyl-1-pyrazolyl)borate]manga
nese,
chloro[dihydrobis(3,5-diisobutyl-1-pyrazolyl)borate]mangane
10 se,
chloro[dihydrobis(3,5-di-tert-butyl-1-pyrazolyl)borate]mang
anese,
chloro[dihydrobis(3,5-diphenyl-1-pyrazolyl)borate]manganese,
chloro[dihydrobis(5-methyl-3-isopropyl-1-pyrazolyl)borate]m
15 anganese,
chloro[dihydrobis(3-tert-butyl-5-methyl-1-pyrazolyl)borate]
manganese,
chloro[dihydrobis(5-methyl-3-phenyl-1-pyrazolyl)borate]mang
anese,
20 chloro[dihydrobis(5-methyl-3-p-tolyl-1-pyrazolyl)borate]man
ganese,
chloro[dihydrobis(3-cumyl-5-methyl-1-pyrazolyl)borate]manga
nese,
chloro[dihydrobis(3-adamantyl-5-methyl-1-pyrazolyl)borate]m
25 anganese, chloro[dihydrobis(1-imidazolyl)borate]manganese,
chloro[dihydrobis(7-methyl-1-imidazolyl)borate]manganese,
chloro[dihydrobis(7-isopropyl-1-imidazolyl)borate]manganese,

chloro[dihydrobis(7-tert-butyl-1-imidazolyl)borate]manganese and the like, and transition metal compounds such as compounds in which manganese in these compounds is changed to technetium or rhenium, compounds in which chloro in these compounds is
 5 changed to fluoro, bromo, iodo, methyl, benzyl, methoxy or phenoxy, compounds in which hydrogen in these compounds is changed to methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, isobutyl, tert-butyl, phenyl, p-tolyl, or cumyl, and compounds in which borate in these compounds is changed to
 10 aluminate.

Specific examples of the compound of the above-mentioned general formula [1] further include

dichloro[tris(1-pyrazolyl)methane]manganese,
 dichloro[tris(3-methyl-1-pyrazolyl)methane]manganese,
 15 dichloro[tris(4-methyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-ethyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-n-propyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-isopropyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-n-butyl-1-pyrazolyl)methane]manganese,
 20 dichloro[tris(3-sec-butyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-isobutyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-tert-butyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-phenyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-p-tolyl-1-pyrazolyl)methane]manganese,
 25 dichloro[tris(3-cumyl-1-pyrazolyl)methane]manganese,
 dichloro[tris(3-(trifluoromethyl)-1-pyrazolyl)methane]manganese,
 nese,

dichloro{tris[3-(pentafluoroethyl)-1-pyrazolyl]methane}manganese,
dichloro[tris(3-cyclohexyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3-adamantyl-1-pyrazolyl)methane]manganese,
5 dichloro[tris(4-chloro-1-pyrazolyl)methane]manganese,
dichloro[tris(4-bromo-1-pyrazolyl)methane]manganese,
dichloro[tris(4-iodo-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-dimethyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-diethyl-1-pyrazolyl)methane]manganese,
10 dichloro[tris(3,5-di-n-propyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-diisopropyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-di-n-butyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-di-sec-butyl-1-pyrazolyl)methane]manganese,
15 dichloro[tris(3,5-diisobutyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-di-tert-butyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3,5-diphenyl-1-pyrazolyl)methane]manganese,
dichloro[tris(5-methyl-3-isopropyl-1-pyrazolyl)methane]manganese,
20 anese,
dichloro[tris(3-tert-butyl-5-methyl-1-pyrazolyl)methane]manganese,
dichloro[tris(5-methyl-3-phenyl-1-pyrazolyl)methane]manganese,
25 dichloro[tris(5-methyl-3-p-tolyl-1-pyrazolyl)methane]manganese,
dichloro[tris(3-cumyl-5-methyl-1-pyrazolyl)methane]manganese

e,
dichloro[tris(3-adamantyl-5-methyl-1-pyrazolyl)methane]mang
anese, dichloro[tris(1-imidazolyl)methane]manganese,
dichloro[tris(7-methyl-1-imidazolyl)methane]manganese,
5 dichloro[tris(7-isopropyl-1-imidazolyl)methane]manganese,
dichloro[tris(7-tert-butyl-1-imidazolyl)methane]manganese
and the like, and transition metal compounds such as compounds
in which manganese in these compounds is changed to technetium
or rhenium, compounds in which chlorine in these compounds is
10 changed to fluorine, bromine, iodine, methyl, benzyl, methoxy
or phenoxy, compounds in which tris in these compounds is changed
to bis or tetrakis, and compounds in which methane in these
compounds is changed to silane, methylsilane, ethylsilane,
tert-butylsilane, phenylsilane, germane, methylgermane,
15 ethylgermane, tert-butylgermane, phenylgermane, amine,
phosphine or phosphite.

Specific examples of the compound of the above-mentioned
general formula [1] furthermore include
dichloro[1,1,1-tris(1-pyrazolyl)ethane]manganese,
20 dichloro[1,1,1-tris(3-methyl-1-pyrazolyl)ethane]manganese,
dichloro[1,1,1-tris(4-methyl-1-pyrazolyl)ethane]manganese,
dichloro[1,1,1-tris(3-ethyl-1-pyrazolyl)ethane]manganese,
dichloro[1,1,1-tris(3-n-propyl-1-pyrazolyl)ethane]manganese,
dichloro[1,1,1-tris(3-isopropyl-1-pyrazolyl)ethane]
25 manganese, dichloro[1,1,1-tris(3-n-butyl-1-pyrazolyl)
ethane]manganese,
dichloro[1,1,1-tris(3-sec-butyl-1-pyrazolyl)ethane]

manganese, dichloro[1,1,1-tris(3-isobutyl-1-pyrazolyl)
 ethane]manganese,
 dichloro[1,1,1-tris(3-tert-butyl-1-pyrazolyl)ethane]mangane
 se,
 5 dichloro[1,1,1-tris(3-phenyl-1-pyrazolyl)ethane]manganese,
 dichloro[1,1,1-tris(3-p-tolyl-1-pyrazolyl)ethane]manganese,
 dichloro[1,1,1-tris(3-cumyl-1-pyrazolyl)ethane]manganese,
 dichloro{1,1,1-tris[3-(trifluoromethyl)-1-pyrazolyl]methane
 }manganese,
 10 dichloro{1,1,1-tris[3-(pentafluoroethyl)-1-pyrazolyl]methan
 e}manganese,
 dichloro[1,1,1-tris(3-cyclohexyl-1-pyrazolyl)ethane]mangane
 se,
 dichloro[1,1,1-tris(3-adamantyl-1-pyrazolyl)ethane]manganes
 15 e,
 dichloro[1,1,1-tris(4-chloro-1-pyrazolyl)ethane]manganese,
 dichloro[1,1,1-tris(4-bromo-1-pyrazolyl)ethane]manganese,
 dichloro[1,1,1-tris(4-iodo-1-pyrazolyl)ethane]manganese,
 dichloro[1,1,1-tris(3,5-dimethyl-1-pyrazolyl)ethane]mangane
 20 se,
 dichloro[1,1,1-tris(3,5-diethyl-1-pyrazolyl)ethane]manganes
 e,
 dichloro[1,1,1-tris(3,5-di-n-propyl-1-pyrazolyl)ethane]mang
 anese,
 25 dichloro[1,1,1-tris(3,5-diisopropyl-1-pyrazolyl)ethane]mang
 anese,
 dichloro[1,1,1-tris(3,5-di-n-butyl-1-pyrazolyl)ethane]manga

nese,
 dichloro[1,1,1-tris(3,5-di-sec-butyl-1-pyrazolyl)ethane]man
 ganese,
 dichloro[1,1,1-tris(3,5-diisobutyl-1-pyrazolyl)ethane]manga
 5 nese,
 dichloro[1,1,1-tris(3,5-di-tert-butyl-1-pyrazolyl)ethane]ma
 nganese,
 dichloro[1,1,1-tris(3,5-diphenyl-1-pyrazolyl)ethane]mangane
 se,
 10 dichloro[1,1,1-tris(5-methyl-3-isopropyl-1-pyrazolyl)ethane
]manganese,
 dichloro[1,1,1-tris(3-tert-butyl-5-methyl-1-pyrazolyl)ethan
 e]manganese,
 dichloro[1,1,1-tris(5-methyl-3-phenyl-1-pyrazolyl)ethane]ma
 15 nganese,
 dichloro[1,1,1-tris(5-methyl-3-p-tolyl-1-pyrazolyl)ethane]m
 anganese,
 dichloro[1,1,1-tris(3-cumyl-5-methyl-1-pyrazolyl)ethane]man
 ganese,
 20 dichloro[1,1,1-tris(3-adamantyl-5-methyl-1-pyrazolyl)ethane
]manganese,
 dichloro[1,1,1-tris(1-imidazolyl)ethane]manganese,
 dichloro[1,1,1-tris(7-methyl-1-imidazolyl)ethane]manganese,
 dichloro[1,1,1-tris(7-isopropyl-1-imidazolyl)ethane]mangane
 25 se,
 dichloro[1,1,1-tris(7-tert-butyl-1-imidazolyl)ethane]mangan
 ese and the like, and transition metal compounds such as compounds

in which manganese in these compounds is changed to technetium or rhenium, compounds in which chlorine in these compounds is changed to fluorine, bromine, iodine, methyl, benzyl, methoxy or phenoxy, compounds in which tris in these compounds is changed
 5 to tetrakis, and compounds in which ethane in these compounds is changed to propane, butane, isobutene, pentane, 2-methylbutane, 3-methylbutane or 2,2-dimethylpropane.

Specific examples of the compound of the above-mentioned general formula [1] include

10 [tris(1-pyrazolyl)methane](1,3-butadiene)manganese,
 [tris(3-methyl-1-pyrazolyl)methane](1,3-butadiene)manganese,
 [tris(4-methyl-1-pyrazolyl)methane](1,3-butadiene)manganese,
 [tris(3-ethyl-1-pyrazolyl)methane](1,3-butadiene)manganese,
 [tris(3-n-propyl-1-pyrazolyl)methane](1,3-butadiene)mangane
 15 se,
 [tris(3-isopropyl-1-pyrazolyl)methane](1,3-butadiene)mangan
 ese,
 [tris(3-n-butyl-1-pyrazolyl)methane](1,3-butadiene)manganes
 e,
 20 [tris(3-sec-butyl-1-pyrazolyl)methane](1,3-butadiene)mangan
 ese,
 [tris(3-isobutyl-1-pyrazolyl)methane](1,3-butadiene)mangane
 se,
 [tris(3-tert-butyl-1-pyrazolyl)methane](1,3-butadiene)manga
 25 nese,
 [tris(3-phenyl-1-pyrazolyl)methane](1,3-butadiene)manganese,
 [tris(3-p-tolyl-1-pyrazolyl)methane](1,3-butadiene)manganes

e,

[tris(3-cumyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

{tris[3-(trifluoromethyl)-1-pyrazolyl]methane}manganese,

{tris[3-(pentafluoroethyl)-1-pyrazolyl]methane}manganese,

5 [tris(3-cyclohexyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3-adamantyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(4-chloro-1-pyrazolyl)methane](1,3-butadiene)manganese,

10 [tris(4-bromo-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(4-iodo-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3,5-dimethyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3,5-diethyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

15 ese,

[tris(3,5-di-n-propyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3,5-diisopropyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

20 [tris(3,5-di-n-butyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3,5-di-sec-butyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3,5-diisobutyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

25 ganese,

[tris(3,5-di-tert-butyl-1-pyrazolyl)methane](1,3-butadiene)manganese,

[tris(3,5-diphenyl-1-pyrazolyl)methane](1,3-butadiene)manga
 nese,
 [tris(5-methyl-3-isopropyl-1-pyrazolyl)methane](1,3-butadie
 ne)manganese,
 5 [tris(3-tert-butyl-5-methyl-1-pyrazolyl)methane](1,3-butadi
 ene)manganese,
 [tris(5-methyl-3-phenyl-1-pyrazolyl)methane](1,3-butadiene)
 manganese,
 [tris(5-methyl-3-p-tolyl-1-pyrazolyl)methane](1,3-butadiene
 10)manganese,
 [tris(3-cumyl-5-methyl-1-pyrazolyl)methane](1,3-butadiene)m
 anganese,
 [tris(3-adamantyl-5-methyl-1-pyrazolyl)methane](1,3-butadie
 ne)manganese,
 15 [tris(1-imidazolyl)methane](1,3-butadiene)manganese,
 [tris(7-methyl-1-imidazolyl)methane](1,3-butadiene)manganes
 e,
 [tris(7-isopropyl-1-imidazolyl)methane](1,3-butadiene)manga
 nese,
 20 [tris(7-tert-butyl-1-imidazolyl)methane](1,3-butadiene)mang
 anese and the like, and transition metal compounds such as
 compounds in which manganese in these compounds is changed to
 technetium or rhenium, compounds in which 1,3-butadiene in these
 compounds is changed to 2,4-heptadiene or 1,4-diphenylbutadiene,
 25 compounds in which tris in these compounds is changed to tetrakis,
 and compounds in which methane in these compounds is changed
 to silane, methylsilane, ethylsilane, tert-butylsilane,

phenylsilane, germane, methylgermane, ethylgermane, tert-butylgermane, phenylgermane, amine, phosphine or phosphite.

Specific examples of the compound of the above-mentioned
 5 general formula [2] include $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(1\text{-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-methyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(4\text{-methyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 10 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-ethyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-n-propyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 15 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-isopropyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-n-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-sec-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 20 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-isobutyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-tert-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 25 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-phenyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-p-tolyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$

}, di(μ
 ^{2} -oxo)bis{[hydrotris(3-cumyl-1-pyrazolyl)borate]manganese},
 di(μ^2 -oxo)bis
 [{hydrotris[3-(trifluoromethyl)-1-pyrazolyl]borate]mangan
 5 se] , di(μ^2 -oxo)bis
 [{hydrotris[3-(pentafluoroethyl)-1-pyrazolyl]borate]mangan
 ese] , di(μ
 ^{2} -oxo)bis{[hydrotris(3-cyclohexyl-1-pyrazolyl)borate]mangan
 ese}, di(μ
 10 ^{2} -oxo)bis{[hydrotris(3-adamantyl-1-pyrazolyl)borate]mangan
 se}, di(μ
 ^{2} -oxo)bis{[hydrotris(4-chloro-1-pyrazolyl)borate]manganese},
 di(μ
 ^{2} -oxo)bis{[hydrotris(4-bromo-1-pyrazolyl)borate]manganese},
 15 di(μ
 ^{2} -oxo)bis{[hydrotris(4-iodo-1-pyrazolyl)borate]manganese},
 di(μ
 ^{2} -oxo)bis{[hydrotris(3,5-dimethyl-1-pyrazolyl)borate]mangan
 ese}, di(μ
 20 ^{2} -oxo)bis{[hydrotris(3,5-diethyl-1-pyrazolyl)borate]mangan
 se}, di(μ
 ^{2} -oxo)bis{[hydrotris(3,5-di-n-propyl-1-pyrazolyl)borate]man
 ganese}, di(μ
 ^{2} -oxo)bis{[hydrotris(3,5-diisopropyl-1-pyrazolyl)borate]man
 25 ganese}, di(μ
 ^{2} -oxo)bis{[hydrotris(3,5-di-n-butyl-1-pyrazolyl)borate]mang
 anese}, di(μ

- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3,5\text{-di-sec-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3,5\text{-diisobutyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- 5 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3,5\text{-di-tert-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3,5\text{-diphenyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(5\text{-methyl-3-isopropyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- 10 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-tert-butyl-5-methyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(5\text{-methyl-3-phenyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- 15 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(5\text{-methyl-3-p-tolyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-cumyl-5-methyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(3\text{-adamantyl-5-methyl-1-pyrazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- 20 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(1\text{-imidazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(7\text{-methyl-1-imidazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(7\text{-isopropyl-1-imidazolyl})\text{borate}]\text{manganese}\}, \text{di}(\mu$
- 25 $^2\text{-oxo})\text{bis}\{[\text{hydrotris}(7\text{-tert-butyl-1-imidazolyl})\text{borate}]\text{manganese}\}$ and transition metal compounds such as compounds in which

$\text{di}(\mu^2\text{-oxo})$ in these compounds is changed to $\text{di}(\mu^2\text{-hydroxy})$,
 $\text{di}(\mu^2\text{-methoxy})$, $\text{di}(\mu^2\text{-isopropoxy})$, $\text{di}(\mu^2\text{-tert-butyloxy})$,
 $\text{di}(\mu^2\text{-phenoxy})$, $\text{di}(\mu^2\text{-acetyl})$, $\text{di}(\mu^2\text{-acetate})$, $\text{di}(\mu^2\text{-benzoate})$,
 $(\mu^2\text{-peroxo})$, $(\mu^2\text{-disulfide})$ or $(\mu^2\text{-azide})$,
5 compounds in which manganese in these compounds is changed to
technetium or rhenium, compounds in which hydro in these
compounds is changed to methyl, ethyl, n-propyl, isopropyl,
n-butyl, sec-butyl, isobutyl, tert-butyl, phenyl, p-tolyl,
cumyl, pyrazolyl, 3-methylpyrazolyl, 4-methylpyrazolyl,
10 3-ethylpyrazolyl, 3-n-propylpyrazolyl, 3-isopropylpyrazolyl,
3-n-butylpyrazolyl, 3-sec-butylpyrazolyl,
3-isobutylpyrazolyl, 3-tert-butylpyrazolyl,
3-phenylpyrazolyl, 3-p-tolylpyrazolyl, 3-cumylpyrazolyl,
3-(trifluoromethyl)pyrazolyl, 3-(pentafluoroethyl)pyrazolyl,
15 3-cyclohexylpyrazolyl, 3-adamantylpyrazolyl,
4-chloropyrazolyl, 4-bromopyrazolyl, 4-iodopyrazolyl,
3,5-dimethylpyrazolyl, 3,5-diethylpyrazolyl,
3,5-di-n-propylpyrazolyl, 3,5-diisopropylpyrazolyl,
3,5-di-n-butylpyrazolyl, 3,5-di-sec-butylpyrazolyl,
20 3,5-diisobutylpyrazolyl, 3,5-di-tert-butylpyrazolyl,
3,5-diphenylpyrazolyl, 5-methyl-3-isopropylpyrazolyl,
3-tert-butyl-5-methylpyrazolyl, 5-methyl-3-phenylpyrazolyl,
5-methyl-3-para-tolylpyrazolyl, 3-cumyl-5-methylpyrazolyl,
3-adamantyl-5-methylpyrazolyl, imidazolyl,
25 7-methylimidazolyl, 7-isopropylimidazolyl or
7-tert-butylimidazolyl, and compounds in which borate in these
compounds is changed to aluminate.

Specific examples of the compound of the above-mentioned general formula [2] include $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(1\text{-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-methyl-1-pyrazolyl})\text{borate}]\text{manganese}$
5 $\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(4\text{-methyl-1-pyrazolyl})\text{borate}]\text{manganese}$
 $\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-ethyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu$
10 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-n-propyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-isopropyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-n-butyl-1-pyrazolyl})\text{borate}]\text{manganese}$
15 $\text{e}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-sec-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-isobutyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
20 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-tert-butyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-phenyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-p-tolyl-1-pyrazolyl})\text{borate}]\text{manganese}$
25 $\text{e}\}$, $\text{di}(\mu$
 $^2\text{-oxo})\text{bis}\{[\text{dihydrobis}(3\text{-cumyl-1-pyrazolyl})\text{borate}]\text{manganese}\}$,
 $\text{di}(\mu^2\text{-oxo})\text{bis}$

[{dihydrobis[3-(trifluoromethyl)-1-pyrazolyl]borate}mangan
 ese] , di(μ^2 -oxo)bis
 [{dihydrobis[3-(pentafluoroethyl)-1-pyrazolyl]borate}manga
 nese] , di(μ
 5 ^{2} -oxo)bis{[dihydrobis(3-cyclohexyl-1-pyrazolyl)borate]manga
 nese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3-adamantyl-1-pyrazolyl)borate]mangan
 ese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(4-chloro-1-pyrazolyl)borate]manganese
 10 }, di(μ
 ^{2} -oxo)bis{[dihydrobis(4-bromo-1-pyrazolyl)borate]manganese},
 di(μ
 ^{2} -oxo)bis{[dihydrobis(4-iodo-1-pyrazolyl)borate]manganese},
 di(μ
 15 ^{2} -oxo)bis{[dihydrobis(3,5-dimethyl-1-pyrazolyl)borate]manga
 nese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-diethyl-1-pyrazolyl)borate]mangan
 ese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-di-n-propyl-1-pyrazolyl)borate]ma
 20 nganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-diisopropyl-1-pyrazolyl)borate]ma
 nganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-di-n-butyl-1-pyrazolyl)borate]man
 ganese}, di(μ
 25 ^{2} -oxo)bis{[dihydrobis(3,5-di-sec-butyl-1-pyrazolyl)borate]m
 anganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-diisobutyl-1-pyrazolyl)borate]man

ganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-di-tert-butyl-1-pyrazolyl)borate]
 manganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3,5-diphenyl-1-pyrazolyl)borate]manga
 5 nese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(5-methyl-3-isopropyl-1-pyrazolyl)bora
 te]manganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3-tert-butyl-5-methyl-1-pyrazolyl)bor
 ate]manganese}, di(μ
 10 ^{2} -oxo)bis{[dihydrobis(5-methyl-3-phenyl-1-pyrazolyl)borate]
 manganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(5-methyl-3-para-tolyl-1-pyrazolyl)bor
 ate]manganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3-cumyl-5-methyl-1-pyrazolyl)borate]m
 15 anganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(3-adamantyl-5-methyl-1-pyrazolyl)bora
 te]manganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(1-imidazolyl)borate]manganese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(7-methyl-1-imidazolyl)borate]manganes
 20 e}, di(μ
 ^{2} -oxo)bis{[dihydrobis(7-isopropyl-1-imidazolyl)borate]manga
 nese}, di(μ
 ^{2} -oxo)bis{[dihydrobis(7-tert-butyl-1-imidazolyl)borate]mang
 anese}, and transition metal compounds such as compounds in which
 25 di(μ^2 -oxo) in these compounds is changed to di(μ^2 -hydroxy),
 di(μ^2 -methoxy), di(μ^2 -isopropoxy), di(μ^2 -tert-butyloxy),
 di(μ^2 -phenoxy), di(μ^2 -acetyl), di(μ^2 -acetate), di(μ

μ^2 -benzoate), (μ^2 -peroxo), (μ^2 -disulfide) or (μ^2 -azide), compounds in which manganese in these compounds is changed to technetium or rhenium, compounds in which hydro in these compounds is changed to methyl, ethyl, n-propyl, isopropyl, 5 n-butyl, sec-butyl, isobutyl, tert-butyl, phenyl, para-tolyl or cumyl, and compounds obtained by changing borate in these compounds by aluminate.

Specific examples of the compound of the above-mentioned general formula [2] further include di(μ
 10 μ^2 -oxo)bis{chloro[tris(1-pyrazolyl)methane]manganese}, di(μ
 μ^2 -oxo)bis{chloro[tris(3-methyl-1-pyrazolyl)methane]manganese}, di(μ
 μ^2 -oxo)bis{chloro[tris(4-methyl-1-pyrazolyl)methane]manganese}, di(μ
 15 μ^2 -oxo)bis{chloro[tris(3-ethyl-1-pyrazolyl)methane]manganese}, di(μ
 μ^2 -oxo)bis{chloro[tris(3-n-propyl-1-pyrazolyl)methane]manganese}, di(μ
 μ^2 -oxo)bis{chloro[tris(3-isopropyl-1-pyrazolyl)methane]manganese}, di(μ
 20 μ^2 -oxo)bis{chloro[tris(3-n-butyl-1-pyrazolyl)methane]manganese}, di(μ
 μ^2 -oxo)bis{chloro[tris(3-sec-butyl-1-pyrazolyl)methane]manganese}, di(μ
 25 μ^2 -oxo)bis{chloro[tris(3-isobutyl-1-pyrazolyl)methane]manganese}, di(μ
 μ^2 -oxo)bis{chloro[tris(3-tert-butyl-1-pyrazolyl)methane]manganese}

anese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3-phenyl-1-pyrazolyl)methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3-p-tolyl-1-pyrazolyl)methane]manganese}, di(μ
5 se}, di(μ
 ^{2} -oxo)bis{chloro[tris(3-cumyl-1-pyrazolyl)methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris[3-(trifluoromethyl)-1-pyrazolyl]methane]manganese}, di(μ
10 ^{2} -oxo)bis{chloro[tris[3-(pentafluoroethyl)-1-pyrazolyl]methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3-cyclohexyl-1-pyrazolyl)methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3-adamantyl-1-pyrazolyl)methane]manganese}, di(μ
15 nese}, di(μ
 ^{2} -oxo)bis{chloro[tris(4-chloro-1-pyrazolyl)methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris(4-bromo-1-pyrazolyl)methane]manganese}, di(μ
20 ^{2} -oxo)bis{chloro[tris(4-iodo-1-pyrazolyl)methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3,5-dimethyl-1-pyrazolyl)methane]manganese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3,5-diethyl-1-pyrazolyl)methane]manganese}, di(μ
25 nese}, di(μ
 ^{2} -oxo)bis{chloro[tris(3,5-di-n-propyl-1-pyrazolyl)methane]manganese}, di(μ

- $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3,5\text{-diisopropyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3,5\text{-di-n-butyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
5 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3,5\text{-di-sec-butyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3,5\text{-diisobutyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3,5\text{-di-tert-butyl-1-pyrazolyl})\text{methane}$
10 $]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3,5\text{-diphenyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(5\text{-methyl-3-isopropyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
15 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3\text{-tert-butyl-5-methyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(5\text{-methyl-3-phenyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(5\text{-methyl-3-p-tolyl-1-pyrazolyl})\text{methane}$
20 $\text{e}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3\text{-cumyl-5-methyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(3\text{-adamantyl-5-methyl-1-pyrazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
25 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(1\text{-imidazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$
 $^{2-}\text{oxo})\text{bis}\{\text{chloro}[\text{tris}(7\text{-methyl-1-imidazolyl})\text{methane}]\text{manganese}\}, \text{di}(\mu$

μ^2 -oxo)bis{chloro[tris(7-isopropyl-1-imidazolyl)methane]mang
 anese}, di(μ
 μ^2 -oxo)bis{chloro[tris(7-tert-butyl-1-imidazolyl)methane]man
 ganese}, and transition metal compounds such as compounds in
 5 which di(μ^2 -oxo) in these compounds is changed to di(μ^2 -hydroxy),
 di(μ^2 -methoxy), di(μ^2 -isopropoxy), di(μ^2 -tert-butyloxy),
 di(μ^2 -phenoxy), di(μ^2 -acetyl), di(μ^2 -acetate), di(μ
 μ^2 -benzoate), (μ^2 -peroxo), (μ^2 -disulfide) or (μ^2 -azide),
 compounds in which manganese in these compounds is changed to
 10 technetium or rhenium, compounds in which chlorine in these
 compounds is changed to fluorine, bromine, iodine, methyl, benzyl,
 methoxy or phenoxy, compounds in which tris in these compounds
 is changed to bis or tetrakis, and compounds in which methane
 in these compounds is changed to silane, methylsilane,
 15 ethylsilane, tert-butylsilane, phenylsilane, germane,
 methylgermane, ethylgermane, tert-butylgermane, phenylgermane,
 amine, phosphine or phosphite.

Specific examples of the compound of the above-mentioned
 general formula [2] furthermore include di(μ^2 -oxo)bis
 20 {dichloro[1,1,1-tris(1-pyrazolyl)ethane]manganese}, di(μ
 μ^2 -oxo)bis{dichloro[1,1,1-tris(3-methyl-1-pyrazolyl)ethane]m
 anganese}, di(μ
 μ^2 -oxo)bis{dichloro[1,1,1-tris(4-methyl-1-pyrazolyl)ethane]m
 anganese}, di(μ
 25 μ^2 -oxo)bis{dichloro[1,1,1-tris(3-ethyl-1-pyrazolyl)ethane]ma
 nganese}, di(μ
 μ^2 -oxo)bis{dichloro[1,1,1-tris(3-n-propyl-1-pyrazolyl)ethane

]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-isopropyl-1-pyrazolyl)ethane
 e]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-n-butyl-1-pyrazolyl)ethane]
 5 manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-sec-butyl-1-pyrazolyl)ethane
 e]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-isobutyl-1-pyrazolyl)ethane
]manganese}, di(μ
 10 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-tert-butyl-1-pyrazolyl)ethane
 ne]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-phenyl-1-pyrazolyl)ethane]m
 anganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-para-tolyl-1-pyrazolyl)ethane]
 15 ne]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-cumyl-1-pyrazolyl)ethane]ma
 nganese}, di(μ
 ^{2} -oxo)bis{chloro{tris[3-(trifluoromethyl)-1-pyrazolyl]ethane
 e]manganese}, di(μ
 20 ^{2} -oxo)bis{chloro{tris[3-(pentafluoroethyl)-1-pyrazolyl]ethane
 ne]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-cyclohexyl-1-pyrazolyl)ethane
 ne]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-adamantyl-1-pyrazolyl)ethane
 25 e]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(4-chloro-1-pyrazolyl)ethane]m
 anganese}, di(μ

- ^{2} -oxo)bis(dichloro[1,1,1-tris(4-bromo-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(4-iodo-1-pyrazolyl)ethane]manganese}, di(μ
- 5 ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-dimethyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-diethyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-di-n-propyl-1-pyrazolyl)ethane]manganese}, di(μ
- 10 ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-diisopropyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-di-n-butyl-1-pyrazolyl)ethane]manganese}, di(μ
- 15 ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-di-sec-butyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-diisobutyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-di-tert-butyl-1-pyrazolyl)ethane]manganese}, di(μ
- 20 ^{2} -oxo)bis(dichloro[1,1,1-tris(3,5-diphenyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(5-methyl-3-isopropyl-1-pyrazolyl)ethane]manganese}, di(μ
- 25 ^{2} -oxo)bis(dichloro[1,1,1-tris(3-tert-butyl-5-methyl-1-pyrazolyl)ethane]manganese}, di(μ
- ^{2} -oxo)bis(dichloro[1,1,1-tris(5-methyl-3-phenyl-1-pyrazolyl

)ethane]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(5-methyl-3-para-tolyl-1-pyraz
 ol)ethane]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-cumyl-5-methyl-1-pyrazolyl)
 5 ethane]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(3-adamantyl-5-methyl-1-pyrazo
 lyl)ethane]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(1-imidazolyl)ethane]manganese
 }, di(μ
 10 ^{2} -oxo)bis{dichloro[1,1,1-tris(7-methyl-1-imidazolyl)ethane]
 manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(7-isopropyl-1-imidazolyl)etha
 ne]manganese}, di(μ
 ^{2} -oxo)bis{dichloro[1,1,1-tris(7-tert-butyl-1-imidazolyl)eth
 15 ane]manganese}, and transition metal compounds such as compounds
 in which di(μ^2 -oxo) in these compounds is changed to di(μ
 ^{2} -hydroxy), di(μ^2 -methoxy), di(μ^2 -isopropoxy), di(μ
 ^{2} -tert-butyloxy), di(μ^2 -phenoxy), di(μ^2 -acetyl), di(μ
 ^{2} -acetate), di(μ^2 -benzoate), (μ^2 -peroxo), (μ^2 -disulfide) or
 20 (μ^2 -azide), compounds in which manganese in these compounds
 is changed to technetium or rhenium, compounds in which chlorine
 in these compounds is changed to fluorine, bromine, iodine,
 methyl, benzyl, methoxy or phenoxy, compounds in which tris in
 these compounds is changed to bis or tetrakis, and compounds
 25 in which ethane in these compounds is changed to propane, butane,
 isobutene, pentane, 2-methylbutane, 3-methylbutane or
 2,2-dimethylpropane.

Further, there can be exemplified compounds obtained by coordinating to the transition metal (manganese, technetium or rhenium) of specific compounds above-mentioned represented by the general formulae [1] and [2] a neutral ligand selected from,

5 for example, ethers such as diethyl ether, tetrahydrofuran and dimethoxyethane, amines such as triethylamine, N,N,N',N'-tetramethylethylenediamine, pyridines such as pyridine, 2,6-dimethylpyridine and quinoline, pyrazole, substituted pyrazoles such as 3-methylpyrazole,

10 4-methylpyrazole, 5-methylpyrazole, 3-ethylpyrazole, 3-n-propylpyrazole, 3-isopropylpyrazole, 3-n-butylpyrazole, 3-sec-butylpyrazole, 3-isobutylpyrazole, 3-tert-butylpyrazole, 3-phenylpyrazole, 3-p-tolylpyrazole, 3-cumylpyrazole, 3-(trifluoromethyl)pyrazole,

15 3-(pentafluoroethyl)pyrazole, 3-cyclohexylpyrazole, 3-adamantylpyrazole, 4-chloropyrazole, 4-bromopyrazole, 4-iodopyrazole, 3,5-dimethylpyrazole, 3,5-diethylpyrazole, 3,5-di-n-propylpyrazole, 3,5-diisopropylpyrazole, 3,5-di-n-butylpyrazole, 3,5-di-sec-butylpyrazole,

20 3,5-diisobutylpyrazole, 3,5-di-tert-butylpyrazole, 3,5-diphenylpyrazole, 5-methyl-3-isopropylpyraozole, 3-tert-butyl-5-methylpyrazole, 5-methyl-3-phenylpyrazole, 5-methyl-3-p-tolylpyrazole, 3-cumyl-5-methylpyrazole, 3-adamantyl-5-methylpyrazole, imidazole, 7-methylimidazole,

25 7-isopropylimidazole and 7-tert-butylimidazole, phosphines such as trimethylphosphine, triethylphosphine, triphenylphosphine, dimethylphenylphosphine,

methyldiphenylphosphine, 1,2-bis(dimethylphosphino)ethane,
 1,2-bis(diethylphosphino)ethane,
 1,2-bis(diphenylphosphino)ethane and
 1,3-bis(diphenylphosphino)propane, nitriles such as
 5 acetonitrile and benzonitrile; endo-on type nitrogen molecule;
 carbon monoxide; olefins such as ethylene, propylene and the
 like; dienes such as butadiene, 2,4-hexadiene and
 1,4-diphenylbutadiene; ketones such as acetone and
 acetophenone; and side-on type nitrogen molecule.

10 In the present invention, these transition metal compounds
 may be used alone or in combination of two or more.

Such transition metal compounds are produced, for example,
 by a method described in J. Am. Chem. Soc., Vol. 89, p. 3904-3905
 (1967).

15 The catalyst for addition polymerization of the present
 invention is obtained by contacting the above-mentioned
 transition metal compound with the following (B) and/or the
 following (C).

(B) one or more aluminum compounds selected from the following
 20 (B1) to (B3),

(B1) organoaluminum compounds of the general formula
 $E^1_a AlZ_{3-a}$,

(B2) cyclic aluminoxanes having a structure of the
 general formula $\{-Al(E^2)-O-\}_b$,

25 (B3) linear aluminoxanes having a structure of the
 general formula $E^3\{-Al(E^3)-O-\}_c AlE^3_2$,

(wherein, each of E^1 , E^2 and E^3 represents a hydrocarbon group,

and all of E^1 's, all of E^2 's and all of E^3 's may be the same or different. Z represents a hydrogen atom or halogen atom, all of Zs may be the same or different. a represents a number satisfying $0 < a \leq 3$, b represents an integer of 2 or more, and c represents an integer of 1 or more.).

(C) one or more boron compounds selected from the following (C1) to (C3),

(C1) boron compounds of the general formula $BQ^1Q^2Q^3$,

(C2) boron compounds of the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$,

10 (C3) boron compounds of the general formula

$(L-H)^+(BQ^1Q^2Q^3Q^4)^-$,

(wherein, B represents a boron atom of tri-valent state, Q^1 to Q^4 represent a halogen atom, hydrocarbon group, halogenated hydrocarbon group, substituted silyl group, alkoxy group or di-substituted amino group, and they may be the same or different. G^+ represents an inorganic or organic cation, L represents a neutral Lewis base, and $(L-H)^+$ represents a Brønsted acid.).

The catalyst for addition polymerization will be described further in detail below.

20 (B) Aluminum compound

As the aluminum compound (B), one or more aluminum compounds selected from the above-mentioned (B1) to (B3) are used.

As the hydrocarbon group represented by E^1 , E^2 and E^3 , hydrocarbon groups having 1 to 8 carbon atoms are preferably, and an alkyl group is more preferable.

Specific examples of the organoaluminum compound (B1) of

the general formula $E^1_a AlZ_{3-a}$ include trialkylaluminums such as trimethylaluminum, triethylaluminum, tripropylaluminum, triisobutylaluminum, trihexylaluminum and the like; dialkylaluminum chloride such as dimethylaluminum chloride, 5 diethylaluminum chloride, dipropylaluminum chloride, diisobutylaluminum chloride, dihexylaluminum chloride and the like; alkylaluminum dichlorides such as methylaluminum dichloride, ethylaluminum dichloride, propylaluminum dichloride, isobutylaluminum dichloride, hexylaluminum 10 dichloride and the like, and dialkylaluminum hydrides such as dimethylaluminum hydride, diethylaluminum hydride, dipropylaluminum hydride, diisobutylaluminum hydride, dihexylaluminum hydride and the like.

Preferable are trialkylaluminums, more preferable is 15 triethylaluminum or triisobutylaluminum.

Specific examples of E^2 and E^3 in the cyclic aluminoxane (B2) having a structure of the general formula $\{-Al(E^2)-O-\}_b$ and the linear aluminoxanes (B3) having a structure of the general formula $E^3\{-Al(E^3)-O-\}_c AlE^3_2$ include alkyl groups such as a methyl 20 group, ethyl group, n-propyl group, isopropyl group, n-butyl group, isobutyl group, n-pentyl group, neopentyl group and the like. b represents an integer of 2 or more, and c represents an integer of 1 or more. Preferably, E^2 and E^3 represent a methyl group or isobutyl group, b is 2 to 40, and c is 1 to 40.

25 The above-mentioned aluminoxane is produced by various methods. The method is not particularly restricted, and the aluminoxane may advantageously be produced according to known

methods. For example, it is produced by contacting a solution prepared by dissolving a trialkylaluminum (e.g., trimethylaluminum) in a suitable organic solvent (e.g., benzene, aliphatic hydrocarbon) with water. Further, a method is exemplified in which an aluminoxane is produced by contacting a trialkylaluminum (e.g., trimethylaluminum) with a metal salt containing crystal water (e.g., copper sulfate hydrate).

It is considered that the aluminoxane prepared by such methods is usually a mixture of a cyclic aluminoxane and a linear aluminoxane.

(C) Boron compound

As the boron compound (C), one or more boron compounds selected from (C1), (C2) and (C3) above-mentioned are used.

In the boron compound (C1) of the general formula $BQ^1Q^2Q^3$, B represents a trivalent boron atom, and Q^1 to Q^3 represent a halogen atom, hydrocarbon group, halogenated hydrocarbon group, substituted silyl group, alkoxy group or di-substituted amino group, and they may be the same or different. Q^1 to Q^3 preferably represent 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 carbon atoms, an alkoxy group having 1 to 20 carbon atoms, or an amino group having 1 to 20 carbon atoms, and Q^1 to Q^3 more preferably represent a halogen atom, a hydrocarbon group having 1 to 20 carbon atoms or a halogenated hydrocarbon group having 1 to 20 carbon atoms. Further preferably, Q^1 to Q^4 represent a fluorinated hydrocarbon group having 1 to 20 carbon atoms

containing at least one fluorine atom, and particularly preferably, Q^1 to Q^4 represent a fluorinated aryl group having 6 to 20 carbon atoms containing at least fluorine atom.

Specific examples of the compound (C1) include

5 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,

10 phenylbis(pentafluorophenyl)borane and the like, and
 tris(pentafluorophenyl)borane is most preferable.

In the boron compound (C2) of the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$, G^+ represents an inorganic or organic cation, B represents a trivalent boron atom, and Q^1 to Q^4 are as defined

15 for Q^1 to Q^3 in the above-mentioned (C1).

Specific examples of the inorganic cation G^+ include a ferrocenium cation, alkyl-substituted ferrocenium cation, silver cation and the like, and specific examples of the organic cation G^+ include a triphenylcarbenium cation and the like. G^+

20 represents preferably a carbenium cation, and particularly preferably a triphenylcarbenium cation. Examples of $(BQ^1Q^2Q^3Q^4)^-$ include tetrakis(pentafluorophenyl)borate,
 tetrakis(2,3,5,6-tetrafluorophenyl)borate,
 tetrakis(2,3,4,5-tetrafluorophenyl)borate,

25 tetrakis(3,4,5-trifluorophenyl)borate,
 tetrakis(2,3,4-trifluorophenyl)borate,
 phenyltris(pentafluorophenyl)borate,

tetrakis(3,5-bistrifluoromethylphenyl)borate and the like.

Specific combinations thereof include ferrocenium
 tetrakis(pentafluorophenyl)borate, 1,1'-dimethylferrocenium
 tetrakis(pentafluorophenyl)borate, silver
 5 tetrakis(pentafluorophenyl)borate,
 triphenylcarbeniumtetrakis(pentafluorophenyl)borate,
 triphenylcarbeniumtetrakis(3,5-bistrifluoromethylphenyl)bor
 ate and the like, and
 triphenylcarbeniumtetrakis(pentafluorophenyl)borate is most
 10 preferable.

In the boron compound (C3) of the general formula
 $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$, L represents a neutral Lewis base and $(L-H)^+$
 represents a Brønsted acid, B represents a trivalent boron atom,
 and Q^1 to Q^4 are as defined for Q^1 to Q^3 in the above-mentioned
 15 (C1).

Specific examples of the Brønsted acid $(L-H)^+$ in the
 compound of the general formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$ include
 trialkyl-substituted ammoniums, N,N-dialkylaniliniums,
 dialkylammoniums, triarylphosphoniums and the like, and as
 20 $(BQ^1Q^2Q^3Q^4)^-$, the same moieties as described above are listed.

Specific combinations thereof include
 triethylammoniumtetrakis(pentafluorophenyl)borate,
 tripropylammonium tetrakis(pentafluorophenyl)borate,
 tri(n-butyl)ammoniumtetrakis(pentafluorophenyl)borate,
 25 tri(n-butyl)ammoniumtetrakis
 (3,5-bistrifluoromethylphenyl)borate,
 N,N-dimethylaniliniumtetrakis(pentafluorophenyl)borate,

- N,N-diethylanilinium tetrakis(pentafluorophenyl)borate,
 N,N-2,4,6-pentamethylaniliniumtetrakis(pentafluorophenyl)bo
 rate, N,N-dimethylaniliniumtetrakis
 (3,5-bistrifluoromethylphenyl)borate,
 5 diisopropylammoniumtetrakis(pentafluorophenyl)borate,
 dicyclohexyammoniumtetrakis(pentafluorophenyl)borate,
 triphenylphosphoniumtetrakis(pentafluorophenyl)borate,
 tri(methylphenyl)phosphoniumtetrakis(pentafluorophenyl)bora
 te,
 10 tri(dimethylphenyl)phosphoniumtetrakis(pentafluorophenyl)bo
 rate and the like are listed, and most preferable is
 tri(n-butyl)ammonium tetrakis(pentafluorophenyl)borate, or
 N,N-dimethylaniliniumtetrakis(pentafluorophenyl)borate.

- Contact in producing a stereoregular α -olefin
 15 polymerization catalyst by allowing the above-mentioned
 transition metal compound to contact with a co-catalyst for
 activation may be conducted by any means forming a catalyst by
 contacting the transition metal compound with the co-catalyst
 for activation, and there are adopted a method in which a
 20 transition metal compound and a co-catalyst for activation are
 previously diluted by a solvent or not diluted, before they are
 mixed for mutual contact, and a method in which a transition
 metal compound and a co-catalyst for activation are separately
 fed into a polymerization vessel for mutual contact thereof.
 25 As the co-catalyst for activation, a plurality of compounds may
 be combined and used, however, it is needless to say that a part
 of which may be previously mixed and used, or they may be separately

fed into a polymerization vessel and used.

It is desirable to use components so that the molar ratio of [the aluminum compound (B) in terms of Al atom]/[transition metal compound (A) in terms of transition metal atom] is from 0.1 to 10000, preferably from 5 to 2000, and the molar ratio of boron compound (C)/ [transition metal compound (A) in terms of transition metal atom] is from 0.01 to 100, preferably from 0.5 to 10.

The concentrations of components when they are used in the form of a solution, or suspension or slurry in a solvent are appropriately selected depending on the ability of an apparatus for feeding components into a polymerization reactor, and it is generally desirable that the concentration of the transition metal compound (A) in terms of transition metal atom is usually from 0.001 to 200 mmol/L, more preferably from 0.001 to 100 mmol/L, further preferably from 0.05 to 50 mmol/L, the concentration of the organoaluminum compound (B) in terms of Al atom is usually from 0.01 to 5000 mmol/L, more preferably from 0.1 to 2500 mmol/L, further preferably 0.1 to 2000 mmol/L, and the concentration of the boron compound (C) is usually from 0.001 to 500 mmol/L, more preferably from 0.01 to 250 mmol/L, further preferably from 0.05 to 100 mmol/L.

[Polymerization]

In the present invention, a addition polymer can be produced by polymerizing an addition polymerizable monomer with the catalyst for addition polymerization obtained by contacting the above-mentioned transition metal compound (A) with a

co-catalyst for activation. When the catalyst obtained by contacting the transition metal compound (A) with the aluminum compound (B) is used as the catalyst for addition polymerization, the above-mentioned cyclic aluminoxane (B2) and/or linear
5 aluminoxane (B3) is preferably used as (B). As other preferable embodiments of the catalyst, catalysts obtained by contact the transition metal compound (A), the aluminum compound (B) and the boron compound (C) are listed, and the above-mentioned (B1) is easily used as (B) in this case.

10 The addition polymerizable monomer used in the present invention includes preferably olefins up to 20 carbon atoms such as monoolefins having 2 to 20 carbon atoms and diolefins having 4 to 20 carbon. Two or more monomers can also be used simultaneously. Examples of the monoolefins 2 to 20 carbon atoms include ethylene
15 and α -monoolefins (hereinafter, referred to as α -olefins) such as propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 3-methyl-1-butene, 3-methyl-1-pentene 4-methyl-1-pentene 5-methyl-1-hexene and the like, styrenes such as styrene, p-methylstyrene,
20 p-tert-butylstyrene and the like, vinylcyclohexane and the like, but the scope of the invention is not limited to them. Examples of the diolefin include non-conjugated dienes 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,
25 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-endomethylenehexahydronaphthalene; conjugated dienes such as 1,3-butadiene, isoprene, 1,3-hexadiene, 1,3-octadiene, 1,3-cyclooctadiene, 1,3-cyclohexadiene; and the like.

5 When copolymerization using ethylene is carried out, specific examples of preferable combination of monomers include ethylene and propylene, ethylene and 1-butene, ethylene and 1-hexene, ethylene and 1-octene, ethylene and styrene, ethylene and vinylcyclohexane and the like, but should not be limited
10 thereto. The present invention is preferably applied to production of copolymers of ethylene and an α -olefin having 3 to 20 carbon atoms having a polyethylene crystalline structure, and to production of stereoregular polymers, particularly isotactic polymers of an α -olefin having 3 to 20 carbon atoms.

15 The polymerization catalyst of the present invention is also suitable as an isotactic stereoregular α -olefin polymerization catalyst, and particularly suitable as an isotactic stereoregular propylene polymerization catalyst. The method of producing a stereoregular α -olefin polymer of
20 the present invention is suitable as a method of producing an isotactic stereoregular α -olefin polymer, and particularly suitable as a method of producing an isotactic stereoregular propylene polymer.

 Specific examples of the isotactic stereoregular
25 propylene polymer include a homopolymer of propylene; random copolymers of propylene with comonomers such as ethylene and/or α -olefin having 4 to 12 carbon atoms in an amount not

deteriorating crystallinity; and block copolymers obtained by homo-polymerizing propylene or copolymerizing propylene with ethylene and/or an α -olefin having 4 to 12 carbon atoms (this is called "pre-stage polymerization"), then, polymerizing an
5 α -olefin having 3 to 12 carbon atoms with ethylene (preferably, propylene with ethylene and/or an α -olefin having 4 to 12 carbon atoms) in one-stage or multi-stages (this is called "post-stage polymerization"). As the amount not deteriorating crystallinity in a random copolymer varies depending on the kind
10 of a comonomer, the amount may be properly determined. In the case of, for example, ethylene the amount of repeating units derived from ethylene in the copolymer is usually 10 wt% or less, and in the case of α -olefins except propylene such as 1-butene or the like, the amount of repeating units derived from the α -olefin in the copolymer is usually 30 wt% or less, preferably
15 10 wt% or less. In the pre-stage polymerization for the block copolymer, the polymerization amount of, for example, ethylene is usually 10 wt% or less, preferably 3 wt% or less, further preferably 0.5 wt% or less, and the polymerization amount of
20 an α -olefin is usually 15 wt% or less, preferably 10 wt% or less, and in the post-stage polymerization, the polymerization amount of ethylene is usually 20 to 80 wt%, preferably 30 to 50 wt%.

As the combination of propylene with other monomers
25 constituting a copolymer, combinations of propylene with ethylene, propylene with butene-1, propylene with hexene-1, and the like are exemplified, but the present invention should not

be limited thereto.

As the measure of isotactic stereoregularity, isotactic meso-triad fraction and isotactic meso-pentad fraction are used.

The isotactic meso-triad fraction herein referred to is
5 a fraction of meso-triad units in isotactic sequences of units derived from propylene (hereinafter, referred to as "propylene unit") in a crystalline polypropylene molecule chain, in other word, a fraction of propylene units existing at the center of meso-triad units formed by meso-bonding of successive three
10 propylene units, measured by a method published in A. Zambelli, et al., *Macromolecules*, 8, 687 (1975), namely, measured by using ^{13}C -NMR. The isotactic meso-triad fraction is sometimes abbreviated as [mm]. The theoretical upper limit of [mm] is 1.00.

15 The process for producing an α -olefin polymer of the present invention is preferably applied to a process for producing an isotactic stereoregular α -olefin polymer having [mm] of more than 0.50, more preferably 0.70 or more, further preferably 0.80 or more.

20 The isotactic meso-pentad fraction is a fraction of meso-pentad units in isotactic sequences of propylene units in a crystalline polypropylene molecule chain, in other words, a fraction of propylene units existing at the center of successive five propylene units of meso-bonding in a crystalline
25 polypropylene molecule chain, measured by a method published in A. Zambelli, et al., *Macromolecules*, 6, 925 (1973), namely, measured by using ^{13}C -NMR. However, the assignment of an NMR

absorption peak is effected based on Macromolecules, 8, 687 (1975) introduced for the triad fraction. The isotactic meso-pentad fraction is sometimes abbreviated as [mmmm]. The theoretical upper limit of [mmmm] is 1.00.

5 The process for producing an α -olefin polymer of the present invention is preferably applied to a process for producing an isotactic stereoregular α -olefin polymer having [mmmm] of 0.25 or more, more preferably 0.50 or more, further preferably 0.75 or more.

10 The polymerization method also should not be particularly limited, and there can be applied, for example, solvent polymerization or slurry polymerization using, as a solvent, an aliphatic hydrocarbon (e.g. butane, pentane, hexane, heptane, octane), an aromatic hydrocarbon (e.g. benzene, toluene), or
15 halogenated hydrocarbon (e.g. methylene dichloride), bulk polymerization in a liquefied monomer, gas-phase polymerization in a gaseous monomer, or the like, and any of continuous polymerization and batch-wise polymerization is possible.

 The polymerization temperature can be usually from -
20 50°C to 200°C, and particularly preferably from -20°C to 100°C, and the polymerization pressure is usually from normal pressure to 60 kg/cm²G. The polymerization time is appropriately determined generally depending on the kind of the intended polymer and the reaction apparatus, and can be from 1 minute
25 to 20 hours. Further, for controlling the molecular weight of polymer to be obtained, a chain transfer agent such as hydrogen or the like can also be added.

EXAMPLES

The following Example and Comparative Example illustrate the present invention further in detail, but do not limit the scope of the invention.

Properties of polymers in Examples were measured by the following methods.

(1) Flow rate (FR) was determined by measuring at 190°C according to ASTM D1238.

(2) Content of repeating unit derived from α -olefin in copolymer

It was determined from characteristic absorptions of ethylene and the α -olefin measured with an infrared spectrometer (IR-80 manufactured by Nippon Bunko, Co., Ltd.), and was shown as the number of short chain branches per 1000 carbon (SCB).

(3) Melting point (unit: °C)

Using a differential scanning calorimeter (Seiko SSC-5200 manufactured by Seiko Instrument Inc.), the measurement was carried out under the following conditions:

Heating: 40 to 150°C (10 °C/min.), kept for 5 minutes,
Cooling: 150 to 10°C (5°C/min.), kept for 10 minutes,
Measurement: 10 to 160°C (5°C/min.)

(4) Molecular weight and Molecular weight distribution (Mw/Mn)

It was measured by GPC (gel permeation chromatography) method under the following conditions.

Type: 150 CV type (Millipore Waters)

Column: TSK-GEL GMH-HT 7.5mm ϕ $\times$ 600 mm $\times$ 2 columns

Measuring temperature: 140°C

Solvent: orthodichlorobenzene

Sample concentration: 5 mg/5 mL

(5) Mass spectrometry

5 Apparatus: Mass spectrometer JMS-700 manufactured by JEOL LTD.)

Data processor: MS-MP8220D

Acceleration voltage: 8 kV

Opposite Electrode: 0 kV

10 Emitter : Carbon

Scanning speed: 10 seconds

(6) Stereoregularity

The stereoregularity of a polymer was determined by measuring with ¹³C-NMR spectrometer AS250 manufactured by Bruker Limited, under the following conditions and calculating from an area ratio of peaks of methyl groups:

Solvent: o-dichlorobenzene/deuterated benzene=4/1 (by volume)

Concentration: 10 mg/0.6 mL

20

Reference Example 1

(Synthesis of chloro(3,5-diisopropyl-1-pyrazolyl)
[hydrotris(3,5-diisopropyl-1-pyrazolyl)borate]manganese)

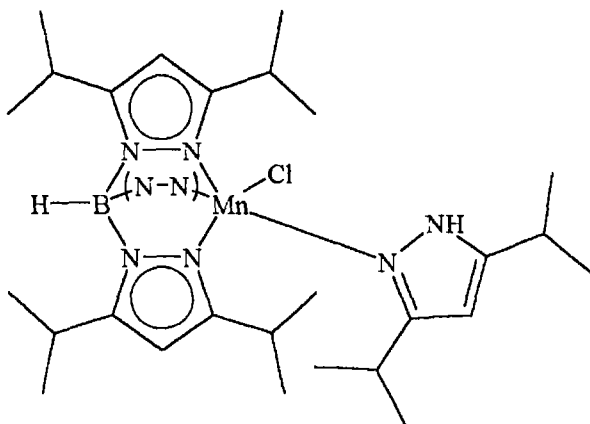
25 35 mL of methylene dichloride solution containing 0.51 g of hydrotris(3,5-diisopropyl-1-pyrazolyl)borate ligand and 0.76 g of 3,5-diisopropyl-1-pyrazol was added into 10 mL of a methanol solution containing 0.21 g of manganese dichloride

tetrahydrate, and the mixture was stirred at room temperature for 2 hours. After completion of the reaction, the solvents were distilled off under reduced pressure, and the residue was dissolved in 45 ml of methylene dichloride, and filtrated. Thus
 5 obtained powder was re-crystallized from acetonitrile, to obtain 0.38 g (yield: 70%) of the title compound of a white crystal.

(Elementary analysis) calculation value: C(61.06%), H(8.61%), N(15.82%), measured value: C(60.88%), H(8.99%), N(15.61%). The result of X-ray structural analysis of a single crystal is shown
 10 in Fig. 1.

(Mass spectrometry) M^+ : 555

The following structural formula is the structural formula of the title compound, partially abbreviating a pyrazolyl ring.



15 Reference Example 2

[Synthesis of chloro[hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese]

20 ml of methylene dichloride solution containing 1.07 g of hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl) borate
 20 ligand was added into 15 ml of a methanol solution containing

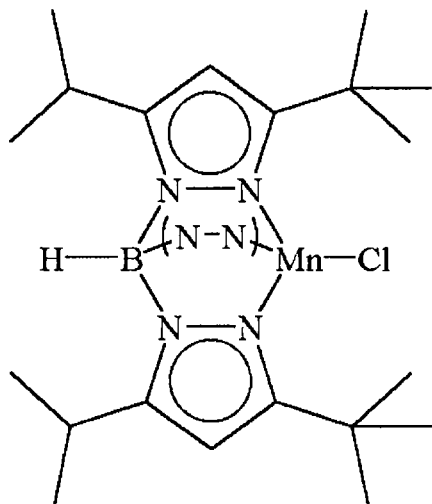
0.47 g of manganese dichloride tetrahydrate, and the mixture was stirred at room temperature for 3 hours. After completion of the reaction, the solvents were distilled off under reduced pressure, and the residue was dissolved in 40 ml of methylene
 5 dichloride, and filtrated. The resulted solid was re-crystallized from an acetonitrile/methylene dichloride mixed solvent, to obtain 0.63 g (yield: 54%) of the title compound of a white crystal.

(Elementary analysis) calculation value: C(60.26%), H(8.77%),
 10 N(14.05%), measured value: C(59.68%), H(8.67%), N(13.94%).

The result of X-ray structural analysis of a single crystal is shown in Fig. 2.

(Mass spectrometry) M^+ : 597

The following structural formula is the structural formula
 15 of the title compound, partially abbreviating a pyrazolyl ring.



Reference Example 3

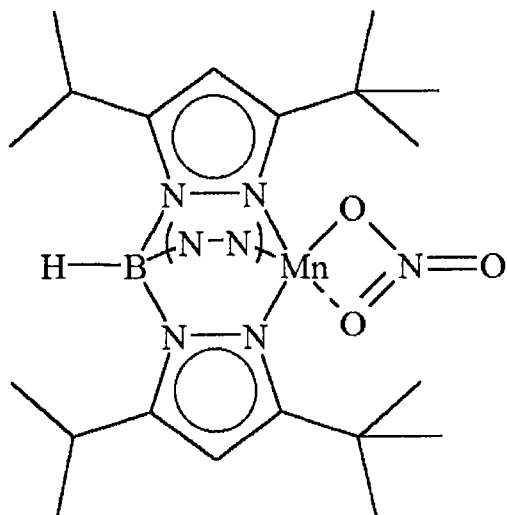
[Synthesis of hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese nitrate]

20 ml of methylene dichloride solution containing 1.07 g of hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl) borate ligand was added into 10 ml of a methanol solution containing 0.47 g of manganese nitrate hexahydrate, and the mixture was stirred at room temperature for 2 hours. After completion of the reaction, the solvents were distilled off under reduced pressure, and the residue was dissolved in 45 ml of methylene dichloride, and filtrated. The resulted powder was re-crystallized from an acetonitrile/methylene dichloride mixed solvent, to obtain 0.31 g (yield: 15%) of the title compound of a light pink crystal.

IR(KBr, cm^{-1}), 2967(C-H), 2931(C-H), 2870(C-H), 2592(B-H), 1523(antisymmetrical NO_3), 1647, 1363, 1271(symmetrical NO_3), 1170, 1061, 1049, 1019(NO), 796, 750, 644.

(Mass spectrometry) M^+ : 624

The following structural formula is the structural formula of the title compound, partially abbreviating a pyrazolyl ring.

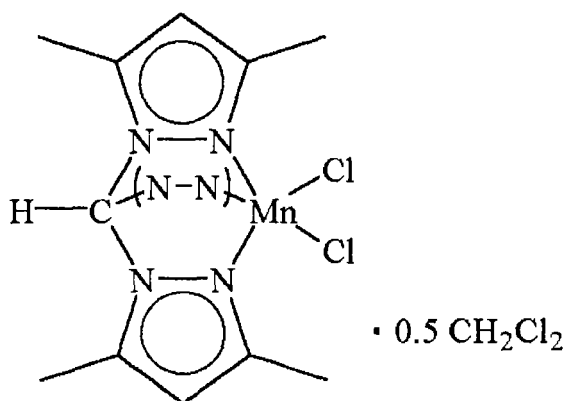


Reference Example 4

(Synthesis of dichloro[tris(3,5-dimethyl-1-pyrazolyl)methane]manganese $\cdot$ 0.5CH₂Cl₂)

10 ml of methylene dichloride solution containing 0.303
 5 g of tris(3,5-dimethyl-1-pyrazolyl)methane ligand was added
 into 10 ml of a methanol solution containing 0.230 g of manganese
 dichloride tetrahydrate, and the mixture was stirred at room
 temperature for 3 hours. After completion of the reaction, the
 solvents were distilled off under reduced pressure, and the
 10 residue was dissolved in 45 ml of methylene dichloride, and
 filtrated. Thus obtained powder was re-crystallized from an
 acetonitrile/methylene dichloride mixed solvent, to obtain
 0.127 g (yield: 27%) of the title compound of a white crystal.

(Elementary analysis) calculation value: C(41.71%), H(5.03%),
 15 N(18.24%), measured value: C(41.84%), H(5.16%), N(17.61%).



The following structural formula is the structural formula
 of the title compound, partially abbreviating a pyrazolyl ring.

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 200 ml of toluene was charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is
 5 adjusted at 2.0 MPa, and after the system was stabilized, 1.0 mmol (mol number in terms of Al atom, hereinafter, the same meaning) of methyisobutylaluminumoxane as a toluene solution (MMAO3A manufactured by Tohso-Akzo Ltd., hereinafter, referred to simply as "MMAO") was charged therein. Subsequently, 10.0
 10 μ mol of chloro(3,5-diisopropyl-1-pyrazolyl) [hydrotris(3,5-diisopropyl-1-pyrazolyl)borate]manganese synthesized in the above-mentioned Reference Example 1 was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

15 As a result of polymerization, an ethylene polymer was produced at a rate of 1.0×10^4 g per hour per mol of a manganese atom.

Example 2

An autoclave having an inner volume of 0.4 L was dried
 20 under vacuum, and purged with argon, then, 200 ml of toluene was charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 0.6 MPa, and after the system was stabilized, 1.0 mmol of triisobutylaluminum was charged therein. Subsequently,
 25 20.0 μ mol of chloro(3,5-diisopropyl-1-pyrazolyl) [hydrotris(3,5-diisopropyl-1-pyrazolyl)borate]manganese synthesized in the above-mentioned Reference Example 1 was added.

Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene polymer having a melting point of 135.9°C was produced at a rate of 2.2×10^5 g per hour per mol of a manganese atom.

Example 3

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 200 ml of toluene was charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 1.0 mmol of triisobutylaluminum was charged therein. Subsequently, 10.0 μ mol of chloro[hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese synthesized in the above-mentioned Reference Example 2 was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene polymer having a melting point of 135.5°C was produced at a rate of 9.2×10^5 g per hour per mol of a manganese atom.

Example 4

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 10g of 1-butene as an α -olefin and 180 ml of toluene as a solvent were charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 0.25 mmol of

triisobutylaluminum was charged therein. Subsequently, 1.0 μ mol of chloro[hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese, and subsequently 3.0 μ mol of triphenylcarbeniumtetrakis(pentafluorophenyl) borate was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene-1-hexene copolymer having a SCB of 3.6, FR of 6.1 g/10 min. and a melting point of 120.1°C was produced at a rate of 1.6×10^7 g per hour per mol of a manganese atom.

Example 5

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 30 ml of 1-hexene as an α -olefin and 170 ml of toluene as a solvent were charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 1.0 MPa, and after the system was stabilized, 0.25 mmol of triisobutylaluminum was charged therein. Subsequently, 1.0 μ mol of chloro[hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese, and subsequently 6.0 μ mol of triphenylcarbeniumtetrakis(pentafluorophenyl) borate was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene-1-hexene copolymer having a SCB of 23.7 and a melting point of 109.5°C was produced at a rate of 2.0×10^5 g per hour per mol of a manganese atom.

Example 6

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 200 ml of toluene was charged therein, and the autoclave was heated to 60°C. After
5 the heating, ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 1.0 mmol of triisobutylaluminum was charged therein. Subsequently, 20.0 μ mol of hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese nitrate synthesized in
10 the above-mentioned Reference Example 3 was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene polymer having a melting point of 135.5°C was produced at a rate of 7.0×10^4
15 g per hour per mol of a manganese atom.

Example 7

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 10g of 1-butene as an α -olefin and 180 ml of toluene as a solvent were charged
20 therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 1.00 mmol of triisobutylaluminum was charged therein. Subsequently, 10.0 μ mol of hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese nitrate, and
25 subsequently 20.0 μ mol of triphenylcarbeniumtetrakis(pentafluorophenyl)borate was

added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene-1-hexene copolymer having a SCB of 11.1, FR of 3.0 g/10 min. and a melting point of 122.6 °C was produced at a rate of 6.4×10^5 g per hour per mol of a manganese atom.

Example 8

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 30 ml of 1-hexene as an α -olefin and 170 ml of toluene as a solvent were charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 1.0 MPa, and after the system was stabilized, 0.25 mmol of triisobutylaluminum was charged therein. Subsequently, 1.0 μ mol of hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese nitrate, and subsequently 6.0 μ mol of triphenylcarbeniumtetrakis(pentafluorophenyl) borate was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene-1-hexene copolymer having a SCB of 13.4 and a melting point of 108.3°C was produced at a rate of 4.0×10^4 g per hour per mol of a manganese atom.

Example 9

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 200 ml of toluene

was charged therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 1.0 mmol of triisobutylaluminum was charged therein. Subsequently,
5 10.0 μ mol of dichloro[tris(3,5-dimethyl-1-pyrazolyl)methane]manganese synthesized in the above-mentioned Reference Example 4 was added. Further, 20.0 μ mol of triphenylcarbeniumtetrakis (pentafluorophenyl) borate was added. Then, polymerization was
10 carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene polymer having a melting point of 134.9°C was produced at a rate of 3.7×10^4 g per hour per mol of a manganese atom.

15 Example 10

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 10g of 1-butene as an α -olefin and 180 ml of toluene as a solvent were charged therein, and the autoclave was heated to 60°C. After the heating,
20 ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 1.0 mmol of triisobutylaluminum was charged therein. Subsequently, 10.0 μ mol of dichloro[tris(3,5-dimethyl-1-pyrazolyl)methane]manganese,
25 and subsequently 30.0 μ mol of triphenylcarbeniumtetrakis(pentafluorophenyl)borate was added. Then, polymerization was carried out for 60 minutes while

controlling the temperature at 60°C.

As a result of polymerization, an ethylene-1-hexene copolymer having a SCB of 9.4, Mw of 5.4×10^4 , Mw/Mn of 1.79, and a melting point of 121.8 °C was produced at a rate of 8.9
5 $\times 10^4$ g per hour per mol of a manganese atom.

Example 11

An autoclave having an inner volume of 0.4 L was dried under vacuum, and purged with argon, then, 10g of 1-butene as an α -olefin and 180 ml of toluene as a solvent were charged
10 therein, and the autoclave was heated to 60°C. After the heating, ethylene was fed while the ethylene pressure is adjusted at 2.0 MPa, and after the system was stabilized, 1.0 mmol of triisobutylaluminum was charged therein. Subsequently, 20.0 μ mol of dichloro[tris(3,5-dimethyl
15 -1-pyrazolyl)methane]manganese, and subsequently 40.0 μ mol of triphenylcarbeniumtetrakis(pentafluorophenyl)borate was added. Then, polymerization was carried out for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an ethylene-1-utene
20 copolymer having a SCB of 23.0, Mw of 5.5×10^4 , Mw/Mn of 1.88, and a melting point of 99.9 °C was produced at a rate of 1.6×10^4 g per hour per mol of a manganese atom.

Example 12

An autoclave having a content volume of 0.1 L sufficiently
25 heated and dried was dried under vacuum, purged with nitrogen, then, 1.25 ml (1.25 mmol) of a 1 mol/L toluene solution of triisobutylaluminum was poured into this, further, 10.0 μ mol

of

chloro[hydrotris(3-tert-butyl-5-isopropyl-1-pyrazolyl)borate]manganese synthesized in the above-mentioned Reference Example 2 was added, and 20 μ mol of

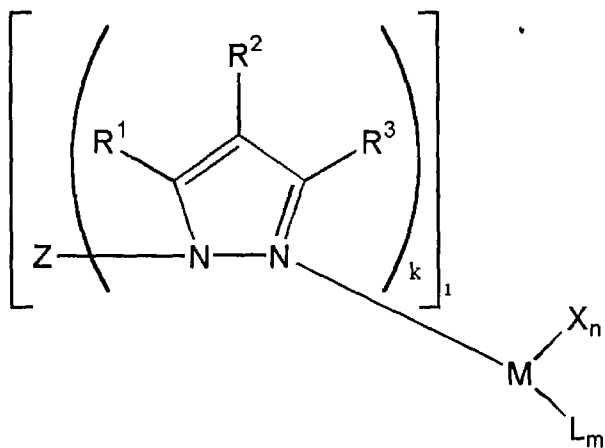
5 triphenylcarbenium[tetrakis(pentafluorophenyl)borate] was added. Subsequently, 40 g of propylene was charged, then, polymerization was conducted for 60 minutes while controlling the temperature at 60°C.

As a result of polymerization, an isotactic stereoregular
10 propylene polymer having a meso-triad fraction [mm] of 0.905 and a pentad fraction [mmmm] of 0.819 was produced at a rate of 4.0×10^4 g per hour per mol of a manganese atom.

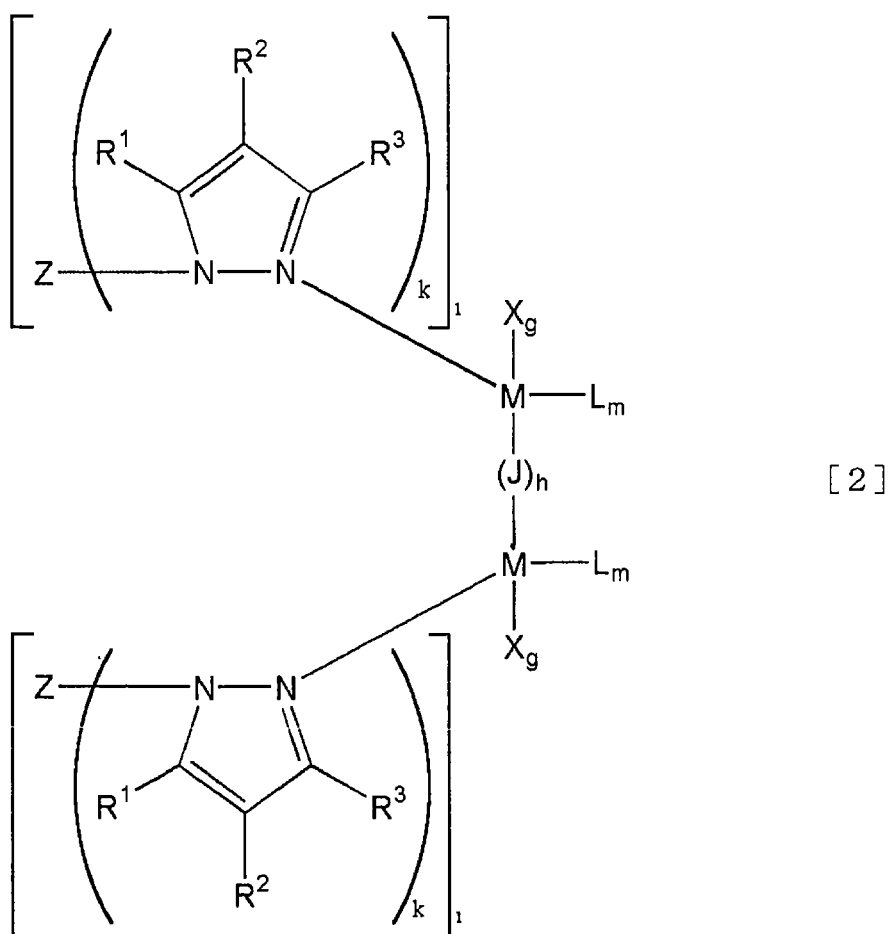
According to the present invention as described in detail
15 above, a catalyst for addition polymerization using a transition metal compound of Group 7, and a process for producing addition polymers such as olefin polymers with the catalyst, are provided.

CLAIMS

1. A catalyst for addition polymerization obtained by a
 5 process comprising contacting a transition metal compound(A)
 of the following general formula [1] or [2] with an aluminum
 compound(B) described below and/or a boron compound(C) described
 below:

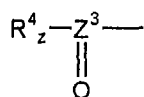
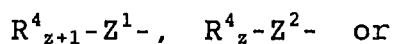


[1]



(wherein, M represents a transition metal atom of Group 7 of the Periodic Table of the Elements; X's represent each independently a hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, alkoxy group, aralkyloxy group, aryloxy group, acyloxy group, acyl group, di-substituted amino group, substituted pyrazolyl group, isocyanate group, thiocyanate group, nitrosyl group, azide group, cyano group, hydroxyl group, perhalide ion, nitrate ion, hexa-halogenated phosphorus ion or tetra-substituted boron ion; L represents a neutral ligand connected with M via a lone pair or π electron;

n represents an integer of 0 to 7 so selected that the compound is neutral; g represents an integer of 0 to 6 so selected that the compound is neutral; m represents an integer of 0 to 5; R^1 to R^3 represent each independently a hydrogen atom, halogen atom, alkyl group, aralkyl group, aryl group or substituted silyl group and all of R^1 to R^3 may be the same or different; Z represents a group of



(wherein, Z^1 represents an atom of Groups 13 to 15 of the Periodic Table of the Elements; Z^2 represents an atom of Groups 13 to 15 of the Periodic Table of the Elements and Z^3 represents an atom of Group 15 of the Periodic Table of the Elements; R^4 in each case represents a hydrogen atom, halogen atom, alkyl group, aralkyl group, substituted silyl group, alkoxy group, aralkyloxy group, aryloxy group, di-substituted amino group or substituted pyrazolyl group.); k represents an integer of 1 to 3 and the sum of k and z is 3; J in the general formula [2] is a bridging group connecting two M's; and h represents an integer of 1 to 3 showing the number of bridging connecting two M's.),

(B): one or more aluminum compounds selected from the following (B1) to (B3),

(B1): organoaluminum compounds of the general formula $E^1_a AlZ_{3-a}$,

(B2): cyclic aluminoxanes having a structure of the

general formula $\{-Al(E^2)-O-\}_b$,

(B3): linear aluminoxanes having a structure of the general formula $E^3\{-Al(E^3)-O-\}_cAlE^3_2$,

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

(C): one or more boron compounds selected from the following (C1) to (C3),

(C1): boron compounds of the general formula $BQ^1Q^2Q^3$,

(C2): boron compounds of the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$,

(C3): boron compounds of the general formula

$(L-H)^+(BQ^1Q^2Q^3Q^4)^-$,

(wherein, B represents a boron atom of tri-valent state, Q^1 to Q^4 represent a halogen atom, hydrocarbon group, halogenated hydrocarbon group, substituted silyl group, alkoxy group or di-substituted amino group, and they may be the same or different.

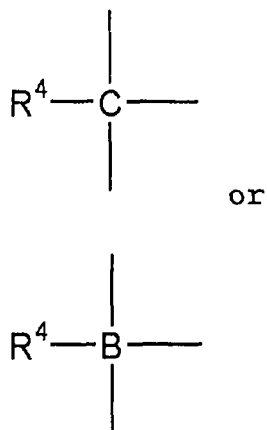
G^+ represents an inorganic or organic cation, L represents a neutral Lewis base, and $(L-H)^+$ represents a Brønsted acid.).

2. The catalyst for addition polymerization according to Claim 1, wherein M is a member selected from the group consisting of a manganese atom, technetium atom and rhenium atom.

3. The catalyst for addition polymerization according to Claim 2, wherein M is a manganese atom.

4. The catalyst for addition polymerization according to

any one of Claims 1 to 3, wherein Z is a group represented by



(wherein, R^4 in these cases represents a hydrogen atom, alkyl group, aralkyl group or substituted pyrazolyl group.).

5 5. A process for producing an addition polymer which comprises polymerizing an addition polymerizable monomer with the catalyst for addition polymerization of any one of claims 1 to 4.

10 6. The process according to claim 5, wherein the addition polymerizable monomer is at least one monomer selected from the group consisting of ethylene and α -olefins having 3 to 20 carbon atoms.

15 7. The process according to claim 6, wherein the addition polymerizable monomer is a combination of ethylene with an α -olefins having 3 to 20 carbon atoms.

8. The process according to claim 5, wherein the α -olefin is propylene.

20 9. The process according to Claim 5, wherein the addition polymer is a stereoregular α -olefin polymer having an isotactic meso-triad fraction [mm] of more than 0.50.

10. The process according to claim 9, wherein the stereoregular α -olefin polymer is a stereoregular propylene polymer.