EUROPEAN PATENT SPECIFICATION

ACTIVATOR COMPOSITION COMPRISING ALUMINUM COMPOUND MIXTURE

ALUMINIUMVERBINDUNGSMISCHUNG-ENTHALTENDE AKTIVATORZUSAMMENSETZUNG
COMPOSITION D'ACTIVATION RENFERMANT UN MELANGE D'UN COMPOSE D'ALUMINIUM

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PROPRIETOR:
The Dow Chemical Company
Midland, Michigan 48674 (US)

INVENTORS:
- CHEN, Eugene, Y.
  Midland, MI 48642 (US)
- KRUPER, William, J., Jr.
  Sanford, MI 48657 (US)
- ROOF, Gordon, R.
  Midland, MI 48642 (US)
- SCHWARTZ, David, J.
  Lake Jackson, TX 77566 (US)
- STORER, Joey, W.
  Plymouth, MN 55442 (US)

REPRESENTATIVE:
Burford, Anthony Frederick
W.H. Beck, Greener & Co.
7 Stone Buildings
Lincoln's Inn
London WC2A 3SZ (GB)

REFERENCES CITED:

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Description

[0001] The present invention relates to compositions that are useful as catalyst activators for olefin polymerizations. More particularly the present invention relates to such compositions that are particularly adapted for use in the coordination polymerization of unsaturated compounds having improved activation efficiency and performance. Such compositions are particularly advantageous for use in a polymerization process wherein catalyst, catalyst activator, and at least one polymerizable monomer are combined under polymerization conditions to form a polymeric product.

[0002] It is previously known in the art to activate Ziegler-Natta polymerization catalysts, particularly such catalysts comprising Group 3-10 metal complexes containing delocalized π-bonded ligand groups, by the use of an activator. Generally in the absence of such an activator compound, also referred to as a cocatalyst, little or no polymerization activity is observed.

[0003] A class of suitable activators are Lewis acids, especially alumoxanes, which are generally believed to be oligomeric or polymeric alkylaluminoxy compounds, including cyclic oligomers. Examples of alumoxanes (also known as aluminoxanes) include methylalumoxane (MAO) made by hydrolysis of trimethylaluminum as well as modified methylalumoxane (MMAO), wherein a portion of the trimethylaluminum in the foregoing hydrolysis is replaced by a higher trialkylaluminum compound such as trisobutyl-aluminum. MMAO advantageously is more soluble in aliphatic solvents than is MAO.

[0004] Generally alumoxanes contain on average 1.5 alkyl groups per aluminum atom, and are prepared by reaction of trialkylaluminum compounds or mixtures of compounds with water (Reddy et al, Prog. Poly. Sci., 1995, 20, 309-367). The resulting product is in fact a mixture of various substituted aluminum compounds including especially, trialkylaluminum compounds (resulting from incomplete reaction of the trialkylaluminum starting reagent or decomposition of the alumoxane). The amount of such free trialkylaluminum compound in the mixture generally varies from 1 to 50 percent by weight of the total product.

[0005] Although effective in forming an active olefin polymerization catalyst when combined with a variety of Group 3-10 metal complexes, especially Group 4 metal complexes, generally a large excess of alumoxane compared to metal complex, such as, molar ratios from 100:1 to 10,000:1, is required in order to produce adequate rates of polymerization. Unfortunately, the use of such large excesses of cocatalyst is expensive and also results in polymer having an elevated residual aluminum content as well as lower molecular weight. This former factor may adversely affect polymer properties, especially clarity and dielectric constant, whereas the latter issue relates to poor polymer performance.

[0006] Other types of monomeric aryloxyaluminum and arylamidoaluminum complexes have been found to be useful in metallocene catalyst activator packages, particularly as water and oxygenate scavengers. Examples include diisobutyl-2,6-di-t-butyl-4-methylphenoxyaluminum (DIBAL-BOT) as described in WO 97/27228 and Japanese kokai, 09-17629, or diisobutylhexamethyldisilylazayl aluminum (DIBAL-NS) as described by Rosen et al in WO 98/03558. This latter reference discloses the possibility that ligand transfer between strong Lewis acids, such as tris(perfluorophenyl)borane, and the aluminum compound may occur.


[0009] Tris(perfluorophenyl)aluminum is a strong Lewis acid as well. It has recently been prepared from the exchange of tris(perfluorophenyl)borane with trialkylaluminum, as described by Biagini et al US-A-5,602,269. However, it generally performs poorly by itself as a catalyst activator compared with tris(perfluorophenyl)borane. Similarly, it has further been demonstrated that active catalysts resulting from the use of an aluminate anion based upon tris(-perfluorophenyl)aluminum for the activation of ansa-metallocenes and biscyclopentadienyl derivatives of zirconium(IV) are generally of lower activity than those formed by the corresponding borane (Ewen, Stud. in Surf. Sci. Catal. 1994, 89,405-410). A possible explanation for the poor performance of tris(perfluorophenyl)aluminum as an activator for metallocenes involving a back exchange reaction of a perfluorophenyl group has been proposed by Bochmann et al (ACS Dallas...
In light of these apparent deficiencies, it would be desirable to provide novel compositions having improved efficiency and operability as activators of metal complexes for olefin polymerizations.

According to the present invention there is now provided a composition comprising:

A) an aluminum compound corresponding to the formula \( \text{AlAr}^d_3 \), where \( \text{Ar}^d \) is a fluorinated aromatic hydrocarbyl moiety of from 6 to 30 carbon atoms;

B) an aluminum compound corresponding to the formula: \( \text{AlAr}^dQ_1Q_2 \), where:

\( \text{Ar}^d \) is as previously defined;

\( Q_1 \) is \( \text{Ar}^d \) or a \( \text{C}_1-20 \) hydrocarbyl group, optionally substituted with one or more cyclohydrocarbyl, hydrocarbyloxy, hydrocarbylsiloxy, hydrocarbylsilylamino, hydrocarbylsilyl, di(hydrocarbylsilyl)amino, hydrocarbylamino, di(hydrocarbyl)amino, di(hydrocarbyl)phosphino, or hydrocarbylsulfido groups having from 1 to 20 atoms other than hydrogen, or, further optionally, such substituents may be covalently linked with each other to form one or more fused rings or ring systems; and

\( Q_2 \) is an aryloxy, arylsulfide or di(hydrocarbyl)amido group, optionally substituted with one or more hydrocarbyl, cyclohydrocarbyl, hydrocarbyloxy, hydrocarbylsiloxy, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, di(hydrocarbylsilyl)amino, hydrocarbylamino, di(hydrocarbyl)amino, di(hydrocarbyl)phosphino, or hydrocarbylsulfido groups having from 1 to 20 atoms other than hydrogen, or, further optionally such substituents may be covalently linked with each other to form one or more fused rings or ring systems, said \( Q_2 \) having from 3 to 20 atoms other than hydrogen; and

the molar ratio of A):B) in the composition being from 0.1:1 to 10:1, preferably from 1:1 to 8:1, more preferably from 1.5:1 to 5:1.

The subject invention further provides a catalyst composition for polymerization of olefins comprising a Group 3-10 metal complex and an activator comprising the above described composition, the molar ratio of metal complex to activator in the composition being from 0.1:1 to 3:1.

The subject invention further provides a process for the polymerization of one or more addition polymerizable monomers comprising contacting one or more addition polymerizable monomers under addition polymerization conditions with the catalyst composition as described above.

The compounds are capable of forming unique bis p-bridged adducts with Group 4 metal complexes, i.e., compounds that are essentially doubly activated, that are useful addition polymerization catalysts.

Preferred compositions according to the present invention are those wherein \( \text{Ar}^d \) is a perfluoroaryl group, more preferably a perfluorophenyl group, \( Q_1 \) is \( \text{C}_3-6 \) alkyl containing at least one secondary or tertiary carbon center, more preferably isopropyl or isobutyl, and \( Q_2 \) is aryloxy or dialkylamido of up to 10 carbons, more preferably 2,6-ditert-butylphenoxy, 2,6-ditert-butyl-4-methylphenoxy, N,N-bis(trimethylsilyl)amido, or N,N-dimethylamido. Most preferred compounds are monomers, rather than dimers or adducts.

A most preferred compound B) for use according to the invention is isobutylperfluorophenyl-2-methyl-4,6-di-t-butylphenoxyaluminum or isobutylperfluorophenyl-4,6-di-t-butylphenoxyaluminum.

The compounds of formula B) are readily prepared by contacting under ligand exchange reaction conditions a trifluoroarylaluminum compound of the formula \( \text{AlAr}^d_3 \), wherein \( \text{Ar}^d \) is as previously defined,

with a Group 13 organometallic compound of the formula: \( Q^3 \text{Me}^2Q^2 \), wherein

\( Q^2 \) is as previously defined;

\( Q^3 \) is independently each occurrence \( \text{C}_3-6 \) alkyl; and

\( \text{Me}^2 \) is a Group 13 metal, preferably aluminum.

Preferably the exchange reaction is conducted in an aliphatic, cycloaliphatic or aromatic hydrocarbon liquid or mixture thereof under anhydrous conditions. Further preferably, the trifluoroaryl aluminum compound is provided in greater than a stoichiometric amount with respect to the Group 13 organometallic compound, more preferably at a molar ratio from 1.5:1 to 20:1, most preferably from 2:1 to 10:1. Preferred are the use of solutions of the foregoing reactants in concentrations of trifluoroarylaluminum compound and Group 13 organometallic compound from 0.005 to
2M, preferably from 0.02 to 1.5 M, and most preferably from 0.05 to 1.2 M. Generally, the Group 13 organometallic compound readily transfers one Q^3 group. However, the rate of transfer of a second Q^3 group is kinetically disfavored, thereby allowing for the preparation of mixtures of the desired components A) and B) in high yield and efficiency.

The rate of ligand exchange can be enhanced by heating the reaction mixture or by removing any alkyl exchange byproducts in the reaction mixture. A preferred temperature range for the exchange reaction is from 0 to 50 °C, more preferably from 15 to 35 °C. Suitable techniques for removing alkyl exchange byproducts from the reaction mixture include degassing optionally at reduced pressures, distillation, solvent exchange, solvent extraction, extraction with a volatile agent, contacting with a zeolite or molecular sieve, and combinations of the foregoing techniques, all of which are conducted according to conventional procedures. Purity of the resulting product may be determined by analysis of the resulting product. Removal of volatile by-products will assist in shifting the equilibrium concentration of desired end products. Generally, reaction times from 10 minutes to 6 hours, preferably 15 minutes to 1 hour are used to ensure formation of the desired ligand exchange products.

In as much as the compounds of formula B) are desirably prepared by an exchange reaction as previously described, it is to be understood that additional components of the reaction mixture may include alternative exchange products, as such multiple compounds corresponding to the formula, AlAr_f^Q_1Q_2, as well as compounds of the formula AlAr_fQ_1^2 wherein at least one Q^1 group is not Ar_f. A particularly preferred embodiment of the invention is a composition comprising:

A) an aluminum compound corresponding to the formula AlAr_f^Q_3, where Ar_f is a fluorinated aromatic hydrocarbyl moiety of from 6 to 30 carbon atoms;

B) an aluminum compound corresponding to the formula: AlAr_fQ_1^1Q_2, where:

\[ \text{Ar}_f \text{ is as previously defined; } \]

\[ \text{Q}_1 \text{ is Ar}_f \text{ or a C}_{1-20} \text{ hydrocarbyl group, optionally substituted with one or more cyclohydrocarbyl, hydrocarbyloxyl, hydrocarbylsilyloxyl, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, di(hydrocarbylsilyl)amino, hydrocarbylsilylamino, di(hydrocarbylsilyl)phosphino, or hydrocarbylsilylsulphido groups having from 1 to 20 atoms other than hydrogen, or, further optionally, such substituents may be covalently linked with each other to form one or more fused rings or ring systems; } \]

\[ \text{Q}_2 \text{ is an aryloxyl, arylsulfide or di(hydrocarbyl)amido group, optionally substituted with one or more hydrocarbyl, cyclohydrocarbyl, hydrocarbyloxyl, hydrocarbylsilyloxyl, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, di(hydrocarbylsilyl)amino, hydrocarbylsilylamino, di(hydrocarbylsilyl)phosphino, or hydrocarbylsilylsulphido groups having from 1 to 20 atoms other than hydrogen; or, further optionally such substituents may be covalently linked with each other to form one or more fused rings or ring systems, said Q^2 having from 3 to 20 atoms other than hydrogen; and } \]

C) an aluminum exchange compound or mixture thereof, in the aggregate corresponding to the formula, AlAr_f^2Q_1, wherein Q^1 is not Ar_f,

the molar ratio of A):B):C) in the composition being from 0.1:1.0:0.001 to 10.0:1.0:1.0, preferably from 1.0:1.0:0.01 to 8.0:1.0:1.0.

The present mixture of compounds in the indicated molar ratio provides highly active co-catalysts for use in activation of metal complexes, especially Group 4 metallocones for the polymerization of olefins. When amounts of AlAr_f^3 less than the quantity specified are employed, the cocatalytic activity of the mixture is generally reduced. When amounts of AlAr_f^3 greater than the quantity specified are employed, no significant improvement in properties results and the excess amount is wasted. It is to be further understood that the moieties A), B) and C) may exist as discreet entities or as dynamic exchange products. In addition, additional minor exchange products may also be formed in the foregoing exchange reaction. These additional exchange products do not affect the performance of the present compositions. When used as a cocatalyst, the mixture desirably is employed as a dilute solution in a hydrocarbon liquid, especially an aliphatic hydrocarbon liquid for use as a homogeneous catalyst, especially solution polymerizations. Additionally, the composition may be deposited on an inert support, especially a particulated metal oxide or polymer, in combination with the metal complex to be activated according to known techniques for producing supported olefin polymerization catalysts, and thereafter used for gas phase or slurry polymerizations.

When in use as a catalyst activator, the molar ratio of metal complex to activator composition is preferably from 0.1:1.0 to 3:1, more preferably from 0.2:1 to 2:1, most preferably from 0.25:1 to 1:1, based on the metal contents of each component. In most polymerization reactions, the molar ratio of metal complex: polymerizable compound employed is from 10^-12:1 to 10^-1:1, more preferably from 10^-12:1 to 10^-5:1.

The support for the activator component may be any inert, particulated material, but most suitably is a metal oxide or mixture of metal oxides, preferably alumina, silica, an aluminosilicate or clay material. Suitable volume average
particle sizes of the support are from 1 to 1000 µM, preferably from 10 to 100 µM. Most desired supports are calcined silica, which may be treated prior to use to reduce surface hydroxyl groups thereon, by reaction with a silane, a trialkyloxylalumnum, or similar reactive compound. Any suitable means for incorporating the perfluoroarylaluminum containing co-catalyst mixture onto the surface of a support may be used, including dispersing the co-catalyst in a liquid and contacting the same with the support by slurring, impregnation, spraying, or coating and thereafter removing the liquid, or by combining the cocatalyst and a support material in dry or paste form and intimately contacting the mixture, thereafter forming a dried, particulated product.

[0026] Suitable metal complexes for use in combination with the foregoing cocatalysts include any complex of a metal of Groups 3-10 of the Periodic table of the Elements capable of being activated to polymerize addition polymerizable compounds, especially olefins by the present activators. Examples include Group 10 diimine derivatives corresponding to the formula:

\[
\begin{align*}
\text{M}^* & = \text{Ni(II) or Pd(II)}; \\
\text{X} & = \text{halo, hydrocarbyl, or hydrocarboxyloxy}; \\
\text{Ar}^* & = \text{an ary group, especially 2,6-diisopropylphenyl or aniline group; and} \\
\text{CT-CT} & = \text{1,2-ethanediyl, 2,3-butadienyl, or form a fused ring system wherein the two T groups together are a 1,8-naphthenediyl.}
\end{align*}
\]

[0027] Similar complexes to the foregoing are disclosed by M. Brookhart, et al., in J.


[0029] Additional complexes include derivatives of Group 3,4, or Lanthanide metals containing from 1 to 3 π-bonded anionic or neutral ligand groups, which may be cyclic or non-cyclic delocalized π-bonded anionic ligand groups. Examples of such π-bonded anionic ligand groups are conjugated or nonconjugated, cyclic or non-cyclic dienyl groups, allyl groups, boratabenzene groups, and arene groups. By the term "π-bonded" is meant that the ligand group is bonded to the transition metal by a sharing of electrons from a delocalized π-bond.

[0030] Each atom in the delocalized π-bonded group may independently be substituted with a radical selected from the group consisting of hydrogen, halogen, hydrocarbyl, halohydrocarbyl, hydrocarboxyloxy, hydrocarboxylsulfide, dihydrocarbylamino, and hydrocarbyl-substituted metalloid radicals wherein the metalloid is selected from Group 14 of the Periodic Table of the Elements, and such hydrocarbylamino-, hydrocarboxyloxy-, hydrocarboxylsulfide-, dihydrocarbylamino- or hydrocarbyl-substituted metalloid- radicals that are further substituted with a Group 14 or 15 or 16 hetero atom containing moiety. Included within the term "hydrocarbyl" are C1-20 straight, branched and cyclic alkyl radicals, C6-20 aromatic radicals, C7-20 alkyl-substituted aromatic radicals, and C7-20 aryl-substituted alkyl radicals. In addition two or more such radicals may together form a fused ring system, including partially or fully hydrogenated fused ring systems, or they may form a metallocycle with the metal. Suitable hydrocarbyl-substituted organometalloid radicals include mono-, di- and tri-substituted organometalloid radicals of Group 14 elements wherein each of the hydrocarbyl groups contains from 1 to 20 carbon atoms. Examples of suitable hydrocarboxyl-substituted organometalloid radicals include trimethylsilyl, triethylylsilyl, ethyldimethysilyl, trimethylgermyl, and trimethylgermyl groups. Examples of Group 15 or 16 hetero atom containing moieties include amine, phosphine, ether or thioether moieties or divalent derivatives thereof, for example amide, phosphide, ether or thioether groups bounded to the transition metal or Lanthanide metal, and bonded to the hydrocarboxyloxy group or to the hydrocarboxyl- substituted metalloid containing group.

[0031] Examples of suitable anionic, delocalized s-bonded groups include cyclopentadienyl, indenyl, fluorenyl, tetrahydroindenyl, tetrahydrofluorenyl, octahydrofluorenyl, pentadienyl, cyclohexadienyl, dihydroarancenyl, hexahydroarancenyl, decahydroarancenyl groups, and boratabenzene groups, as well as C1-10 hydrocarboxyl-substituted, C1-10 hydrocarboxyloxy- substituted, di(C1-10 hydrocarboxyl)amino- substituted, or tri(C1-10 hydrocarboxyl)silyl- substituted derivatives thereof. Preferred anionic delocalized π-bonded groups are cyclopentadienyl, pentamethylcyclopentadienyl, tetramethylcyclopentadienyl, indenyl, 2,3-dimethylindenyl, fluorenyl, 2-methylindenyl, 2-methyl-4-phenylinenyl, tetrahydrofluorenyl, octahydrofluorenyl, and tetrahydroindenyl.

[0032] The boratabenzene are anionic ligands which are boron containing analogues to benzene. They are previously known in the art having been described by G. Herberich, et al., in Organometallics, 1995, 14, 1, 471-480. Preferred...
wherein R" is selected from the group consisting of hydrocarbyl, silyl, or germyl, said R" having up to 20 non-
hydrogen atoms. In complexes involving divalent derivatives of such delocalized π-bonded groups one atom thereof
is bonded by means of a covalent bond or a covalently bonded divalent group to another atom of the complex thereby
forming a bridged system.

[0033] Suitable metal complexes for use in the catalysts of the present invention may be derivatives of any transition
metal including Lanthanides, but preferably of Group 3, 4, or Lanthanide metals which are in the +2, +3, or +4 formal
oxidation state meeting the previously mentioned requirements. Preferred compounds include metal complexes (met-
allocenes) containing from 1 to 3 π-bonded anionic ligand groups, which may be cyclic or noncyclic delocalized π-
bonded anionic ligand groups. Exemplary of such π-bonded anionic ligand groups are conjugated or nonconjugated,
cyclic or non-cyclic dienyl groups, allyl groups, and arene groups.

[0034] By the term "π-bonded" is meant that the ligand group is bonded to the transition metal by means of delocalized
electrons present in a π bond.

[0035] Examples of suitable anionic, delocalized π-bonded groups include cyclopentadienyl, indenyl, fluorenyl, tet-
rahydroindenyl, tetrahydrofluorenyl, octahydrofluorenyl, pentadienyl, cyclohexadienyl, dihydroanthracenyl, hexahy-
droanthracenyl, and decahydroanthracenyl groups, as well as C110 hydrocarbyl-substituted derivatives thereof. Pre-
ferred anionic delocalized π-bonded groups are cyclopentadienyl, pentamethylcyclopentadienyl, tetramethylcyclopen-
tadienyl, indenyl, 2,3-dimethylindenyl, fluorenyl, 2-methylindenyl and 2-methyl-4-phenylindenyl.

[0036] More preferred are metal complexes corresponding to the formula:

L MX m X' n X" p,

or a dimer thereof

wherein:

L is an anionic, delocalized, π-bonded group that is bound to M, containing up to 50 atoms not counting hydrogen,
onoptionally two L groups may be joined together through one or more substituents thereby forming a bridged struc-
ture, and further optionally one L may be bound to X through one or more substituents of L;
M is a metal of Group 4 of the Periodic Table of the Elements in the +2, +3 or +4 formal oxidation state;
X is an optional, divalent substituent of up to 50 non-hydrogen atoms that together with L forms a metallocycle
with M;
X' is an optional neutral Lewis base having up to 20 non-hydrogen atoms;
X" each occurrence is a monovalent, anionic moiety having up to 40 non-hydrogen atoms, optionally, two X" groups
may be covalently bound together forming a dative dianionic moiety having both valences bound to M, or form a
neutral, conjugated or nonconjugated diene that is π-bonded to M (whereupon M is in the +2 oxidation state), or
further optionally one or more X" and one or more X' groups may be bonded together thereby forming a moiety
that is both covalently bound to M and coordinated thereto by means of Lewis base functionality;
I is 1 or 2;
m is 0 or 1;
n is a number from 0 to 3;
p is an integer from 0 to 3; and

the sum, I+m+p, is equal to the formal oxidation state of M.

[0037] Such preferred complexes include those containing either one or two L groups. The latter complexes include
those containing a bridging group linking the two L groups. Preferred bridging groups are those corresponding to the
formula (ER"2)x wherein E is silicon or carbon, R" independently each occurrence is hydrogen or a group selected
from silyl, hydrocarbyl, hydrocarbyloxy and combinations thereof, said R" having up to 30 carbon or silicon atoms,
x is 1 to 8. Preferably, $R^*$ independently each occurrence is methyl, benzyl, tert-butyl or phenyl.

[0038] Examples of the foregoing bis(L) containing complexes are compounds corresponding to the formula:

\[
\begin{align*}
\text{(I)} & \\
\text{(II)} &
\end{align*}
\]

wherein:

M is titanium, zirconium or hafnium, preferably zirconium or hafnium, in the +2 or +4 formal oxidation state; $R^3$ in each occurrence independently is selected from the group consisting of hydrogen, hydrocarbyl, dihydrocarbylamino, hydrocarbyleneamino, silyl, germyl, cyano, halo and combinations thereof, said $R^3$ having up to 20 atoms not counting hydrogen, or adjacent $R^3$ groups together form a divalent derivative thereby forming a fused ring system, and $X^*$ independently each occurrence is an anionic ligand group of up to 40 atoms not counting hydrogen, or two $X^*$ groups together form a divalent anionic ligand group of up to 40 atoms not counting hydrogen or together are a conjugated diene having from 4 to 30 atoms not counting hydrogen forming a $\pi$-complex with M, whereupon M is in the +2 formal oxidation state, and $R^*$, E and x are as previously defined.

[0039] The foregoing metal complexes are especially suited for the preparation of polymers having stereoregular molecular structure. In such capacity it is preferred that the complex possess $C_2$ symmetry or possess a chiral, stereo rigid structure.

[0040] Examples of the first type are compounds possessing different delocalized $\pi$-bonded systems, such as one cyclopentadienyl group and one fluorenyl group. Similar systems based on Ti(IV) or Zr(IV) were disclosed for preparation of syndiotactic olefin polymers in Ewen, et al., J. Am. Chem. Soc. 110, 6255-6256 (1980).

[0041] Examples of chiral structures include bis-indenyl complexes. Similar systems based on Ti(IV) or Zr(IV) were disclosed for preparation of isotactic olefin polymers in Wild et al., J. Organomet. Chem, 232, 233-47, (1982).

[0042] Exemplary bridged ligands containing two $\pi$-bonded groups are: (dimethylsilyl-bis-cyclopentadienyl), (dimethylsilyl-bis-methylcyclopentadienyl), (dimethylsilyl-bis-ethylcyclopentadienyl), (dimethylsilyl-bis-t-butylcyclopentadienyl), (dimethylsilyl-bis-tetramethylcyclopentadienyl), (dimethylsilyl-bis-tert-hydroindienyl), (dimethylsilyl-bis-tetrafluorocyclopentadienyl), (dimethylsilyl-bis-2-methyl-4-phenylindenyl), (dimethylsilyl-bis-2-methylindenyl), (dimethylsilyl-bis-tetrahydroindenyl), (1,1,2,2-tetramethyl-1,2-disilyl-bis-cyclopentadienyl), (1, 2-bis(cyclopentadienyl)ethane, and (isopropylidene-cyclopentadienyl-fluorenyl).

[0043] Preferred $X^*$ groups are selected from hydride, hydrocarbyl, silyl, germyl, halohydrocarbyl, halosilyl, silylhydrocarbyl and aminohydrocarbyl groups, or two $X^*$ groups together form a divalent derivative of a conjugated diene or else together they form a neutral, $\pi$-bonded, conjugated diene. Most preferred $X^*$ groups are $C_{1,20}$ hydrocarbyl groups.

[0044] A further class of metal complexes utilized in the present invention correspond to the formula:

\[
L_{m}MX_{n}X^*_{x}X^*_{p},
\]

or a dimer thereof

wherein:

L is an anionic, delocalized, $\pi$-bonded group that is bound to M, containing up to 50 atoms not counting hydrogen; M is a metal of Group 4 of the Periodic Table of the Elements in the +2, +3 or +4 formal oxidation state; X is a divalent substituent of up to 50 non-hydrogen atoms that together with L forms a metallocycle with M;
X' is an optional neutral Lewis base ligand having up to 20 non-hydrogen atoms; X" each occurrence is a monovalent, anionic moiety having up to 20 non-hydrogen atoms, optionally two X" groups together may form a divalent anionic moiety having both valences bound to M or a neutral C\textsubscript{5-30} conjugated diene, and further optionally X' and X" may be bonded together thereby forming a moiety that is both covalently bound to M and coordinated thereto by means of Lewis base functionality;
l is 1 or 2;
m is 1;
n is a number from 0 to 3;
p is an integer from 1 to 2; and
the sum, l+m+p, is equal to the formal oxidation state of M.

Preferred divalent X substituents preferably include groups containing up to 30 atoms not counting hydrogen and comprising at least one atom that is oxygen, sulfur, boron or a member of Group 14 of the Periodic Table of the Elements directly attached to the delocalized \( \pi \)-bonded group, and a different atom, selected from the group consisting of nitrogen, phosphorus, oxygen or sulfur that is covalently bonded to M.

A preferred class of such Group 4 metal coordination complexes used according to the present invention correspond to the formula:

\[
\begin{align*}
\text{M} & \quad \text{R}^3 \\
& \quad \text{Z-Y} \\
& \quad \text{X}^{"} \\
& \quad \text{R}^3
\end{align*}
\]

wherein:

M is titanium or zirconium in the +2, +3 or +4 formal oxidation state;
R\textsuperscript{3} in each occurrence independently is selected from the group consisting of hydrogen, hydrocarbyl, silyl, germyl, cyano, halo and combinations thereof, said R\textsuperscript{3} having up to 20 non-hydrogen atoms, or adjacent R\textsuperscript{3} groups together form a divalent derivative (that is, a hydrocarbadiyl, siladiyl or germadiyl group) thereby forming a fused ring system, each X" is a halo, hydrocarbyl, hydrocarbyloxy or silyl group, said group having up to 20 atoms not counting hydrogens, or two X" groups together form a C\textsubscript{5-30} conjugated diene;
Y is -O-, -S-, -NR\textsuperscript{*}-, -NR\textsuperscript{*2}, -PR\textsuperscript{*}; and
Z is SiR\textsuperscript{*2}, CR\textsuperscript{*2}, SiR\textsuperscript{*2}SiR\textsuperscript{*2}, CR\textsuperscript{*2}CR\textsuperscript{*2}, CR\textsuperscript{*}+CR\textsuperscript{*}+CR\textsuperscript{*2}SiR\textsuperscript{*2}, or GeR\textsuperscript{*2}, wherein: R* is as previously defined.

Illustrative Group 4 metal complexes that may be employed in the practice of the present invention include:

cyclopentadienyltitaniumtrimethyl,
cyclopentadienyltitaniumtriethyl,
cyclopentadienyltitaniumtriisopropyl,
cyclopentadienyltitaniumtriphenyl,
cyclopentadienyltitaniumtribenzyl,
cyclopentadienyltitaniumt-2,4-pentadienyl,
(tet-butylamido)(tetramethyl-\( \eta^5 \)-cyclopentadienyl)dimethylsilanetitanium dimethyl,
(tet-butylamido)(tetramethyl-\( \eta^5 \)-cyclopentadienyl)-1,2-ethanediyltitanium dimethyl,
(tet-butylamido)(hexamethyl-\( \eta^5 \)-indenyl)dimethylsilanetitanium dimethyl,
(tet-butylamido)(tetramethyl-\( \eta^5 \)-cyclopentadienyl)dimethylsilane titanium (III) 2-(dimethylamino)benzyl;
(tet-butylamido)(tetramethyl-\( \eta^5 \)-cyclopentadienyl)dimethylsilanetitanium (III) allyl,
(tet-butylamido)(tetramethyl-\( \eta^5 \)-cyclopentadienyl)dimethylsilanetitanium (II) 1,4-diphenyl-1,3-butadiene,
(tet-butylamido)(2-methylindenyl)dimethylsilanetitanium (II) 1,4-diphenyl-1,3-butadiene,
(tet-butylamido)(2-methylindenyl)dimethylsilanetitanium (IV) 1,3-butadiene,
(tert-butylamido)(2,3-dimethylindenyl)dimethylsilanetitanium (IV) 1,3-butadiene,
(tert-butylamido)(2,3-dimethylindenyl)dimethylsilanetitanium (II) 1,3-pentadiene, (tert-butylamido)(2-methylindenyl)dimethylsilanetitanium (II) 1,3-pentadiene,
(tert-butylamido)(2-methylindenyl)dimethylsilanetitanium (IV) dimethyl,
(tert-butylamido)(2-methyl-4-phenylindenyl)dimethylsilanetitanium (II) 1,4-diphenyl-1,3-butadiene,
(tert-butylamido)(tetr methyl-η^5-cyclopentadienyl)dimethylsilanetitanium (IV) 1,3-butadiene,
(tert-butylamido)(tetr methyl-η^5-cyclopentadienyl)dimethylsilanetitanium (II) 1,4-dibenyl-1,3-butadiene,
(tert-butylamido)(tetr methyl-η^5-cyclopentadienyl)dimethylsilanetitanium (II) 2,4-hexadiene,
(tert-butylamido)(tetr methyl-η^5-cyclopentadienyl)dimethylsilanetitanium (II) 3-methyl 1,3-pentadiene,
(tert-butylamido)(2,4-dimethyl-1,3-pentadien-2-yl)dimethylsilanetitaniumdimethyl,
(tert-butylamido)(1,1-dimethyl-2,3,4,9,10-η^1,4,5,6,7,8-hexahydronaphthalen-4-yl)dimethylsilanetitaniumdimethyl,
(tert-butylamido)(1,1,2,3-tetramethyl-2,3,4,9,10-η^1,4,5,6,7,8-hexahydronaphthalen-4-yl)dimethylsilanetitaniumdimethyl,
(tert-butylamido)(tetramethylcyclopentadienyl)dimethylsilanetitanium 1,3-pentadiene,
(tert-butylamido)(1,3-pentadien-2-yl)dimethylsilanetitaniumdimethyl,
(tert-butylamido)(tetramethylcyclopentadienyl)dimethylsilanetitanium 1,3-pentadiene, and
(tert-butylamido)(3,4-cyclopenta(l)phenanthren-2-yl)dimethylsilanetitanium 1,4-diphenyl-1,3-butadiene.

Bis(L) containing complexes including bridged complexes suitable for use in the present invention include:

bis(cyclopentadienyl)zirconiumdimethyl,
bis(cyclopentadienyl)zirconiumdiethyl,
bis(cyclopentadienyl)zirconiumdiisopropyl,
bis(cyclopentadienyl)zirconiumdiphenyl,
bis(cyclopentadienyl)zirconium dibenzyl,
bis(cyclopentadienyl)zirconium-2,4-pentadienyl,
bis(cyclopentadienyl)zirconiummethylmethoxide,
bis(cyclopentadienyl)zirconiummethylchloride,
bispentamethylcyclopentadienylzirconiumdimethyl,
bisindenylzirconiumdimethyl,
indenylfluorenylzirconiumdiethyl,
bisindenylzirconiummethyl(2-(dimethylamino)benzyl),
bisindenylzirconium methyltrimethylsilyl,
bis(tetrahydroindenyl)zirconium methyltrimethylsilyl,
bispentamethylcyclopentadienylzirconiumdibenzyl,
bis(tetrahydroindenyl)zirconiummethylmethoxide,
(bisdimethylsilyl-bis-cyclopentadienyl)zirconiumdimethyl,
(bisdimethylsilyl-bis-pentamethylcyclopentadienyl)zirconium-2,4-pentadienyl,
(bisdimethylsilyl-bis-pentamethylcyclopentadienyl)zirconium(III) 2-(dimethylamino)benzyl,
(bisdimethylsilyl-bis-2-methylindenyl)zirconiumdimethyl,
(bisdimethylsilyl-bis-2-methyl-4-phenylindenyl)zirconiumdimethyl,
(bisdimethylsilyl-bis-2-methylindenyl)zirconium-1,4-diphenyl-1,3-butadiene,
(bisdimethylsilyl-bis-tetrahydroindenyl)zirconium(II) 1,4-diphenyl-1,3-butadiene,
(bisdimethylsilyl-bis-tetrahydrofluorenyl)zirconiumdimethyl(trimethylsilyl),
(isopropylidene)(cyclopentadienyl)(fluorenyl)zirconiumdibenzyl, and
(bisdimethylsilylpentamethylcyclopentadienylfluorenyl)zirconiumdimethyl.

Suitable addition polymerizable monomers for use with the foregoing novel catalyst compositions include ethylenically unsaturated monomers, acetylenic compounds, conjugated or non-conjugated dienes, and polyenes. Preferred monomers include olefins, for example alpha-olefins having from 2 to 20,000, preferably from 2 to 20, more preferably from 2 to 8 carbon atoms and combinations of two or more of such alpha-olefins. Particularly suitable alpha-olefins include, for example, ethylene, propylene, 1-butene, isobutylene, 1-pentene, 4-methylpentene-1, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, or combinations thereof, as well as long chain vinyl terminated oligomeric or polymeric reaction products formed during the polymerization, and C_{10-30} a-olefins specifically added to the reaction mixture in order to produce relatively long
chain branches in the resulting polymers. Preferably, the alpha-olefins are ethylene, propylene, 1-butene, 1-pentene, 4-methyl-pentene-1, 1-hexene, 1-octene, and combinations of ethylene and/or propene with one or more other alpha-olefins. Other preferred monomers include styrene, halo- or alkyl substituted styrenes, vinylbenzocyclobutene, 1,4-hexadiene, dicyclopentadiene, ethylidene norbornene, and 1,7-octadiene. Mixtures of the above-mentioned monomers may also be employed.

In general, the polymerization may be accomplished under conditions well known in the prior art for Ziegler-Natta or Kaminsky-Sinn type polymerization reactions. Suspension, solution, slurry, gas phase or high pressure, whether employed in batch or continuous form or other process conditions, may be employed if desired. Examples of such well known polymerization processes are depicted in WO 88/02009, U.S. Patent Nos. 5,084,534, 5,405,922, 4,588,790, 5,032,652, 4,543,399, 4,564,647, 4,522,987, and elsewhere. Preferred polymerization temperatures are from 0-250°C. Preferred polymerization pressures are from atmospheric to 3000 atmospheres.

Preferred processing conditions include solution polymerization, more preferably continuous solution polymerization processes, conducted in the presence of an aliphatic or alicyclic liquid diluent. By the term "continuous polymerization" is meant that at least the products of the polymerization are continuously removed from the reaction mixture. Preferably one or more reactants are also continuously added to the polymerization mixture during the polymerization. Examples of suitable aliphatic or alicyclic liquid diluents include straight and branched-chain C4-12 hydrocarbons and mixtures thereof; alicyclic hydrocarbons such as cyclohexane, cycloheptane, methycyclohexane, methycycloheptane, and mixtures thereof; and perfluorinated hydrocarbons such as perfluorinated C4-10 alkanes. Suitable diluents also include aromatic hydrocarbons (particularly for use with aromatic a-olefins such as styrene or ring alkyl-substituted styrenes) including toluene, ethylbenzene or xylene, as well as liquid olefins (which may act as monomers or comonomers) including ethylene, propylene, 1-butene, isobutylene, butadiene, 1-pentene, cyclopentene, 1-hexene, cyclohexene, 3-methyl-1-pentene, 4-methyl-1-pentene, 1,4-hexadiene, 1-octene, 1-decene, styrene, divinylbenzene, allylbenezene, and vinyltoluene (including all isomers alone or in admixture). Mixtures of the foregoing are also suitable. The foregoing diluents may also be advantageously employed during the synthesis of the metal complexes and catalyst activators of the present invention.

In most polymerization reactions the molar ratio of catalyst: polymerizable compounds employed is from 10⁻¹²:1 to 10⁻¹:1, more preferably from 10⁻¹²:1 to 10⁻⁵:1.

The catalyst composition of the invention may also be utilized in combination with at least one additional homogeneous or heterogeneous polymerization catalyst in separate reactors connected in series or in parallel to prepare polymer blends having desirable properties. An example of such a process is disclosed in WO 94/00500. A more specific process is disclosed in copending application U. S. Serial Number 08/10958, filed January 29,1993. Molecular weight control agents can be used in combination with the present cocatalysts. Examples of such molecular weight control agents include hydrogen, trialkyl aluminum compounds or other known chain transfer agents. A particular benefit of the use of the present cocatalysts is the ability (depending on reaction conditions) to produce narrow molecular weight distribution α-olefin homopolymers and copolymers of greatly improved catalyst efficiencies. Preferred polymers have Mw/Mn of less than 2.5, more preferably less than 2.3. Such narrow molecular weight distribution polymer products are highly desirable due to improved tensile strength properties.

The catalyst composition of the present invention can also be employed to advantage in the gas phase polymerization and copolymerization of olefins, preferably by supporting the catalyst composition by any suitable technique. Gas phase processes for the polymerization of olefins, especially the homopolymerization and copolymerization of ethylene and propylene, and the copolymerization of ethylene with higher alpha olefins such as, for example, 1-butene, 1-hexene, 4-methyl-1-pentene are well known in the art. Such processes are used commercially on a large scale for the manufacture of high density polyethylene (HDPE), medium density polyethylene (MDPE), linear low density polyethylene (LLDPE) and polypropylene.

The gas phase process employed can be, for example, of the type which employs a mechanically stirred bed or a gas fluidized bed as the polymerization reaction zone. Preferred is the process wherein the polymerization reaction is carried out in a vertical cylindrical polymerization reactor containing a fluidized bed of polymer particles supported above a perforated plate, the fluidization grid, by a flow of fluidization gas.

The gas employed to fluidize the bed comprises the monomer or monomers to be polymerized, and also serves as a heat exchange medium to remove the heat of reaction from the bed. The hot gases emerge from the top of the reactor, normally via a tranquilization zone, also known as a velocity reduction zone, having a wider diameter than the fluidized bed and wherein fine particles entrained in the gas stream have an opportunity to gravitate back into the bed. It can also be advantageous to use a cyclone to remove ultra-fine particles from the hot gas stream. The gas is then normally recycled to the bed by means of a blower or compressor and one or more heat exchangers to strip the gas of the heat of polymerization.

A preferred method of cooling of the bed, in addition to the cooling provided by the cooled recycle gas, is to feed a volatile liquid to the bed to provide an evaporative cooling effect. The volatile liquid employed in this case can be, for example, a volatile inert liquid, for example, a saturated hydrocarbon having 3 to 8, preferably 4 to 6, carbon
In the case that the monomer or comonomer itself is a volatile liquid or can be condensed to provide such a liquid, this can be suitably fed to the bed to provide an evaporative cooling effect. Examples of olefin monomers which can be employed in this manner are olefins containing from 3 to 8, preferably from 3 to 6 carbon atoms. The volatile liquid evaporates in the hot fluidized bed to form gas which mixes with the fluidizing gas. If the volatile liquid is a monomer or comonomer, it may undergo some polymerization in the bed. The evaporated liquid then emerges from the reactor as part of the hot recycle gas, and enters the compression/heat exchange part of the recycle loop. The recycle gas is cooled in the heat exchanger and, if the temperature to which the gas is cooled is below the dew point, liquid will precipitate from the gas. This liquid is desirably recycled continuously to the fluidized bed. It is possible to recycle the precipitated liquid to the bed as liquid droplets carried in the recycle gas stream, as described, for example, in EP-A-89691, US-A-4543399, WO 94/25495 and US-A-5352749. A particularly preferred method of recycling the liquid to the bed is to separate the liquid from the recycle gas stream and to re-inject this liquid directly into the bed, preferably using a method which generates fine droplets of the liquid within the bed. This type of process is described in WO 94/28032.

The polymerization reaction occurring in the gas fluidized bed is catalyzed by the continuous or semi-continuous addition of catalyst. Such catalyst can be supported on an inorganic or organic support material if desired. The catalyst can also be subjected to a prepolymerization step, for example, by polymerizing a small quantity of olefin monomer in a liquid inert diluent, to provide a catalyst composite comprising catalyst particles embedded in olefin polymer particles.

The polymer is produced directly in the fluidized bed by catalyzed (co)polymerization of the monomer(s) on the fluidized particles of catalyst, supported catalyst or prepolymer within the bed. Start-up of the polymerization reaction is achieved using a bed of preformed polymer particles, which, preferably, is similar to the target polyolefin, and conditioning the bed by drying with a dry inert gas such as nitrogen prior to introducing the catalyst, the monomer(s) and any other gases which it is desired to have in the recycle gas stream, such as a diluent gas, hydrogen chain transfer agent, or an inert condensable gas when operating in gas phase condensing mode. The produced polymer is discharged continuously or discontinuously from the fluidized bed as desired, optionally exposed to a catalyst kill and optionally pelletized.

It is understood that the present invention is operable in the absence of any component which has not been specifically disclosed. The following examples are provided in order to further illustrate the invention and are not to be construed as limiting. Unless stated to the contrary, all parts and percentages are expressed on a weight basis. The term "overnight", if used, refers to a time of approximately 16-18 hours, "room temperature", if used, refers to a temperature of 20-25 °C, and "mixed alkanes" refers to a mixture of hydrogenated propylene oligomers, mostly C₆-C₁₂ isoalkanes, available commercially under the trademark Isopar E™ from Exxon Chemicals Inc.

EXAMPLES

Tris(perfluorophenyl)borane (FAB) was obtained as a solid from Boulder Scientific Inc. and used without further purification. Modified methalumoxane (MMAO-3A) in heptane was purchased from Akzo-Nobel. MAO and trimethylaluminum (TMA) both in toluene were purchased from Aldrich Chemical Co. Tris(perfluorophenyl)aluminum (FAAL) in toluene was prepared by exchange reaction between tris(perfluorophenyl)borane and trimethylaluminum. All solvents were purified using the technique disclosed by Pangborn et al, Organometallics, 1996, 15, 1518-1520. All compounds and solutions were handled under an inert atmosphere (dry box). All chemical shift for 19F NMR spectra were filtered prior to use. 1H and 13C NMR shifts were referenced to internal solvent resonances and are reported relative to a fixed external standard (CFCl₃) in benzene d₆ or toluene d₈, either of which were dried over N/K alloy and relative to TMS.

Preparation of diisobutyl(2,6-di-t-butyl-4-methylphenoxy)aluminum (DIBAL-BOT) was conducted according to the method of Skowronska-Plasinska,M. et al., J. Organometallic Chem., 1978, 160, 403-409. The product was isolated as a colorless oil. NMR spectroscopic data are as follows: 1H NMR (CD₆D₆) 7.08, 2.27(s,3H), 2.03, m, 1H, 1.48 (s, 18H), 1.02 (d, 12H, J=6.8 Hz), 0.39 (d, 12H, J=6.8 Hz); 13C NMR (CD₆D₆) 153.9, 138.1, 127.2, 126.0, 34.8, 32.1, 28.2, 25.8, 24.0, 21.5.

EXAMPLE 1

In a glove box, FAAL (0.012 g, 0.02 mmol, toluene adduct) and di(isobutyl)(2,6-di-t-butyl-4-methylphenoxy)aluminum (dibal-bot) (0.007 g, 0.02 mmol) were mixed in 0.7 mL of benzene-d₆ and the mixture was loaded into a NMR tube. NMR spectra were recorded after mixing these reagents in the NMR tube for 10 min. Two new species: isobutylpentfluorophenyl(2,4-di-t-butyl-4-methylphenoxy)aluminum, and isobutylbis(pentfluorophenyl)aluminum were found to form from the exchange. No significant spectroscopic changes in products or ratios of products were found after 4 h.
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5 [0064] iBu(C₆F₅)₂Al(BHT) ¹H NMR (C₆D₆, 23°C): δ 7.10 (s, 2 H, Ar), 2.25 (s, 3 H, Ar-CH₃), 1.89 (septet, Jₘ-H = 6.6 Hz, 1 H, Me₂CHCH₂), 1.50 (s, 18 H, iBu), 0.89 (d, Jₚ-H = 6.6 Hz, 6 H, Me₂CHCH₂), 0.50 (d, Jₘ-H = 7.2 Hz, 2 H, Me₂CHCH₂). ¹³F NMR (C₆D₆, 23°C): δ -120.93 (dd, Jₚ-F = 18.3 Hz, 2 F, o-F), -149.65 (t, Jₚ-F = 21.4 Hz, 1 F, p-F), -159.61 (tt, Jₚ-F = 24.5 Hz, 2 F, m-F). iBuAl(C₆F₅)₂ ¹H NMR (C₆D₆, 23°C): δ 1.89 (overlapping with the above structure, 1 H, Me₂CHCH₂), 0.99 (d, Jₚ-H = 6.6 Hz, 6 H, Me₂CHCH₂), 0.55 (s, br, 2 H, Me₂CHCH₂). ¹³F NMR (C₆D₆, 23°C): δ -121.74 (d, Jₚ-F = 18.3 Hz, 2 F, o-F), -151.45 (t, Jₚ-F = 20.9 Hz, 1 F, p-F), -161.20 (tt, Jₚ-F = 24.5 Hz, 2 F, m-F).

10 EXAMPLE 2

15 [0065] In a glove box, FAAL, (0.020 g, 0.032 mmol, toluene adduct) and di(isobutyl)(2,6-di-tert-butyl-4-methylphenox)-aluminum (0.003 g, 0.008 mmol) were mixed in 0.7 mL of benzene-d₆ and the mixture was loaded into a NMR tube. NMR spectra were recorded after mixing these reagents in the NMR tube for 20 min. Two new species, isobutyl(pentafluorophenyl)(2,6-ditert-butyl-4-methylphenoxy)aluminum (i-Bu(C₆F₅)Al(BHT)) and isobutylbis(pentafluorophenyl)aluminum (i-BuAl(C₆F₅)₂), as well as a small amount of bis(pentafluorophenyl)(2,6-ditert-butyl-4-methylphenoxy)aluminum ((C₆F₅)₂Al(BHT)) were found to form from the exchange reaction. No di(isobutyl)(2,6-di-tert-butyl-4-methylphenox)-aluminum reagent remained. Residual FAAL reagent was also present.

20 [0066] iBu(C₆F₅)₂Al(BHT) ¹H NMR (C₆D₆, 23°C): δ 7.10 (s, 2 H, Ar), 2.25 (s, 3 H, Ar-CH₃), 1.89 (septet, Jₘ-H = 6.6 Hz, 1 H, Me₂CHCH₂), 1.50 (s, 18 H, iBu), 0.89 (d, Jₚ-H = 6.6 Hz, 6 H, Me₂CHCH₂), 0.50 (d, Jₘ-H = 7.2 Hz, 2 H, Me₂CHCH₂). ¹³F NMR (C₆D₆, 23°C): δ -120.93 (dd, Jₚ-F = 18.3 Hz, 2 F, o-F), -149.65 (t, Jₚ-F = 21.4 Hz, 1 F, p-F), -159.61 (tt, Jₚ-F = 24.5 Hz, 2 F, m-F). iBuAl(C₆F₅)₂ ¹H NMR (C₆D₆, 23°C): δ 1.89 (overlapping with the above structure, 1 H, Me₂CHCH₂), 0.99 (d, Jₚ-H = 6.6 Hz, 6 H, Me₂CHCH₂), 0.55 (s, br, 2 H, Me₂CHCH₂). ¹³F NMR (C₆D₆, 23°C): δ -121.74 (d, Jₚ-F = 18.3 Hz, 2 F, o-F), -151.45 (t, Jₚ-F = 20.9 Hz, 1 F, p-F), -161.20 (tt, Jₚ-F = 24.5 Hz, 2 F, m-F).

25 POLYMERIZATIONS

[0067] A 2-liter Parr reactor was used in the polymerizations. All feeds were passed through columns of alumina and a decontaminant (Q-5™ catalyst available from Englehardt Chemicals Inc.) prior to introduction into the reactor. Catalyst and cocatalysts are handled in a glovebox containing an atmosphere of argon or nitrogen.

[0068] A stirred 2.0 liter reactor is charged with 740 g of mixed alkanes solvent and 118 g of 1-octene comonomer. Hydrogen is added as a molecular weight control agent by differential pressure expansion from a 75 ml addition tank at 25 psi (2070 kPa). The reactor is heated to the polymerization temperature of 130 °C and saturated with ethylene at 500 psig (3.4 MPa). FAAL is combined with disobutyl(2,6-di-tert-butyl)-4-methylphenox)aluminum as toluene solutions and allowed to stand at 25 °C for 15 minutes prior to use. Catalyst (t-butylamido)(dimethyl(tetramethylcyclopentadienyl) silanetitanium 1,3-pentadiene) and the indicated cocatalyst, as dilute solutions in toluene, are mixed and transferred to a catalyst addition tank, and injected into the reactor. The polymerization conditions are maintained for 15 minutes with ethylene added on demand. The resulting solution is removed from the reactor, quenched with isopropyl alcohol, and stabilized by addition of 10 ml of a toluene solution containing approximately 67 mg of a hindered phenol antioxidant (Irganox™ 1010 from Ciba Geigy Corporation) and 133 mg of a phosphorus stabilizer (Irgafos™ 168 from Ciba Geigy Corporation).

[0069] Between polymerization runs a wash cycle in which 850 g of mixed alkanes is added to the reactor and the reactor heated to 150 °C. The reactor is emptied of the heated solvent immediately before beginning a new polymerization run.

[0070] Polymers are recovered by drying in a vacuum oven set at 140 °C for 20 hours. Density values are derived by determining the polymer’s mass when in air and when immersed in methylethylketone. Micro melt index values (MMI) are obtained using a “Custom Scientific Instrument Inc. Model CS-127MF-015” apparatus at 190°C. MMI (micro-melt index) are unit-less values calculated as follows: MMI = 1/(0.00343 t - 0.00251), where t = time in seconds. Results are contained in Table 1.
The above polymerization conditions were substantially repeated excepting that 250 g of mixed alkanes solvent and 300 g of propylene are polymerized at a polymerization temperature of 70 °C.

The cocatalyst was prepared by combining FAAL with disisobutyl(2,6-di-tert-butyl-4-methylphenoxy)aluminum and allowing the mixture to stand at 25 °C for 15 minutes. The mixture was not devolatilized to remove triisopropylborane byproducts. Catalyst, dimethylsilanebis(2-methyl-4-phenylindenyl)zirconium 1,4-diphenyl-1,3-butadiene and the Indicated cocatalyst, as dilute solutions in toluene, are then mixed at the indicated ratio (zirconium complex: FAAL: DIBAL-BOT), transferred to a catalyst addition tank, and injected into the reactor. The polymerization conditions are maintained for 15 minutes. Results are contained in Table 2.

### Table 1

<table>
<thead>
<tr>
<th>Run</th>
<th>Activator(s)</th>
<th>catalyst/ activator**</th>
<th>ΔT*** (°C)</th>
<th>Yield (g)</th>
<th>Efficiency g polymer/μg Ti</th>
<th>Density g/ml</th>
<th>MMt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FAAL/ Dibal-Bot</td>
<td>1/4/1</td>
<td>36.8</td>
<td>71.6</td>
<td>1.50</td>
<td>0.902</td>
<td>5.6</td>
</tr>
<tr>
<td>2</td>
<td>FAAL/Dibal-Bot</td>
<td>0.25/ 1/0.25</td>
<td>8.6</td>
<td>57.8</td>
<td>4.83</td>
<td>0.899</td>
<td>2.5</td>
</tr>
<tr>
<td>A*</td>
<td>B((\text{C}_6\text{F}_5))_3</td>
<td>1.5/1.5</td>
<td>6.0</td>
<td>85.5</td>
<td>1.19</td>
<td>0.898</td>
<td>4.2</td>
</tr>
<tr>
<td>B*</td>
<td>FAAL</td>
<td>0.5/ 0.5</td>
<td>0.0</td>
<td>0.9</td>
<td>0.038</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* comparative example, not an example of the invention.
** catalyst ratios reflect μmole metal complex/μmole first activator/μ mole second activator
*** exotherm

### Table 2

<table>
<thead>
<tr>
<th>Run</th>
<th>Activator(s)</th>
<th>catalyst/ activator**</th>
<th>Yield (g)</th>
<th>Efficiency (g polymer/ μg Zr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>FAAL/ DIBAL-BOT</td>
<td>0.25/ 1/ 0.25</td>
<td>91.9</td>
<td>4.03</td>
</tr>
<tr>
<td>4</td>
<td>&quot;</td>
<td>0.25/ 0.5/ 0.125</td>
<td>82.7</td>
<td>3.25</td>
</tr>
<tr>
<td>5</td>
<td>&quot;</td>
<td>0.125/ 0.5/ 0.125</td>
<td>80.0</td>
<td>7.02</td>
</tr>
<tr>
<td>6</td>
<td>&quot;</td>
<td>0.125/ 0.25/ 0.125</td>
<td>37.1</td>
<td>3.25</td>
</tr>
<tr>
<td>D*</td>
<td>B((\text{C}_6\text{F}_5))_3</td>
<td>2.5/ 2.5</td>
<td>31.3</td>
<td>0.14</td>
</tr>
</tbody>
</table>

* comparative example, not an example of the invention.
** catalyst ratios, μmole metal complex/μmole first activator/μmole second activator

### Example 3

In a glove box, FAAL (0.032 mmol, toluene adduct) and dibal-bot (0.008 mmol) were mixed in 0.7 mL of benzene-\(\text{d}_6\) and the mixture was loaded into a NMR tube. All species in the mixture were identified as being the same as in Example 2. The metal complex, \((t\text{-butylamido})(\text{tetramethylcyclopentadienyl})\text{dimethylsilane-}\text{titanium dimethyl}\), (8 mmol) was added to the above solution and the resulting mixture immediately turned to an orange color. NMR spectroscopic features of the major product are consistent with a µ-bridged bisadduct of the formula \(\text{Me}_2\text{Si}(\eta^5-\text{Me}_4\text{C}_5)\{(t-\text{BuN})\text{Ti}[(\mu-\text{Me})\text{Al}(\text{C}_6\text{F}_5)_3]\_2\).

### Example 4

In a glove box, FAAL (0.032 mmol, toluene adduct) and dibal-bot (0.008 mmol) were mixed in 0.7 mL of benzene-\(\text{d}_6\) and the mixture was loaded into a NMR tube. All species in the mixture were identified as being the same as in Example 2. The complex \((\text{rac-}\text{dimethylsilyl-}\text{bis(1-indenyl})\text{zirconium dimethyl}, 8 \mu\text{mol})\) was added to the above solution whereupon the resulting mixture immediately turned to deep red color. NMR spectroscopic features of the major product are consistent with a µ-bridged bisadduct of the formula: rac-\(\text{Me}_2\text{Si}(\eta^5-\text{Ind})_2\text{Zr}[(\mu-\text{Me})\text{Al}(\text{C}_6\text{F}_5)_3]\_2\).

### Claims

1. A composition comprising:
A) an aluminum compound corresponding to the formula \( \text{AlAr}_3 \), where \( \text{Ar}^f \) is a fluorinated aromatic hydrocarbyl moiety of from 6 to 30 carbon atoms;

B) an aluminum compound corresponding to the formula: \( \text{AlAr}^f Q_1 Q_2 \); where:

\( \text{Ar}^f \) is as previously defined;

\( Q_1 \) is \( \text{Ar}^f \) or a \( \text{C}_{1-20} \) hydrocarbyl group, optionally substituted with one or more cyclohydrocarbyl, hydrocarbyloxy, hydrocarbylsiloxy, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, \( \text{di(hydrocarbylsilyl)} \) amino, hydrocarbylamino, \( \text{di(hydrocarbyl)} \) amino, \( \text{di(hydrocarbylsilyl)} \) phosphino, or hydrocarbylsulfido groups having from 1 to 20 atoms other than hydrogen, or, further optionally, such substituents may be covalently linked with each other to form one or more fused rings or ring systems; and

\( Q_2 \) is an aryloxy, arylsulfide or \( \text{di(hydrocarbyl)} \) amido group, optionally substituted with one or more hydrocarbyl, cyclohydrocarbyl, hydrocarbyloxy, hydrocarbylsiloxy, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, \( \text{di(hydrocarbylsilyl)} \) amino, hydrocarbylamino, \( \text{di(hydrocarbyl)} \) amino, \( \text{di(hydrocarbylsilyl)} \) phosphino, or hydrocarbylsulfido groups having from 1 to 20 atoms other than hydrogen, or, further optionally such substituents may be covalently linked with each other to form one or more fused rings or ring systems, said \( Q_2 \) having from 3 to 20 atoms other than hydrogen; and

the molar ratio of A):B) in the composition being from 0.1:1 to 10:1.

2. A composition according to claim 1 where \( \text{Ar}^f \) is pentafluorophenyl, \( Q_1 \) is isobutyl, and \( Q_2 \) is 4-methyl-2,6-di-t-butylphenoxy or bis(trimethylsilyl)amido.

3. A composition comprising:

A) an aluminum compound corresponding to the formula \( \text{AlAr}_3 \), where \( \text{Ar}^f \) is a fluorinated aromatic hydrocarbyl moiety of from 6 to 30 carbon atoms;

B) an aluminum compound corresponding to the formula: \( \text{AlAr}^f Q_1 Q_2 \); where:

\( \text{Ar}^f \) is as previously defined;

\( Q_1 \) is \( \text{Ar}^f \) or a \( \text{C}_{1-20} \) hydrocarbyl group, optionally substituted with one or more cyclohydrocarbyl, hydrocarbyloxy, hydrocarbylsiloxy, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, \( \text{di(hydrocarbylsilyl)} \) amino, hydrocarbylamino, \( \text{di(hydrocarbyl)} \) amino, \( \text{di(hydrocarbylsilyl)} \) phosphino, or hydrocarbylsulfido groups having from 1 to 20 atoms other than hydrogen, or, further optionally, such substituents may be covalently linked with each other to form one or more fused rings or ring systems; and

\( Q_2 \) is an aryloxy, arylsulfide or \( \text{di(hydrocarbyl)} \) amido group, optionally substituted with one or more hydrocarbyl, cyclohydrocarbyl, hydrocarbyloxy, hydrocarbylsiloxy, hydrocarbylsilylamino, hydrocarbylsilyl, silylhydrocarbyl, \( \text{di(hydrocarbylsilyl)} \) amino, hydrocarbylamino, \( \text{di(hydrocarbyl)} \) amino, \( \text{di(hydrocarbylsilyl)} \) phosphino, or hydrocarbylsulfido groups having from 1 to 20 atoms other than hydrogen, or, further optionally such substituents may be covalently linked with each other to form one or more fused rings or ring systems, said \( Q_2 \) having from 3 to 20 atoms other than hydrogen; and

C) an aluminum exchange compound or mixture thereof, in the aggregate corresponding to the formula, \( \text{AlAr}_2 Q_1 \), where \( Q_1 \) is not \( \text{Ar}^f \),

the molar ratio of A):B):C) in the composition being from 0.1:1.0:0.001 to 10.0:1.0:1.0.

4. A catalyst composition comprising a Group 3-10 metal complex and an activator comprising a composition according to any one of claims 1-3, the molar ratio of metal complex to activator in the composition being from 0.1: 1 to 3:1

5. The catalyst composition of claim 4 wherein the metal complex is a Group 4 metal complex.

6. The catalyst composition of claim 4 wherein the molar ratio of metal complex to activator composition is from 0.1: 1 to 2:1.

7. The catalyst composition of claim 4 additionally comprising a support material in the form of a particulated solid.

8. The catalyst composition of claims 7 wherein the metal complex is:
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(tert-butylamido)(tetramethylcyclopentadienyl)dimethylsilanetitanium dimethyl,
(tert-butylamido)(tetramethylcyclopentadienyl)dimethylsilanetitanium 1,3-pentadiene,
(tert-butylamido)(2-methyl-s-indacen-1-yl)dimethylsilanetitanium 1,3-pentadiene,
(tert-butylamido)(3-(N-pyrrolidinyl)inden-1-yl)dimethylsilanetitanium 1,3-pentadiene,
(tert-butylamido)(3,4-cyclopenta(1phenanthren-2-yl)dimethylsilanetitanium 1,4-diphenyl-1,3-butadiene,
(dimethylsilyl-bis-2-methyl-4-phenyldienyl)zirconium dimethyl, or
(dimethylsilyl-bis-2-methyl-4-phenyldienyl)zirconium 1,4-diphenyl-1,3-butadiene.

9. A process for polymerization of one or more addition polymerizable monomers comprising contacting the same,
optionally in the presence of an inert aliphatic, alicyclic or aromatic hydrocarbon, with the catalyst composition
according to claim 4.

10. The process of claim 9 wherein one or more α-olefins having from 2 to 20,000 carbon atoms are polymerized.

11. The process according to claim 9 which is a gas phase polymerization of one or more C_{2-8} α-olefins.

12. The process according to claim 9 which is a slurry polymerization of one or more C_{2-8} olefins.

Patentansprüche

1. Zusammensetzung enthaltend:

A) eine Aluminiumverbindung entsprechend der Formel AlAr^f_3,

arin Ar^f eine fluorierte aromatische Hydrocarbyleinheit mit 6 bis 30 Kohlenstoffatomen ist;

B) eine Aluminiumverbindung entsprechend der Formel AlAr^fQ_1Q_2,

arin Ar^f wie zuvor definiert ist;

Q_1 gleich Ar^f oder eine C_{1-20}-Hydrocarbylgruppe ist, die optional mit einer oder mehreren Cyclohydrocar-
byl-, Hydrocarboxy-, Hydroarboxylsiloxan-, Hydroarboxylamin-, Sillyhydrocarbyl-, Di
(hydroarboxylsiloxan)-amin-, Hydroarboxylamin-, Di(hydrocarbyl)amin-, Di(hydrocarbyl)phosphino-
oder Hydroarboxylsulfidogruppen mit 1 bis 20 Nichtwasserstoffatomen substituiert ist, oder weiterhin optional
solche Substituenten kovalent miteinander verbunden sein können, um einen oder mehrere anellierte
Ringe oder Ringsysteme auszubilden; und

Q_2 eine Aryloxy-, Arylsulfoxid- oder Di(hydroarboxylamidogruppe ist, die optional mit einer oder mehreren
Hydrocarbyl-, Cyclohydrocarbyl-, Hydroarboxyl-, Hydroarboxylsiloxan-, Hydroarboxylamin-, Hydro-
hydroarboxyl-, Sillyhydroarboxyl-, Di(hydroarboxylsiloxan)-amin-, Hydroarboxylamin-, Di(hydrocarbyl)amin-, Di(hy-
droarboxyl)phosphino- oder Hydroarboxylsulfidogruppen mit 1 bis 20 Nichtwasserstoffatomen substituiert
ist, oder weiterhin optional solche Substituenten kovalent miteinander verbunden sein können, um einen
oder mehrere anellierte Ringe oder Ringsysteme auszubilden, wobei Q_2 3 bis 20 Nichtwasserstoffatome
aufweist; und
das Molverhältnis von A):B) in der Zusammensetzung von 0,1:1 bis 10:1 reicht.

2. Zusammensetzung nach Anspruch 1, wobei Ar^f gleich Pentafluorphenyl ist, Q_1 gleich Isobutyl ist und Q_2 gleich
4-Methyl-2,6-di-tbutylphenoxy oder Bis(trimethylsilyl)amido ist.

3. Zusammensetzung enthaltend:

A) eine Aluminiumverbindung entsprechend der Formel AlAr^f_3,

arin Ar^f eine fluorierte aromatische Hydrocarbyleinheit mit 6 bis 30 Kohlenstoffatomen ist:

B) eine Aluminiumverbindung entsprechend der Formel AlAr^fQ_1Q_2,

arin Ar^f wie zuvor definiert ist;
Q¹ gleich Ar² oder eine C₁₂-Hydrocarbylgruppe ist, die optional mit einer oder mehreren Cyclohydrocarbyl-, Hydrocarbyloxy-, Hydrocarbylsilyl-, Silylhydrocarbyl-, Di(hydrocarbylsilyl)-amino-, Hydrocarbylamino-, Di(hydrocarbyl)phosphino- oder Hydrocarbylsulfidogruppen mit 1 bis 20 Nichtwasserstoffatomen substituiert ist, oder weiterhin optional solche Substituenten kovalent miteinander verbunden sein können, um einen oder mehrere anellierte Ringe oder Ringsysteme auszubilden;  
Q² eine Arylox-, Arylsulfid- oder Di(hydrocarbyl)amidogruppe ist, die optional mit einer oder mehreren Hydrocarbyl-, Cyclohydrocarbyl-, Hydrocarbyloxy-, Hydrocarbylsilyl-, Silylhydrocarbyl-, Di(hydrocarbylsilyl)-amino-, Hydrocarbylamino-, Di(hydrocarbyl)amino-, Di(hydrocarbyl)phosphino- oder Hydrocarbylsulfidogruppen mit 1 bis 20 Nichtwasserstoffatomen substituiert ist, oder weiterhin optional solche Substituenten kovalent miteinander verbunden sein können, um einen oder mehrere anellierte Ringe oder Ringsysteme auszubilden, wobei Q² 3 bis 20 Nichtwasserstoffatome aufweist; und  
C) eine Aluminiumaustauschverbindung oder Mischung davon im Aggregat entsprechend der Formel AlAr³Q¹, worin Q¹ nicht Ar² ist,

wobei das Molverhältnis von A):B):C) in der Zusammensetzung von 0,1:1,0:0,001 bis 10,0:1,0:1,0 reicht.

4. Katalysatorzusammensetzung, die einen Komplex eines Metalls der Gruppe 3-10 und einen Aktivator enthält, der eine Zusammensetzung nach einem der Ansprüche 1-3 enthält, wobei das Molverhältnis von Metallkomplex zu Aktivator in der Zusammensetzung von 0,1:1 bis 3:1 reicht.

5. Katalysatorzusammensetzung nach Anspruch 4, wobei der Metallkomplex ein Gruppe-4-Metallkomplex ist.

6. Katalysatorzusammensetzung nach Anspruch 4, wobei das Molverhältnis von Metallkomplex zu Aktivator von 0,1:1 bis 2:1 reicht.

7. Katalysatorzusammensetzung nach Anspruch 4, die weiterhin ein Trägermaterial in Form eines teilenförmigen Feststoffs enthält.

8. Katalysatorzusammensetzung nach Anspruch 7, wobei der Metallkomplex ist:

\[(\text{tert.-Butylamido})(\text{tetramethylcyclopentadienyl})\text{dimethylsilan} \text{titandimethyl, (tert.-Butylamido})(\text{tetramethylcyclopentadienyl})\text{dimethylsilan} \text{titan}1,3\text{-pentadien, (tert.-Butylamido})(\text{2-methyl-sindacen}1\text{-yl})\text{dimethylsilan} \text{titan}1,3\text{-pentadien, (tert.-Butylamido})(3,4\text{-cyclo} \text{penta} \text{phan} \text{en} \text{th} \text{en} \text{r}2\text{-yl})\text{dimethylsilan} \text{titan}1,4\text{-diphenyl}1,3\text{-butadien, (Dimethylsilyl-bis-2-methyl-4} \text{-phenylindenyl})zirkonium-dimethyl oder (Dimethylsilyl-bis-2-methyl-4phenylindenyl)zirkonium-1,4-diphenyl1,3-butadien.\]


10. Verfahren nach Anspruch 9, wobei ein oder mehrere α-Olefine mit 2 bis 20.000 Kohlenstoffatomen polymerisiert werden.

11. Verfahren nach Anspruch 9, das eine Gasphasenpolymerisation von einem oder mehreren C₂₈-α-Olefinen ist.


Revidications

1. Composition comprenant :

A) un composé d' aluminium correspondant à la formule AlAr³, dans laquelle Ar² est un fragment hydrocarbure aromatique fluoré de 6 à 30 atomes de carbone ;
B) un composé d'aluminium correspondant à la formule AlAr\textsubscript{f}Q\textsubscript{1}Q\textsubscript{2}, dans laquelle

\begin{align*}
\text{Ar}\textsubscript{f} & \text{ est comme précédemment défini ;} \\
Q\textsubscript{1} & \text{ est Ar}\textsubscript{f} ou un groupe hydrocarbyle en C\textsubscript{1-20}, facultativement substitué avec un ou plusieurs groupes cyclohydrocarbyle, hydrocarbyleoxy, hydrocarbylesiloxy, hydrocarbysilylamino, hydrocarbysilylile, silylhydrocarbyle, di(hydrocarbysilyl)amino, hydrocarbysilylamine, di(hydrocarbyle)phosphino, ou hydrocarbysilysulfure comportant de 1 à 20 atomes autres que l'hydrogène ou, encore facultativement, ces substituants peuvent être liés de façon covalente entre eux pour former un ou plusieurs noyaux ou systèmes à noyaux condensés ; \\
\text{et} \quad Q\textsubscript{2} & \text{ est un groupe aryloxy, arylsulfure ou di(hydrocarbyle)amido, facultativement substitué avec un ou plusieurs groupes hydrocarbyle, cyclohydrocarbyle, hydrocarbyleoxy, hydrocarbylesiloxy, hydrocarbysilylamine, hydrocarbysilylile, silylhydrocarbyle, di(hydrocarbysilyl)amino, hydrocarbysilylamine, di(hydrocarbyle)phosphino, ou hydrocarbysilysulfure comportant de 1 à 20 atomes autres que l'hydrogène ou, encore facultativement, ces substituants peuvent être liés de façon covalente entre eux pour former un ou plusieurs noyaux ou systèmes à noyaux condensés, le dit Q\textsubscript{2} comportant de 3 à 20 atomes autres que l'hydrogène ; et
\end{align*}

tout en gardant le rapport molaire de A)/B) dans la composition étant de 0,1/1 à 10/1.

2. Composition selon la revendication 1, dans laquelle Ar\textsubscript{f} est le pentafluorophényle, Q\textsubscript{1} est l'isobutyle et Q\textsubscript{2} est le 4-méthyl-2,6-di-t-butylphénoxy ou le bis(triméthylsilyl)amido.

3. Composition comprenant :

\begin{align*}
\text{A) un composé d'aluminium correspondant à la formule } & \text{AlAr}\textsubscript{f}\text{, dans laquelle } \\
\text{Ar}\textsubscript{f} & \text{ est un fragment hydrocarbyle aromatique fluori de 6 à 30 atomes de carbone ;} \\
\text{B) un composé d'aluminium correspondant à la formule } & \text{AlAr}\textsubscript{f}Q\textsubscript{1}Q\textsubscript{2}, dans laquelle }
\end{align*}

\begin{align*}
\text{Ar}\textsubscript{f} & \text{ est comme défini précédemment défini ;} \\
Q\textsubscript{1} & \text{ est Ar}\textsubscript{f} ou un groupe hydrocarbyle en C\textsubscript{1-20}, facultativement substitué avec un ou plusieurs groupes cyclohydrocarbyle, hydrocarbyleoxy, hydrocarbylesiloxy, hydrocarbysilylamino, hydrocarbysilylile, silylhydrocarbyle, di(hydrocarbysilyl)amino, hydrocarbysilylamine, di(hydrocarbyle)phosphino, ou hydrocarbysilysulfure comportant de 1 à 20 atomes autres que l'hydrogène ou, encore facultativement, ces substituants peuvent être liés de façon covalente entre eux pour former un ou plusieurs noyaux ou systèmes à noyaux condensés ; \\
Q\textsubscript{2} & \text{ est un groupe aryloxy, arylsulfure ou di(hydrocarbyle)amido, facultativement substitué avec un ou plusieurs groupes hydrocarbyle, cyclohydrocarbyle, hydrocarbyleoxy, hydrocarbylesiloxy, hydrocarbysilylamine, hydrocarbysilylile, silylhydrocarbyle, di(hydrocarbysilyl)amino, hydrocarbysilylamine, di(hydrocarbyle)phosphino, ou hydrocarbysilysulfure comportant de 1 à 20 atomes autres que l'hydrogène ou, encore facultativement, ces substituants peuvent être liés de façon covalente entre eux pour former un ou plusieurs noyaux ou systèmes à noyaux condensés, le dit Q\textsubscript{2} comportant de 3 à 20 atomes autres que l'hydrogène ; et}
\end{align*}

C) un composé d'échange d'aluminium ou un mélange de ce dernier, dans l'agrégat correspondant à la formule AlAr\textsubscript{f}\textsubscript{2}Q\textsubscript{1}, dans laquelle Q\textsubscript{1} n'est pas Ar\textsubscript{f},

tout en gardant le rapport molaire de A)/B)/C) dans la composition étant de 0,1/1,0/0,001 à 10,0/1,0/1,0.

4. Composition de catalyseur comprenant un complexe de métal du groupe 3-10 et un activateur comprenant une composition selon l'une quelconque des revendications 1-3, le rapport molaire du complexe de métal à l'activateur dans la composition étant de 0,1/1 à 3/1.

5. Composition de catalyseur de la revendication 4, dans laquelle le complexe de métal est un complexe de métal du groupe 4.

6. Composition de catalyseur de la revendication 4, dans laquelle le rapport molaire du complexe de métal à l'activateur est de 0,1/1 à 2/1.
7. Composition de catalyseur de la revendication 4, comprenant en outre une matière support sous la forme d'une matière solide particulière.

8. Composition de catalyseur de la revendication 7, dans laquelle le complexe de métal est :

   le (tert-butylamido)(tétraméthylcyclopentadiényle)-diméthysilanetitane diméthyle,
   le (tert-butylamido)tétraméthylcyclopentadiényle)-diméthysilanetitane 1,3-pentadiène,
   le (tert-butylamido)(2-méthyl-s-indacén-1-yl)-diméthysilanetitane 1,3-pentadiène,
   le (tert-butylamido)(3-(N-pyrrolidiny)indén-1-yl)-diméthysilanetitane 1,3-pentadiène,
   le (tert-butylamido)(3,4-cyclopenta(/)phénanthren-2-yl(diméthysilanetitane 1,4-diphényl-1,3-butadiène,
   le (diméthylsilyl-bis-2-méthyl-4-phénylindényl)-zirconium diméthyle, ou
   le (diméthylsilyl-bis-2-méthyl-4-phénylindényl)-zirconium 1,4-diphényl-1,3-butadiène.

9. Procédé de polymérisation d'un ou plusieurs monomères polymérisables par addition comprenant la mise en contact de ces derniers, facultativement en présence d'un hydrocarbure aliphatique, alicyclique ou aromatique inerte, avec la composition de catalyseur selon la revendication 4.

10. Procédé selon la revendication 9, dans lequel une ou plusieurs alpha-oléfines comportant de 2 à 20 000 atomes de carbone sont polymérisées.

11. Procédé selon la revendication 9, qui est une polymérisation en phase gazeuse d'une ou plusieurs α-oléfines en C₂₋₈.

12. Procédé selon la revendication 9, qui est une polymérisation en suspension épaisse d'une ou plusieurs oléfines en C₂₋₈.