METALLOCENE COMPOUNDS, CATALYSTS COMPRISING THEM, PROCESS FOR PRODUCING AN OLEFIN POLYMER BY USE OF THE CATALYSTS, AND OLEFIN HOMO- AND COPOLYMERS

BACKGROUND

1. Field of the Invention

The present invention relates to novel metallocene compounds useful as components in polymerization catalysts, to catalysts comprising such metallocene compounds, to a process for the polymerization of olefins and to particularly propylene, and olefin homopolymers, random, and impact copolymers prepared by using the metallocene catalysts.

2. Background of the Art

One of the most important factors determining the success of a catalyst is its versatility, that is the possibility to use it for the broadest possible range of products. For a long time, the limitations for the development of metallocene catalysts for polypropylene has been their inability to produce propylene-ethylene copolymers of high molar mass, due to the fact that ethylene behaves as a chain transfer agent with most metallocenes. This effect has been observed for all basic metallocene structures, such as the syndiospecific C_s symmetric $Me_2C(Cp)(Flu)ZrCl_2$, the aspecific C_{2v} symmetric $Me_2Si(Flu)_2ZrCl_2$, and both the C_2 symmetric rac-$Me_2C(3\text{-}iPr\text{-}Ind)_2ZrCl_2$ and the fluxional $(2\text{-}Ph\text{-}Ind)_2ZrCl_2$ catalysts for elastomeric polypropylene. This effect has also been found for the isospecific C_2 symmetric rac-$Me_2Si(2\text{-}Me\text{-}4,5\text{-}Benz\text{-}Ind)_2ZrCl_2$ and rac-$Me_2Si(2\text{-}Me\text{-}4\text{-}Ph\text{-}Ind)_2ZrCl_2$ [L. Resconi, C. Fritze, "Metallocene Catalysts for Propylene Polymerization" In Polypropylene Handbook (N. Pasquini, Ed.), ch. 2.2, Hanser Publishers, Munic 2005]. While the 2-Me substitution of this catalyst family suppresses the β-hydrogen transfer to the propylene monomer and thus prevents the formation of low molar mass polymer, it fails to prevent the β-hydrogen transfer to the ethylene comonomer in case of the latter's presence. This β-hydrogen

transfer to the ethylene comonomer becomes the favored chain termination mechanism and leads to the formation of low molar mass propylene-ethylene copolymers [A. Tynys et al., Macromol. Chem. Phys. 2005, vol. 206, pp. 1043-1056: "Ethylene-Propylene Copolymerizations: Effect of Metallocene Structure on Termination Reactions and Polymer Microstructure"]. Exceptions have been found in some zirconocenes with highly bulky ligands, such as rac-Me_2C(3-tBu-Ind)$_2ZrCl_2$, which show a marked increase in molar masses by ethylene incorporation. This catalyst, however, has shortcomings in terms of homopolymer molar mass and activity.

Another key requirement of a metallocene catalyst is its capability to produce polypropylene with a high melting point. This is equivalent with a catalyst that has a very high stereospecificity and regioselectivity. Within the rac-Alk_2Si(2-Alk-Ind)$_2ZrCl_2$ catalyst family, the stereospecificity and regioselectivity has continuously been improved during the last 15 years. EP-A1 834 519 relates to metallocenes of the rac-Me_2Si(2-Me-4-Ar-Ind)$_2ZrCl_2$ for the production of high rigid, high Tm polypropylenes with very high stereoregularity and very low amounts of regio errors. Although not tested for their copolymerization performance, the metallocenes disclosed in EP-A1 834 519 anticipated substitution patterns in 2-position that would later be identified as particularly suitable for the production of propylene/ethylene random copolymers when combined with additional substituents in certain positions. However, the highly stereo- and regio regular polypropylenes were not obtained under commercially relevant process conditions and suffered from too low activity/productivity levels.

US-A1 2001/0053833 discloses metallocenes having substituents in 2-position consisting of an unsubstituted heteroaromatic ring or a heteroaromatic ring having at least one substituent bonded to the ring. Such catalysts afford C3/C2 copolymers with reasonably high molar mass, but fail to produce high Tm homopolymers under conditions typical for commercial scale production, i. e. on a support and at temperatures from 60 deg C and higher. Also, the productivities of this catalyst family are unsatisfactory.

WO 01/058970 relates to impact copolymers having a high melting point and a high rubber molar mass, produced by catalysts comprising metallocenes of the rac-Me_2Si(2-Alk-4-Ar-Ind)$_2ZrCl_2$ family. High molar masses in the propylene/ethylene rubber were achieved when both Alk substituents were i-propyl groups. WO 02/002576 discloses bridged metallocenes of the (2-R-4-Ph-Ind)$_2ZrCl_2$ family having particular combinations of substituents in the 2-positions of the indenyl ligands and the Ph substituents. A high PP melting point is favored if the Ph group exhibits a substitution pattern in the 3 and 5 positions, particularly in case of butyl substituents. A combination of high homopolymer melting point and high copolymer molar mass is achieved if both substituents R in 2-position are isopropyl groups. The major shortcoming is the very low activity/productivity of the rac-Me_2Si(2-R-4-Ar-Ind)$_2ZrCl_2$ catalysts if both ligands R are branched in the α-position. WO 03/002583 discloses bridged metallocenes of the (2-R-4-Ph-Ind)$_2ZrCl_2$ family having particular combinations of substituents in the 2-positions of the indenyl ligands and the 4-Ph substituents. A high PP melting point is favored if the Ph group exhibits a substitution pattern in the 2-position, particularly in case of biphenyl substituents. A combination of high homopolymer melting point and high copolymer molar mass is achieved if both substituents R in 2-position of the indenyl ligand are isopropyl groups. One major shortcoming is the very low activity/productivity of the rac-Me_2Si(2-R-4-Ar-Ind)$_2ZrCl_2$ catalysts if both ligands R are branched in the α-position. Moreover, the highest possible molar masses of the homopolymers produced by using such catalysts are relatively low which corresponds to relatively high melt flow rates. This, in turn excludes such metallocenes from catering applications such as pipe, blown film, cast film and injection stretch blow molding.

EP-A2 1 250 365, WO 97/40075 and WO 03/045551 relate to metallocenes having substituents in the 2-positions of either of the indenyl ligands with the imperative that at least one of the ligands in 2-position is branched or cyclicized in the α-position. WO 04/106351 relates to metallocenes having subsitutents in the 2-positions of the indenyl ligands with the proviso that one ligand is unbranched or

bound via an sp^2-hybridized carbon atom and the other ligand is branched in the α-position. Such catalysts afford high Tm homopolymers and high molar mass propylene/ethylene copolymers. However, there still are limitations with regard to catalyst activity/productivity and lowest achievable homopolymer melt flow rate.

In summary, the main deficiency of supported catalyst systems comprising metallocenes of the above mentioned prior art, is that so far no catalyst has been found that, when used for the homopolymerization of propylene, affords isotactic polypropylene with a high melting point and very high molar mass (or very low melt flow rate) and that, when used for the copolymerization of propylene with ethylene, affords high molar mass propylene/ethylene copolymers, all at very high catalyst productivity. As a consequence, when compared to Ziegler/Natta catalysts, the industrial usefulness of these catalysts is limited because certain applications that require a combination of a high melting point, a very low melt flow rate, and/or a high molar mass copolymer or copolymer component, such as in impact copolymers, are not available at cost competitive productivities.

The object of the present invention is to address this shortcoming of the state of the art metallocene compounds and to provide metallocenes that afford high melting point, high molar mass homopolymers and high molar mass copolymers at high productivities when used as components of supported catalysts under industrially relevant polymerization conditions at temperatures of from 50 °C to 100 °C.

Another objective of the present invention is to provide a process for the polymerization of olefins, particularly propylene, ethylene, and optionally one or more higher 1-olefins.

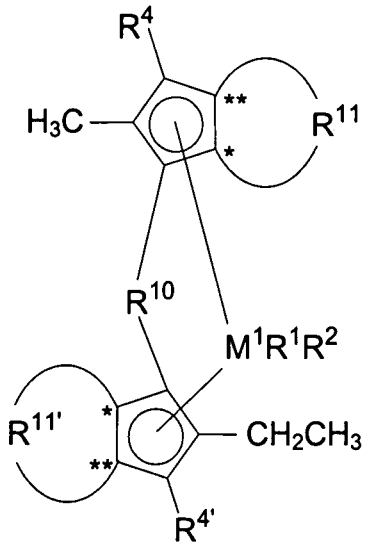
Furthermore, it is an objective of the present invention to provide olefin polymers, particularly propylene homopolymers, random copolymers of propylene with ethylene and/or higher 1-olefins, impact copolymers comprised of propylene, ethylene and/or optionally higher 1-olefins, and random impact copolymers comprised of propylene, ethylene and/or optionally higher 1-olefins.

SUMMARY

Certain metallocene compounds are provided that, when used as a component in a supported polymerization catalyst under industrially relevant polymerization conditions, afford high molar mass homo polymers or copolymers like polypropylene or propylene/ethylene copolymers without the need for any α-branched substituent in either of the two available 2-positions of the indenyl ligands. The substituent in the 2-position of one indenyl ligand is a methyl group and the substituent in the 2-position of the other indenyl ligand is an ethyl group. This metallocene topology affords high melting point, very high molar mass homo polypropylene and very high molar mass propylene-based copolymers. Furthermore, the activity/productivity levels of catalysts comprising the metallocenes of the present invention are exceptionally high. While various metallocenes are disclosed, for example, in U.S. Publication No. 2006/0116490, the improvement in olefin polymerization achieved by the metallocene topology of the present invention is both new and unexpected.

Accordingly, provided herein is a process for olefin polymerization comprising:

contacting one or more olefin with a catalyst system under polymerization reaction conditions, wherein said catalyst system includes at least one metallocene component of the general Formula 1 below,



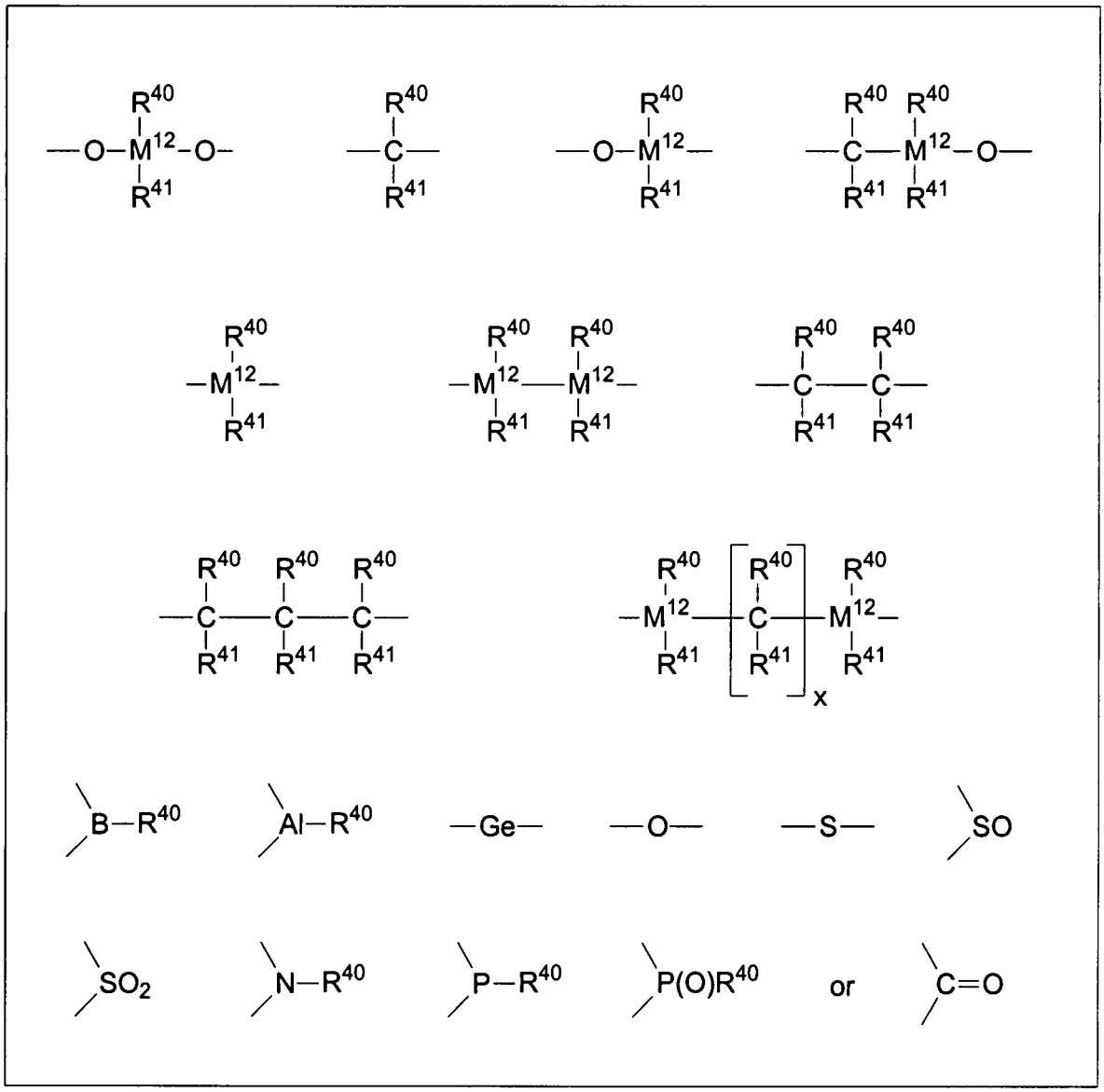
(Formula 1)

where M^1 is a metal of Group IVb of the Periodic Table of the Elements,

R^1 and R^2 are identical or different and are each a hydrogen atom, an alkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an OH group, a halogen atom, or a NR_2^{32} group, where R^{32} is an alkyl group of from 1 to about 10 carbon atoms or an aryl group of from 6 to about 14 carbon atoms and R^1 and R^2 may form one or more ring system(s),

R^4 and $R^{4'}$ are each a hydrogen atom,

R^{10} is a bridging group wherein R^{10} is selected from:



where

R^{40} and R^{41}, even when bearing the same index, can be identical or different and are each selected from the group consisting of a hydrogen atom, an alkyl group having from 1 to about 30 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, a fluoroalkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, a substituted or unsubstituted alkylsilyl, alkyl(aryl)silyl or

arylsilyl group and an arylalkenyl group of from 8 to about 40 carbon atoms or wherein R^{40} and R^{41} together with the atoms connecting them form one or more cyclic systems or wherein R^{40} and/or R^{41} contain additional hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, Cl and Br,

x is an integer from 1 to 18,

M^{12} is silicon, germanium or tin, and

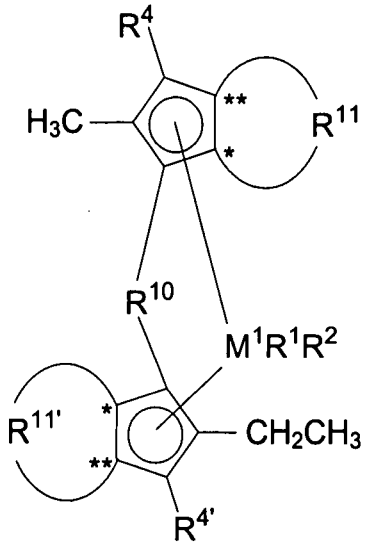
R^{10} may also link two units of the formula 1 to one another, and

R^{11} and $R^{11'}$ are identical or different and are each a divalent C_2-C_{40} group which together with the cyclopentadienyl ring forms a further saturated or unsaturated ring system having a ring size of from 5 to 7 atoms, with or without heteroatoms selected from the group consisting of Si, Ge, N, P, O and S within the ring system fused onto the cyclopentadienyl ring, and wherein the symbols * and ** denote chemical bonds joining R^{11} and $R^{11'}$ to the cyclopentadienyl ring.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

We have found that this object is achieved by a supported catalyst system comprising at least one specifically substituted and bridged metallocene, at least one cocatalyst, at least one support and, if desired, at least one metal compound and further one additive component. According to the present invention, the catalyst system is prepared by mixing at least one specifically substituted and bridged metallocene, at least one cocatalyst, at least one support and if desired at least one metal compound and one further additive component.

The first embodyment of the invention relates to a specifically substituted, bridged metallocene component of the general Formula 1 below,



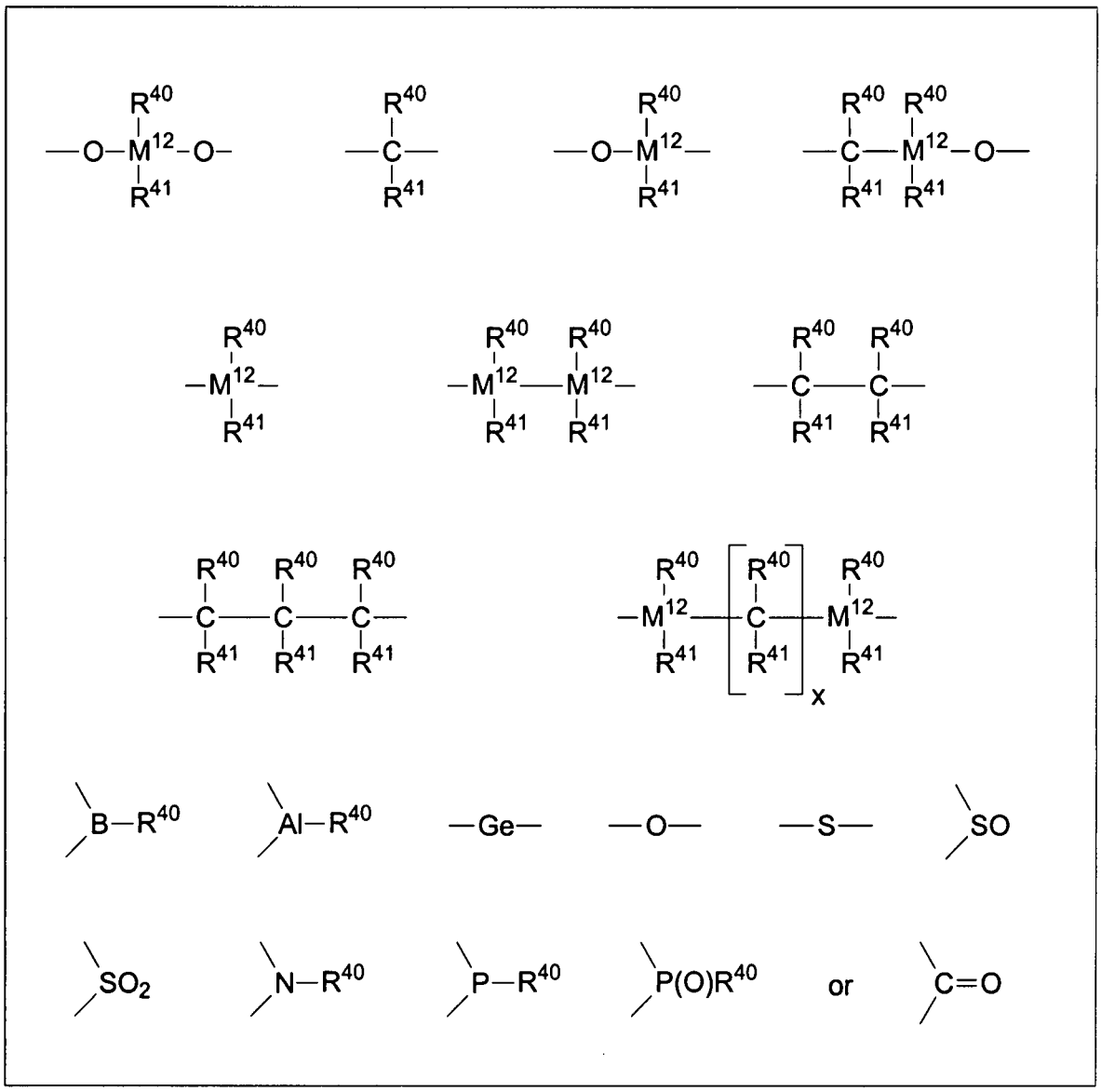
(Formula 1)

where M^1 is a metal of Group IVb of the Periodic Table of the Elements, preferably Zirconium or Hafnium, and particularly preferably Zirconium.

R^1 and R^2 are identical or different and are each a hydrogen atom, an alkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an OH group, a halogen atom, or a NR_2^{32} group, where R^{32} is an alkyl group of from 1 to about 10 carbon atoms or an aryl group of from 6 to about 14 carbon atoms and R^1 and R^2 may form one or more ring system(s). Preferably, R^1 and R^2 are identical or different and are an alkyl group of from1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms or a halogen atom, or R^1 and R^2 together may form one or more ring system(s). Particularly preferably, R^1 and R^2 are identical or different and are methyl, chlorine or phenolate.

R^4 and $R^{4'}$ are each a hydrogen atom,

R^{10} is a bridging group wherein R^{10} is selected from:



where

R^{40} and R^{41}, even when bearing the same index, can be identical or different and are each a hydrogen atom, a C_1-C_{40} group such as an alkyl group having from 1 to about 30 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, a fluoroalkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, a substituted or unsubstituted alkylsilyl, alkyl(aryl)silyl or arylsilyl

group,or an arylalkenyl group of from 8 to about 40 carbon atoms. R^{40} and R^{41} together with the atoms connecting them can form one or more cyclic systems or R^{40} and/or R^{41} can contain additional hetero atoms (i.e., non-carbon atoms) like Si, B, Al, O, S, N or P or halogen atoms like Cl or Br,

x is an integer from 1 to 18,

M^{12} is silicon, germanium or tin, and

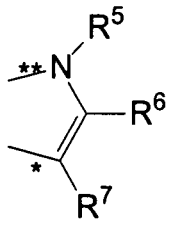
R^{10} may also link two units of the formula 1 to one another,

Preferably, R^{10} is $R^{40}R^{41}Si=$, $R^{40}R^{41}Ge=$, R^{40} $R^{41}C=$ or $-(R^{40}R^{41}C-CR^{40}R^{41})-$, where R^{40} and R^{41} are identical or different and are each a hydrogen atom, a hydrocarbon group of from 1 to about 30 carbon atoms, in particular an alkyl group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 14 carbon atoms, an alkylaryl group of from 7 to about 14 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl or an arylsilyl group.

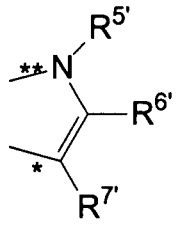
Particularly preferably, the bridging unit R^{10} is $R^{40}R^{41}Si=$ or $R^{40}R^{41}Ge=$, where R^{40} and R^{41} are identical or different and are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, cyclopentyl, cyclopentadienyl, cyclohexyl, phenyl, naphthyl, benzyl, trimethylsilyl or 3,3,3-trifluoropropyl.

R^{11} and $R^{11'}$ are identical or different and are each a divalent C_2-C_{40} group which together with the cyclopentadienyl ring forms a further saturated or unsaturated ring system having a ring size of from 5 to 7 atoms, where R^{11} and $R^{11'}$ may contain the heteroatoms Si, Ge, N, P, O or S within the ring system fused onto the cyclopentadienyl ring. Preferably, the groups R^{11} and $R^{11'}$ are identical or different and are each a divalent group selected from those given in Formulae 1 $\alpha, \beta, \gamma, \delta, \phi$, and ν and Formulae 1 $\alpha', \beta', \gamma', \delta', \phi'$, and ν', respectively. The asterisks "*" and "**" in Formula 1 and Formulae 1 α–ν and 1 α'-ν', repectively, denote the chemical bonds joining R^{11} and $R^{11'}$ to the cyclopentadienyl rings. For illustration, if R^{11} is represented by Formula 1γ and $R^{11'}$ is represented by Formula

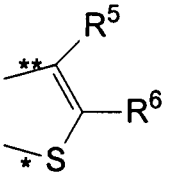
1γ', then the structure given in Formula 1a (see below) is obtained. Particularly preferably, R^{11} and $R^{11'}$ are identical or different and R^{11} is a divalent group according to Formula 1γ and $R^{11'}$ is selected from the divalent groups in Formulae 1α', β', and γ' or R^{11} and $R^{11'}$ are identical or different and are divalent groups according to Formula 1α and 1α' or Formula 1β and 1β' or Formula 1γ and 1γ' or Formula 1δ and 1δ' or Formula 1ϕ and 1ϕ' or Formula 1ν and 1ν', respectively.



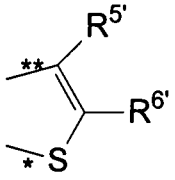
Formula 1α



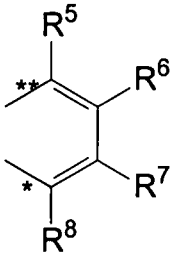
Formula 1α'



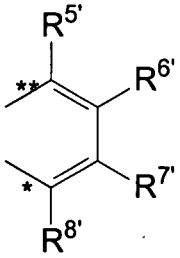
Formula 1β



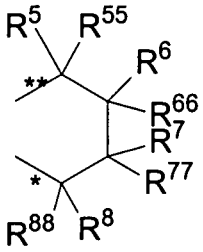
Formula 1β'



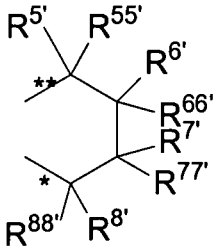
Formula 1γ



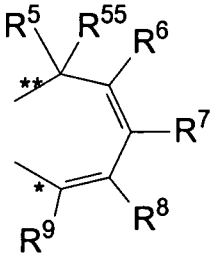
Formula 1γ'



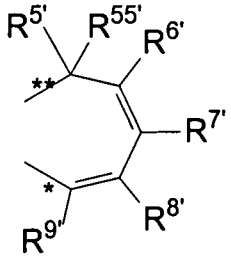
Formula 1δ



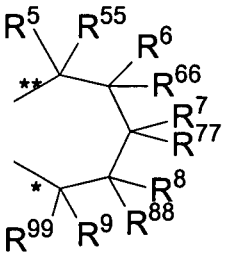
Formula 1δ'



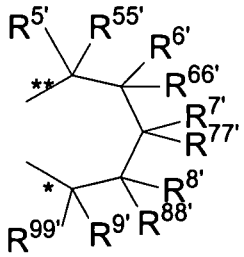
Formula 1ϕ



Formula 1ϕ'



Formula 1ν



Formula 1ν'

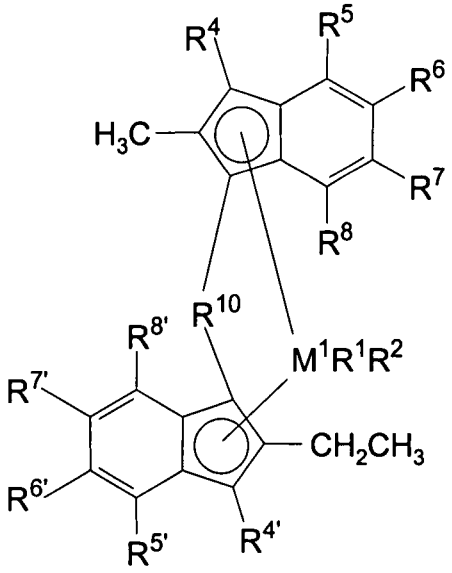
R^5, R^6, R^7, R^8, and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ as well as R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 2 to about 20 carbon atoms, an alkenyl group of from 2 to about 20 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group. Two adjacent radicals R^5, R^6 or $R^{5'}$, $R^{6'}$ or R^6, R^7 or $R^{6'}$, $R^{7'}$ or R^7, R^8 or $R^{7'}$, $R^{8'}$ or R^8, R^9 or $R^{8'}$, $R^{9'}$ as well as R^{55}, R^{66} or $R^{55'}$, $R^{66'}$ or R^{66},

R^{77} or $R^{66'}$, $R^{77'}$ or R^{77}, R^{88} or $R^{77'}$, $R^{88'}$ or R^{88}, R^{99} or $R^{88'}$, $R^{99'}$ in each case may form a saturated or unsaturated hydrocarbon ring system. The groups may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br.

Preferably, R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are each a hydrogen atom and R^5, R^6, R^7, R^8 and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms, which may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br. The two adjacent radicals R^5/R^6 and also $R^{5'}/R^{6'}$ may form a hydrocarbon ring system or R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

Particularly preferably, R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are each a hydrogen atom and R^5, R^6, R^7, R^8 and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms. The two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ together may form a ring system or R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

Preferably, the specifically substituted, bridged metallocene component of the first embodyment of the invention is as given in Formula 1a below.



Formula 1a

M^1, R^1, R^2, R^4, $R^{4'}$ and R^{10} have the meaning set forth above with respect to Formula 1.

For the substituents R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ of Formula 1a, there are two equitable sustitution patterns.

In the first substitution pattern, R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 1 to about 20 carbon atoms, an alkenyl group of from 2 to about 20 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group. The groups may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br, and / or two adjacent radicals R^5, R^6 or R^6, R^7 or R^7, R^8 and also $R^{5'}$, $R^{6'}$ or $R^{6'}$, $R^{7'}$ or $R^{7'}$, $R^{8'}$ in each case may form a hydrocarbon ring system.

Preferably, R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms, which may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br, and / or the two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ may form a saturated or unsaturated hydrocarbon ring system.

Particularly preferably, R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms and / or the two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ together may form a saturated or unsaturated ring system.

In the second substitution pattern, R^6, R^7, R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 1 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group. Two adjacent radicals R^6, R^7 or R^7, R^8 as well as $R^{6'}$, $R^{7'}$ or $R^{7'}$, $R^{8'}$ in each case may form a hydrocarbon ring system. The groups may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br. R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms. They may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br.

Preferably, R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms,

or an aryl group of from 6 to about 10 carbon atoms, which may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br. R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

Particularly preferably, R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms. R^5 and $R^{5'}$ are identical or different and are each naphthyl, 4-(C_1-C_{10}-alkyl)phenyl or 4-(C_6-C_{20}-aryl)phenyl such as 4-methyl-phenyl, 4-biphenyl, 4-ethyl-phenyl, 4-n-propyl-phenyl, 4-isopropyl-phenyl, 4-tert-butyl-phenyl, 4-sec-butyl-phenyl, 4-cyclohexyl-phenyl, 4-trimethylsilyl-phenyl, 4-adamantyl-phenyl, 4-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_1-C_{10}-alkyl)-phenyl, 3-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_6-C_{20}-aryl)phenyl like 3-biphenyl, 3,5-di-(C_1-C_{10}-alkyl)-phenyl such as 3,5-dimethyl-phenyl, 3,5-di-(C_1-C_{10}-fluroalkyl)-phenyl, such as 3,5-di(trifluoromethyl)-phenyl or 3,5-(C_6-C_{20}-aryl)phenyl like 3,5-terphenyl.

Very particularly preferred metallocenes of formula 1a are compounds, where:

M1 is Zirconium,

R^1 and R^2 are identical and are methyl, chlorine or phenolate,

R^4 and $R^{4'}$ are hydrogen,

R^{10} is $R^{40}R^{41}Si=$ or $R^{40}R^{41}Ge=$, where R^{40} and R^{41} are identical or different and are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, cyclopentyl, cyclopentadienyl, cyclohexyl, phenyl, naphthyl, benzyl, trimethylsilyl or 3,3,3-trifluoropropyl, and

R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms.

R^5 and $R^{5'}$ are identical and are naphthyl, 4-(C_1-C_{10}-alkyl)phenyl or 4-(C_6-C_{20}-aryl)phenyl such as 4-methyl-phenyl, 4-biphenyl, 4-ethyl-phenyl, 4-n-propyl-phenyl, 4-isopropyl-phenyl, 4-tert-butyl-phenyl, 4-sec-butyl-phenyl, 4-cyclohexyl-

phenyl, 4-trimethylsilyl-phenyl, 4-adamantyl-phenyl, 4-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_1-C_{10}-alkyl)-phenyl, 3-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_6-C_{20}-aryl)phenyl like 3-biphenyl, 3,5-di-(C_1-C_{10}-alkyl)-phenyl such as 3,5-dimethyl-phenyl, 3,5-di-(C_1-C_{10}-fluroalkyl)-phenyl, such as 3,5-di(trifluoromethyl)-phenyl or 3,5-(C_6-C_{20}-aryl)phenyl like 3,5-terphenyl.

Non-limiting examples for the very particularly preferred metallocene compounds according to Formula 1a are given below:

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-indenyl][2-methyl-4-(2-naphthyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-indenyl][2-methyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-indenyl][2-methyl-4-(4-biphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-indenyl][2-methyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-indenyl][2-methyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-indenyl][2-methyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-indenyl][2-methyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-indenyl][2-methyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-indenyl][2-methyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-indenyl][2-methyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-indenyl][2-methyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-indenyl][2-methyl-4-(3-biphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-indenyl][2-methyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl][2-methyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-indenyl][2-methyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-indenyl][2-methyl-4-(2-naphthyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-indenyl][2-methyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-indenyl][2-methyl-4-(4-biphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-indenyl][2-methyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-indenyl][2-methyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-indenyl][2-methyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-indenyl][2-methyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-indenyl][2-methyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-indenyl][2-methyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-indenyl][2-methyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-indenyl][2-methyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-indenyl][2-methyl-4-(3-biphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-indenyl][2-methyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl][2-methyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-indenyl][2-methyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride;

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride;

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride;

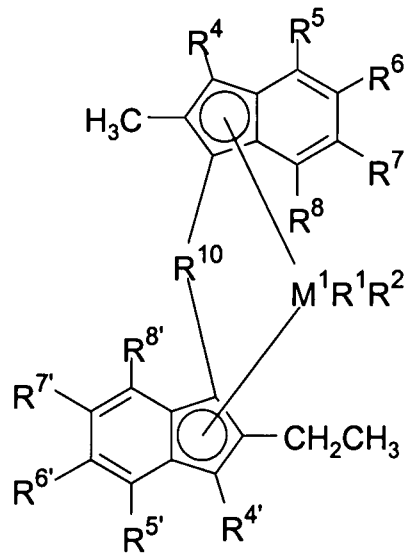
Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

as well as the analogous zirconiumdimethyl-compounds and zirconium-biphenolates and zirconium-bisphenolates.

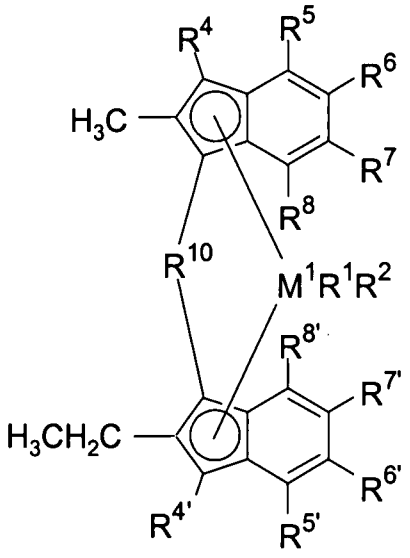
Instead of the preferred pure chiral bridged racemic or pseudoracemic

metallocene compounds of formulas 1 and 1a, mixtures of the metallocenes of formulas 1 and 1a and the corresponding meso or pseudomeso metallocenes may be used in the catalyst preparation. However, the preparation of the isomerically pure racemic form is especially preferred for the use of metallocenes in the polymerization of olefins to isotactic polyolefins, since the corresponding meso form may produce undesired atactic polypropylene ("PP"). The "isomerically pure" racemic form is understood to mean a rac:meso ratio of greater than 5:1 preferably of at least 10:1, more preferred of at least 15:1 and most preferred of at least 20:1.

As used herein the term "racemic" (or "rac") includes "pseudoracemic" (or "pseudorac"), and the term "meso" includes "pseudomeso."



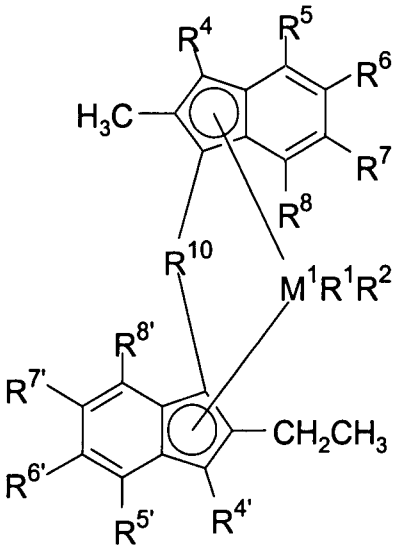
rac/pseudoracemic isomer



meso/pseudomeso isomer

The present invention also includes a process for producing the transition-metal compounds of formulas 1 and 1a of the invention.

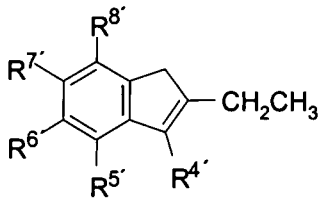
An object of the invention is thus a process for producing compounds of formula 1a,



(Formula 1a)

in which the variables R and M^1 have the meaning specified above, including the preferred embodiments, comprising the steps of:

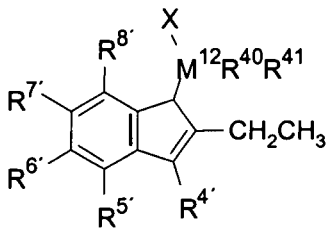
a) Deprotonation of the compound of formula 2:



(Formula 2)

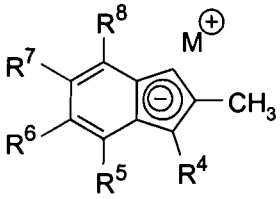
with a base, in which $R^{4'}$, $R^{5'}$, $R^{6'}$, $R^{7'}$, and $R^{8'}$ have the meaning specified above.

b) If R^{10} has the meaning $M^{12}R^{40}R^{41}$, then the further production proceeds by the reaction of the deprotonated compounds from step (a) with $R^{40}R^{41}M^{12}X_2$ to form the compound of formula 3, where R^{40}, R^{41}, and M^{12} have the meanings specified above, and X may be the same or different and means a halogen atom, preferably chlorine, bromine, or iodine, or another leaving group, preferably triflate, tosylate, or mesylate.



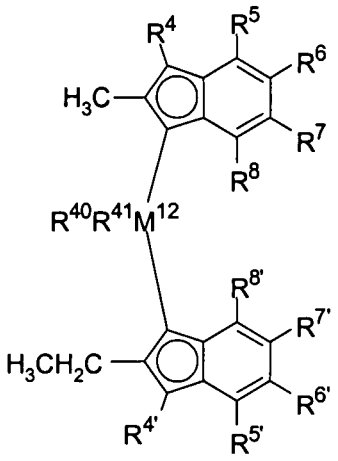
(Formula 3)

c) After the production of chlorosilane indenes or chlorogermane indenes of formula 3, these are reacted with a metal-indene compound of formula 4



(Formula 4)

in which M stands for Li, Na, or K, and R^4, R^5, R^6, R^7, and R^8 have the meanings specified above, to obtain the compound of formula 5.



(Formula 5)

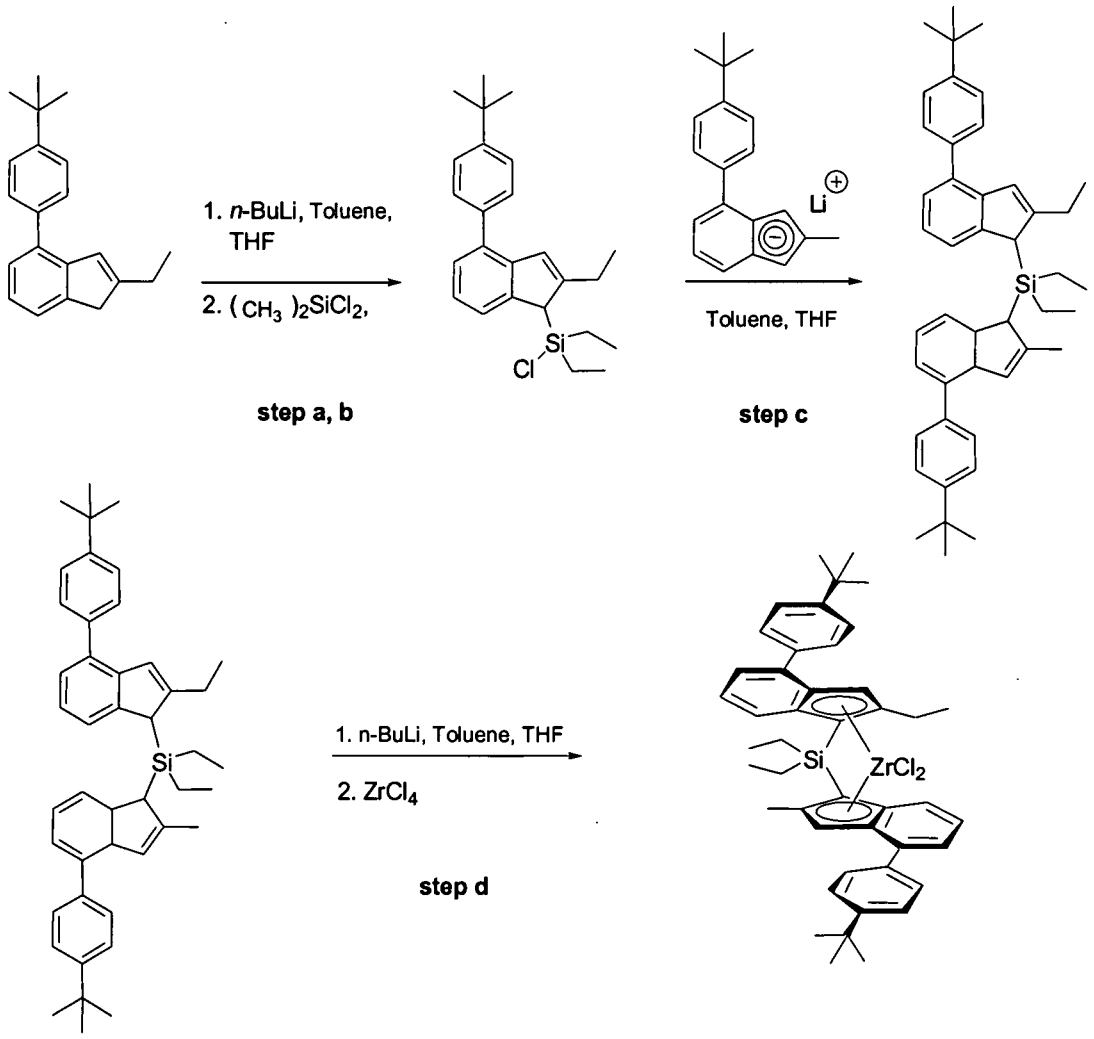
d) Reaction of the compound of formula 5 with a base and addition of M^1Cl_4, in which M^1 stands for zirconium, titanium, or hafnium, to form the compound of formula 1a.

In step (a), the compound of formula 2, for example, 2-(ethyl)-7-(4'-*tert*-butylphenyl)indene in an inert solvent, which consists of one or more aromatic or aliphatic hydrocarbons and/or one or more polar, aprotic solvents, is deprotonated with a strong base, for example, *n*-butyllithium. The deprotonation is carried out at temperatures of –70°C to 80°C, and preferably 0°C to 80°C. The resulting metal salt is then reacted directly, without further isolation, in step (b) with a silicon compound or germanium compound that contains two leaving groups. Compounds of formula 3 are reacted in step (c) with a metal-indenyl compound of formula 4 and compounds of formula 5 are formed. In the following step (d), the bis(indenyl)silanes of formula 5 are doubly deprotonated with a strong base, such as *n*-butyllithium, in an inert solvent, which consists of one or more aromatic or aliphatic hydrocarbons and/or one or more polar, aprotic solvents, and the bislithium salt formed in this way is reacted, without isolation, directly with a source of Ti, Zr, or Hf to obtain the compound of formula 1a. The deprotonation is carried out at temperatures of –70°C to 80°C, and preferably 0°C to 80°C. Depending on

the nature of the ligand system of formula 5, the metallocenes are isolated directly from the reaction mixture with rac:meso ratios or pseudo-rac:meso ratios of greater than 5:1 preferably of at least 10:1, more preferred of at least 15:1 and most preferred of at least 20:1 or further rac:meso separation steps have to be applied to reach rac:meso ratios or pseudo-rac:meso ratios of at least 5:1 preferably of at least 10:1, more preferred of at least 15:1 and most preferred of at least 20:1 to obtain a suitable catalyst.

In the following diagram 1, the individual steps of the process of the invention for producing transition-metal compounds of formulas 1a are shown once again for the example of a preferred embodiment.

Diagram 1



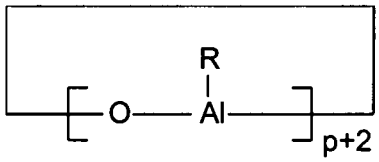
In addition, the present invention relates to a catalyst system comprising at least one compound of formulas 1 or 1a and at least one cocatalyst.

A suitable cocatalyst component which may be present according to the present invention in the catalyst system comprises at least one compound of the type of an aluminoxane, a Lewis acid or an ionic compound which reacts with a metallocene to convert the latter into a cationic compound.

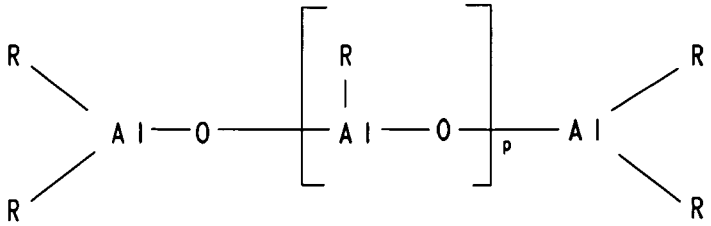
Aluminoxanes are oligomeric or polymeric aluminum oxy compounds, which may exist in the form of linear, cyclic, caged or polymeric structures. Although the exact structure(s) of aluminoxanes is still unknown, it is well accepted that alkylaluminoxanes have the general formula 6.

$(R\text{-}Al\text{-}O)_p$ (Formula 6).

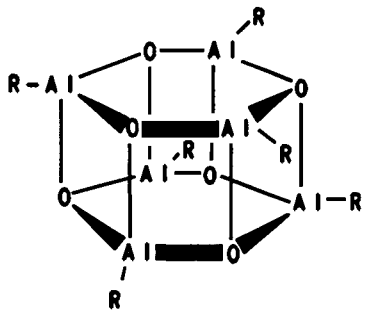
Examples for cyclic, linear or cage structures of aluminoxanes are depicted in the formulas 7, 8 and 9:



(Formula 7)



(Formula 8)



(Formula 9)

The radicals R in the formulas (6), (7), (8) and (9) can be identical or different and are each a C_1 -C_{20} group such as an alkyl group of from 1 to about 6 carbon atoms, an aryl group of from 6 to about 18 carbon atoms, benzyl or hydrogen and p is an integer from 2 to 50, preferably from 10 to 35.

Preferably, the radicals R are identical and are methyl, isobutyl, n-butyl, phenyl or benzyl, particularly preferably methyl.

If the radicals R are different, they are preferably methyl and hydrogen, methyl and isobutyl or methyl and n-butyl, with hydrogen, isobutyl or n-butyl preferably being present in a proportion of from 0.01 to 40% (number of radicals R).

The aluminoxane can be prepared in various ways by known methods. One of the methods comprises the reaction of an aluminum-hydrocarbon compound and/or a hydridoaluminum-hydrocarbon compound with water, which may be gaseous, solid, liquid or bound as water of crystallization, in an inert solvent such as toluene. To prepare an aluminoxane having different alkyl groups R, two different trialkylaluminums (AlR_3 +AlR'_3) corresponding to the desired composition and reactivity are reacted with water, cf. S. Pasynkiewicz, Polyhedron 9 (1990) 429 and EP-A-0 302 424.

Regardless of the method of preparation, all aluminoxane solutions have in common a variable content of unreacted aluminum starting compound which is present in free form or as an adduct.

Furthermore, instead of the aluminoxane compounds of the formulas 6, 7, 8 or 9, it is also possible to use modified aluminoxanes in which the hydrocarbon radicals or hydrogen atoms have been partly replaced by alkoxy, aryloxy, siloxy or amide radicals.

The amounts of aluminoxane and metallocene used in the preparation of the supported catalyst system can be varied within a wide range. However, it has been found to be advantageous to use the metallocene compound of formulas 1 or 1a and the aluminoxane compounds in such amounts that the atomic ratio of aluminum from the aluminoxane compounds to the transition metal from the metallocene compound is in the range from 10:1 to 1000:1, preferably from 20:1 to 500:1 and in particular in the range from 30:1 to 400:1. In the case of methylaluminoxane, preference is given to using ≥ 30% strength toluene solutions, but the use of 10% strength solutions is also possible.

As Lewis acid, preference is given to using compounds of the formula 10

$$M^2X^1X^2X^3 \quad \text{(Formula 10)}$$

where M^2 is an element of Group 13 of the Periodic Table of Elements, in particular B, Al or Ga, preferably B or Al,

X^1, X^2 and X^3 are the same or different and each are a hydrogen atom, an alkyl group of from 1 to about 20 carbon atoms, an aryl group of from 6 to about 15 carbon atoms, alkylaryl, arylalkyl, haloalkyl or haloaryl each having from 1 to 10 carbon atoms in the alkyl radical and from 6-20 carbon atoms in the aryl radical or fluorine, chlorine, bromine or iodine. Preferred examples for X^1, X^2 and X^3 are methyl, propyl, isopropyl, isobutyl or trifluoromethyl, unsaturated groups such as aryl or haloaryl like phenyl, tolyl, benzyl groups, p-fluorophenyl, 3,5-difluorophenyl,

pentachlorophenyl, pentafluorophenyl, 3,4,5-trifluorophenyl and 3,5-di(trifluoromethyl)phenyl.

Preferred Lewis acids are trimethylaluminum, triethylaluminum, triisobutylaluminum, tributylaluminum, trifluoroborane, triphenylborane, tris(4-fluorophenyl)borane, tris(3,5-difluorophenyl)borane, tris(4-fluoromethylphenyl)borane, tris(2,4,6-trifluorophenyl)borane, tris(penta-fluorophenyl)borane, tris(tolyl)borane, tris(3,5-dimethyl-phenyl)borane, tris(3,5-difluorophenyl)borane and/or tris (3,4,5-trifluorophenyl)borane.

Particular preference is given to tris(pentafluorophenyl)borane.

As ionic cocatalysts, preference is given to using compounds which contain a non-coordinating anion such as tetrakis(pentafluorophenyl)borate, tetraphenylborate, SbF_6^-, $CF_3SO_3^-$ or ClO_4^-. Suitable counterions are either Lewis acid or Broenstedt acid cation.

As Broensted acids, particular preference is given to protonated amine or aniline derivatives such as methylammonium, anilinium, dimethylammonium, diethylammonium, N-methylanilinium, diphenylammonium, N,N-dimethylanilinium, trimethylammonium, triethylammonium, tri-n-butylammonium, methyldiphenylammonium, pyridinium, p-bromo-N,N-dimethylanilinium or p-nitro-N,N-dimethylanilinium,

Suitable Lewis-acid cations are cations of the formula 11

$$[(Y^{a+})Q_1Q_2...Q_z]^{d+} \quad \text{(Formula 11)}$$

where Y is an element of Groups 1 to 16 of the Periodic Table of the Elements,

Q_1 to Q_z are singly negatively charged groups such as C_1-C_{28}-alkyl, C_6-C_{15}-aryl, alkylaryl, arylalkyl, haloalkyl, haloaryl each having from 6 to 20 carbon atoms in the aryl radical and from 1 to 28 carbon atoms in the alkyl radical, cycloalkyl groups of from 3 to about 10 carbon atoms, which may in turn bear alkyl groups of from 1 to about 10 carbon atoms as substitutents, halogen, alkoxy

groups of from 1 to 28 carbon atoms, aryloxy groups of from 6 to 15 carbon atoms, silyl or mercaptyl groups.

a is an integer from 1-6,

z is an integer from 0 to 5 and

d corresponds to the difference a-z, but d is larger than or equal to 1

Particulary suitable cations are carbonium cations such as triphenylcarbenium, oxonium cations, sulfonium cations such as tetrahydrothiophenium, phosphonium cations such as triethylphosphonium, triphenylphosphonium and diphenylphosphonium, and also cationic transition metal complexes such as the silver cation and the 1,1'-dimethylferrocenium cation.

Preferred ionic compounds which can be used according to the present invention include:

triethylammoniumtetra(phenyl)borate,

tributylammoniumtetra(phenyl)borate,

trimethylammoniumtetra(tolyl)borate,

tributylammoniumtetra(tolyl)borate,

tributylammoniumtetra(pentafluorophenyl)borate,

tributylammoniumtetra(pentaffluorophenyl) aluminate,

tripropylammoniumtetra(dimethylphenyl)borate,

tributylammoniumtetra(trifluoromethylphenyl)borate,

tributylammoniumtetra(4-fluorophenyl)borate,

N,N-dimethylcyclohexylammoniumtetrakis(pentafluorophenyl)borate,

N,N-dimethylbenzylammoniumtetrakis(pentafluorophenyl)borate

N,N-dimethylaniliniumtetra(phenyl)borate,

N,N-diethylaniliniumtetra(phenyl)borate,

N,N-dimethylaniliniumtetrakis(pentafluorophenyl)borate,

N,N-dimethylaniliniumtetrakis(pentafluorophenyl)aluminate,

di(propyl)ammoniumtetrakis(pentafluorophenyl)borate,

di(cyclohexyl)ammoniumtetrakist(pentafluorophenyl)borate,

triphenylphosphoniumtetrakis(phenyl)borate,

triethylphosphoniumtetrakis(phenyl)borate,

diphenylphosphoniumtetrakis(phenyl)borate,

tri(methylphenyl)phosphoniumtetrakis(phenyl)borate,

tri(dimethylphenyl)phosphoniumtetrakis(phenyl)borate,

triphenylcarbeniumtetrakis(pentafluorophenyl)borate,

triphenylcarbeniumtetrakis(pentafluorophenyl)aluminate,

triphenylcarbeniumtetrakis(phenyl)aluminate,

ferroceniumtetrakis(pentafluorophenyl)borate and/or

ferroceniumtetrakis(pentafluorophenyl)aluminate,

Preference is given to triphenylcarbeniumtetrakis(pentafluorophenyl) borate, N,N-dimethylcyclohexylammoniumtetrakis(pentafluorophenyl)borate or N,N-dimethylbenzylammoniumtetrakis(pentafluorophenyl)borate.

It is also possible to use mixtures of all of the above and below mentioned cation-forming compounds. Preferred mixtures comprise aluminoxanes and an ionic compound, and/or a Lewis acid.

Other useful cocatalyst components are likewise borane or carborane compounds such as

7,8-dicarbaundecaborane(13),

undecahydrido-7,8-dimethyl-7,8-dicarbaundecaborane,

dodecahydrido-1-phenyl-1,3-dicarbanonaborane,

tri(butyl)ammoniumun decahydrido-8-ethyl-7,9-dicarbaundecaborate,

4-carbanonaborane(14),

bis(tri(butyl)ammonium)nonaborate,

bis(tri(butyl)ammonium)undecaborate,

bis(tri(butyl)ammonium)dodecaborate,

bis(tri(butyl)ammonium)decachlorodecaborate,

tri(butyl)ammonium-1-carbadecaborate,

tri(butyl)ammonium-1-carbadodecaborate,

tri(butyl)ammonium-1-trimethylsilyl-1-carbadecaborate,

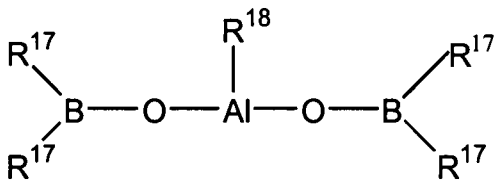
tri(buyl)ammoniumbis(nonahydrido-1, 3-dicarbanonaborato)cobaltate(III),
tri(butyl)ammonium bis(undecahydrido-7,8-dicarbaundecaborato)ferrate(III).

The amount of Lewis acids or ionic compounds having Lewis–acid or Broensted-acid cations is preferably from 0.1 to 20 equivalents, preferably from 1 to 10 equivalents, based on the metallocene compound of the formulas 1 or 1a.

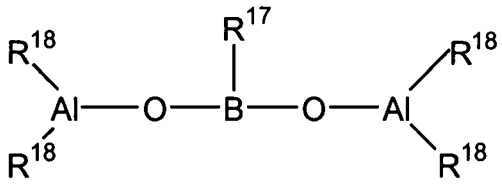
Combinations of at least one Lewis base with bimetallic compounds of the type $R_i^{17}M^3(\text{-O-}M^3R_j^{18})_v$ or $R_i^{18}M^3(\text{-O-}M^3R_j^{17})_v$ (formula 12), as described in Patent Application WO 99/40,129, are likewise important as cocatalyst systems.

In this regard, R^{17} and R^{18} are the same or different and represent a hydrogen atom, a halogen atom, a C_1-C_{40} carbon-containing group, especially an alkyl group of from 1 to about 20 carbon atoms, haloalkyl of from 1 to about 20 carbon atoms, alkoxy of from 1 to about 10 carbon atoms, aryl of from 6 to about 20 carbon atoms, haloaryl of from 6 to about 20 carbon atoms, aryloxy of from 6 to about 20 carbon atoms, arylalkyl of from 7 to about 40 carbon atoms, haloarylalkyl of from 7 to about 40 carbon atoms, alkylaryl of from 7 to about 40 carbon atoms, or haloalkylaryl of from 7 to about 40 carbon atoms. R^{17} may also be an $-OSiR^{51}_3$ group, in which the R^{51} groups are the same or different and have the same meaning as R^{17}, M^3 is the same or different and represents an element of main group III of the periodic table of elements, i, j, and v each stands for a whole number 0, 1, or 2, and i + j + v is not equal to 0.

Preferred cocatalyst systems are the compounds of formulas (A) and (B)



(A)



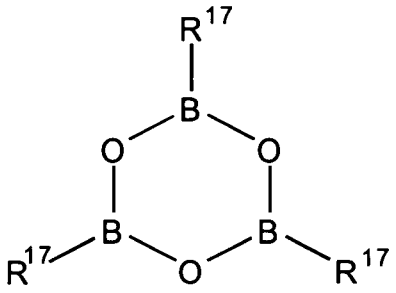
(B)

where R^{17} and R^{18} have the same meaning as specified above.

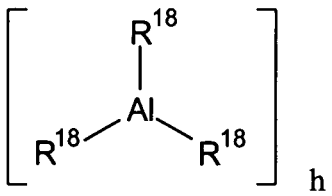
Furthermore, compounds that are generally to be regarded as preferred are those formed by the reaction of at least one compound of formulas (C) and/or (D) and/or (E) with at least one compound of formula (F).

$$R_f^{17}B\text{-}(DR^{27})_g \qquad (C)$$

$$R_2^{17}B\text{-}D\text{-}BR^{17}{}_2 \qquad (D)$$



(E)



(F)

in which

R^{27} may be a hydrogen atom or a boron-free C_1-C_{40} carbon-containing group, such as an alkyl of from 1 to about 20 carbon atoms, aryl of from 6 to about

20 carbon atoms, arylalkyl of from 7 to about 40 carbon atoms, and alkylaryl of from 7 to about 40 carbon atoms, and in which R^{17}, R^{18} have the same meaning as specified above,

D is an element of main Group VI of the periodic table of elements or an NR^{61} group, where R^{61} is a hydrogen atom or a C_1-C_{20} hydrocarbon group, such as alkyl of from 1 to about 20 carbon atoms or aryl of from 6 to about 20 carbon atoms,

f is a whole number from 0 to 3,

g is a whole number from 0 to 3 where f + g corresponds to the valency of Boron, and

h is a whole number from 1 to 10.

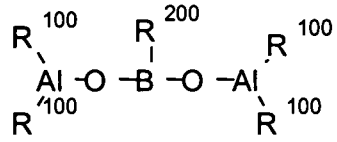
The bimetallic compounds of formula 12 are possibly combined with an organometallic compound of formula 13, i.e., $[M^4R^{19}_q]_k$, in which M^4 is an element of main Group I, II, or III of the periodic table of the elements, R^{19} is the same or different and represents a hydrogen atom, a halogen atom, a C_1-C_{40} carbon-containing group, an alkyl group of from 1 to about 20 carbon atoms, an aryl group of from about 6 to about 40 carbon atoms, arylalkyl of from 7 to about 40 carbon atoms, and alkylaryl of from 7 to about 40 carbon atoms, q is a whole number from 1 to 3, and k is a whole number from 1 to 4.

The organometallic compounds of formula 13 are preferably neutral Lewis acids, in which M^4 stands for lithium, magnesium, and/or aluminum, especially aluminum. Examples of preferred organometallic compounds of formula 13 are trimethylaluminum, triethylaluminum, triisopropylaluminum, trihexylaluminum, trioctylaluminum, tri-*n*-butylaluminum, tri-*n*-propylaluminum, triisoprene aluminum, dimethyl aluminum monochloride, aluminum monochloride, diisobutyl aluminum monochloride, methyl aluminum sesquichloride, ethyl aluminum sesquichloride, dimethyl aluminum hydride, aluminum hydride, diisopropyl aluminum hydride, dimethyl aluminum(trimethylsiloxide), dimethyl aluminum(triethylsiloxide), phenylalan, pentafluorophenylalan, and *o*-tolylalan.

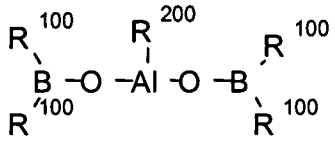
The catalyst system of the invention contains an organoboroaluminum

compound, which contains units of formula 12, as the cocatalytically active chemical compound. Compounds of formula 12 in which M^3 stands for boron or aluminum are preferred. The compounds that contain units of formula 12 may be present as monomers or as linear, cyclic, or cage-like oligomers. Two or more chemical compounds that contain units of formula 12 may also form dimers, trimers, or higher combinations among themselves by Lewis acid-base interactions.

Preferred cocatalytically active bimetallic compounds correspond to formulas 14 and 15,



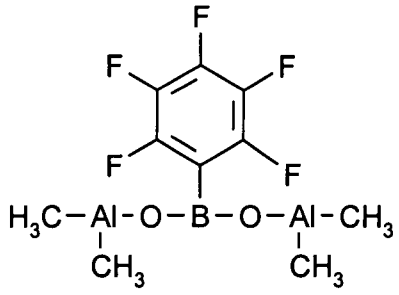
(formula 14)

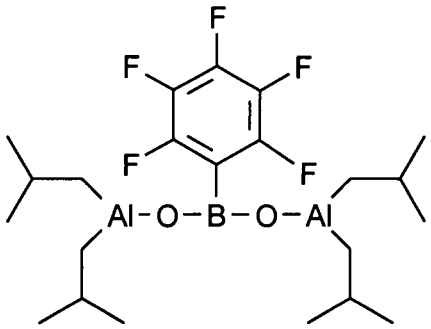


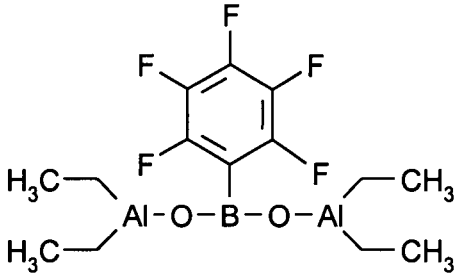
(formula 15)

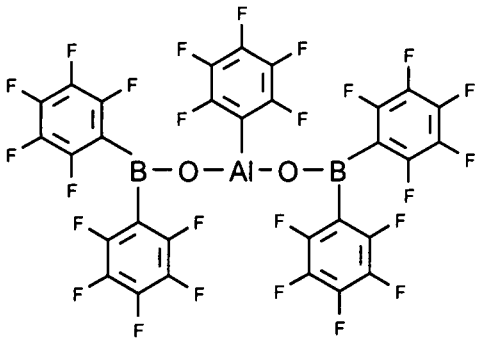
in which R^{100} and R^{200} have the same meaning as the substituents R^{17} and R^{18} in formula 12.

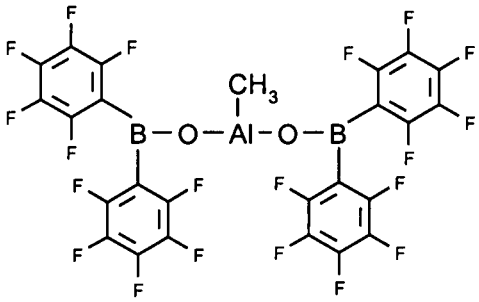
Examples of the cocatalytically active compounds of formulas 14 and 15 are

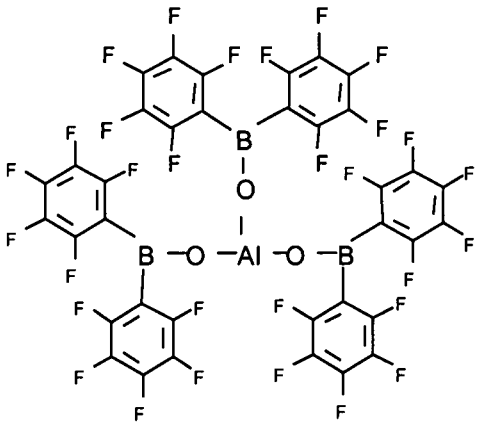












The compounds named in EP-A-924,223, DE 196 22 207.9, EP-A-601,830, EP-A-824,112, EP-A-824,113, WO 99/06,414, EP-A-811,627, WO 97/11,775, DE 196 06 167.9 and DE 198 04 970 can preferably be used as additional cocatalysts, which may be present in unsupported or supported form.

The amount of cocatalysts of formula 12 and/or 14 and/or 15 used in the catalyst of the present invention can vary from 0.1 to 500 equivalents, preferably from 1 to 300 equivalents, most preferably from 5 to 150 equivalents, based on the used amount of metallocene compound of the formulas 1 or 1a.

The catalyst system of the present invention can further comprise, as additional component, a metal compound of the formula 16,

$$M^5(R^{22})_r(R^{23})_s(R^{24})_t \qquad \text{(Formula 16)}$$

wherein

M^5 is an alkali, an alkali earth metal or a metal of Group 13 of the Periodic Table of the Elements,

R^{22} is a hydrogen atom, alkyl of from 1 to about 10 carbon atoms, aryl of from 6 to about 15 carbon atoms, or alkylaryl or

arylalkyl each having from 1 to 10 carbon atoms in the alkyl part and from 6 to 20 carbon atoms in the aryl part,

R^{23} and R^{24} are each a hydrogen atom, a halogen atom, alkyl of from 1 to about 10 carbon atoms, C_6-C_{15}-aryl of from about 6 to about 15 carbon atoms, or alkylaryl, arylalkyl or alkoxy each having from 1 to 10 carbon atoms in the alkyl part and from 6 to 20 carbon atoms in the aryl radical,

r is an integer from 1 to 3 and s and t are integers from 0 to 2, where the sum r+s+t corresponds to the valency of M^5,

where this component is not identical with the above mentioned cocatalyst compounds. It is also possible to use mixtures of various metal compounds of the formula 16.

Among the metal compounds of the formula 16 preference is given to those in which M^5 is lithium, magnesium or aluminum and R^{23} and R^{24} are each alkyl of from 1 to about 10 carbon atoms. Particularly preferred metal compounds of the formula 16 are n-butyllithium, n-butyl-n-octyl-magnesium, n-butyl-n-heptylmagnesium, tri-n-hexylaluminum, triisobutylaluminum, triethylaluminum, trimethylaluminum or mixtures thereof.

If a metal compound of the formula 16 is used, it is preferably present in the catalyst system in such an amount that the molar ratio of M^5 to the transition metal from the metallocene compound of formulas 1 or 1a is from 800:1 to 1:1, in particular from 200:1 to 2:1.

The support component of the catalyst system of the present invention can be any organic or inorganic inert solid or a mixture of such solids, in particulate porous solids such as hydrotalcites, talc, inorganic oxides and finely divided polymer powders.

Suitable inorganic oxides, which are preferably employed include from the Periodic Table of Elements Groups 1, 2, 3, 4, 5, 12, 13 and 14 metal oxides such as silicon dioxide, aluminum oxide, aluminosilicates, zeolites, MgO, ZrO_2, TiO_2 or B_2O_3, CaO, ZnO, ThO_2, Na_2O, K_2O, LiO_2 or mixed oxides like Al/Si oxides, Mg/Al

oxides or Al/Mg/Si oxides. Other suitable inorganic support materials are Na_2CO_3, K_2CO_3, $CaCO_3$, $MgCl_2$, Na_2SO_4, $Al_2(SO_4)_3$, $BaSO_4$, KNO_3, $Mg(NO_3)_2$ and $Al(NO_3)_3$.

Suitable polymer powders are homopolymers, copolymers, crosslinked polymers or polymer blends. Examples of such polymers are polyethylene, polypropylene, polybutene, polystyrene, divinylbenzene-crosslinked polystyrene, polyvinyl chloride, acrylonitrile-butadiene-styrene copolymer, polyamide, polymethacrylate, polycarbonate, polyester, polyacetal or polyvinyl alcohol.

The preferred support materials have a specific surface area in the range from 10 to 1000 m^2/g, a pore volume in the range from 0.1 to 5 cm^3/g and a mean particle size of from 1 to 500 µm. Preference is given to supports having a specific surface area in the range from 50 to 500 m^2/g, a pore volume in the range from 0.5 to 3.5 cm^3/g and a mean particle size in the range from 5 to 250 µm. Particular preference is given to supports having a specific surface area in the range from 200 to 400 m^2/g, a pore volume in the range from 0.8 to 3.0 cm^3/g and a mean particle size of from 10 to 100 µm.

The support materials can be thermally and/or chemically be pretreated in order to adjust certain properties of the carrier such as the water and/or the hydroxyl group content.

If the support material has a low moisture content or residual solvent content, dehydration or drying before use can be omitted. If this is not the case, as when using silica gel as support material, dehydration or drying is advisable. Thermal dehydration or drying of the support material can be carried out under reduced pressure with or without simultaneous inert gas blanketing (nitrogen). The drying temperature is in the range from 80 °C to 1000 °C, preferably from 150 °C to 800 °C and most preferred from 150 °C to 400 °C. The duration of the drying process can be from 1 to 24 hours. But shorter or longer drying periods are also possible.

In a preferred embodiment of the present invention, support materials with a weight loss on dryness (LOD) of 0.5 wt.% or less, and even more preferred with a LOD of 0.3 wt% or less are used. Higher amounts of physically adsorbed water up

to 1 wt% are possible, but result in reduced catalyst activities. The loss on ignition (LOI) of the support material is preferably 1 wt% or greater or even more preferred between 1.5 and 3.5 wt%. The weight loss on dryness (LOD) is thereby defined as the weight loss between room temperature and 300°C and the weight loss on ignition (LOI) as the weight loss between 300°C and 1000°C.

In addition or alternatively, dehydration or drying of the support material can also be carried out by chemical means, by reacting the adsorbed water and/or the surface hydroxyl groups with suitable passivating agents. Reaction with the passivating reagent can convert the hydroxyl groups completely or partially into a form, which does not show any adverse interaction with the catalytically active centers. Suitable passivating agents are silicon halides, silanes or amines, eg. silicon tetrachloride, chlorotrimethylsilane, dichlorodialkylsilanes, dimethylaminotrichlorosilane, N,N-dimethylanilin or N,N-dimethylbenzylamine or organometallic compounds of aluminum, boron and magnesium, eg. aluminoxanes, trimethylaluminum, triethylaluminum, triisobutylaluminum, diisobutylaluminum hydride, triethylborane or dibutylmagnesium.

As outlined above, organic support materials such as finely divided polymer powders, can also be used and should, before use, likewise be freed from any adhering moisture, solvent residues or other impurities by means of appropriate purification and drying operations.

Preference is given to using silica gels having the defined parameters as support materials. Spray dried silica grades, which inherently exhibit meso and macro pores, cavities and channels are preferred over granular silica grades.

The supported catalyst system according to this invention can be made in various ways.

In one embodiment of the present invention, at least one of the above-described metallocene components of formulas 1 or 1a is brought into contact in a suitable solvent with at least one cocatalyst component, preferably giving a soluble reaction product, an adduct or a mixture. The obtained composition is mixed with

the dehydrated or passivated support material, the solvent is removed and the resulting supported metallocene catalyst system is dried to ensure that the solvent is completely or mostly removed from the pores of the support material. The supported catalyst is obtained as a free-flowing powder.

As an example, the process for preparing a free-flowing and, if desired, prepolymerized supported catalyst system comprises the following steps:

a) preparing a metallocene/cocatalyst mixture in a suitable solvent or suspension medium, where the metallocene component has one of the above-described structures,

b) applying the metallocene/cocatalyst mixture to a porous, preferably inorganic, if necessary thermally or chemically pretreated support,

c) removing the major part of solvent from the resulting mixture,

d) isolating the supported catalyst system and

e) if desired, prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

In another embodiment of this invention the metallocene / cocatalyst composition is mixed with the dehydrated or passivated support material, the supported catalyst is recovered and optionally washed with an aromatic hydrocarbon and/or paraffinic hydrocarbon solvent. The isolated catalyst is then dispersed in a non-reactive suspension media such as a paraffinic hydrocarbon solvent, a mineral oil or a wax or mixtures thereof.

In a further embodiment of this invention the catalyst is prepared according to the procedure disclosed in WO 06/60544 (U.S. Patent No. 7,169,864), WO 00/05277 (U.S. Patent No. 6,812,185) and WO 98/01481 (U.S. Patent No. 6,265,339).

As an example, in WO 06/60544, a free flowing and, if desired, prepolymerized supported catalyst system is prepared comprising the following steps:

a) contacting at least one support material with a first portion of at least one co-catalyst in a suitable solvent

b) impregnating the co-catalyst loaded support with a suspension or solution, which comprises at least one metallocene and a second portion of at least one co-catalyst in a suitable solvent

c) isolating the supported catalyst system and

f) if desired, prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

Thus, as an example, the process according to WO 06/60544 for preparing a free-flowing and, if desired, prepolymerized supported catalyst system comprises the following steps:

a) Contacting a support material with a first composition which includes at least one aluminoxane in a first solvent at a temperature of about 10 to 30°C followed by keeping the mixture at about 20°C for 0 to 12 hours, subsequently heating the resulting mixture to a temperature of 30 to 200°C and keeping the mixture at 30 to 200°C for 30 minutes to 20 hours, optionally followed by removing all or part of the first solvent and/or optionally followed by one or more washing step(s) using a suitable solvent,

b) Suspending and/or dissolving, respectively, at least one metallocene of formula 1 and/or 1a and a second portion of an aluminoxane or of a mixture of aluminoxanes or of an ionic compound and/or a Lewis acid in a second solvent or suspension medium at a temperature of 0 to 100°C, optionally followed by a preactivation time of 1 minute to 200 hours at a temperature of 10 to 100°,

c) Applying the mixture prepared in b) to the aluminoxane loaded support material produced in a), at a temperature of 10 to 100°C and a contact time of 1 minute to 24 hours,

d) Removing the major part of the solvent from the resulting mixture and optionally washing the resulting supported catalyst with a suitable solvent,

e) Isolating the supported catalyst system and

f) Optionally prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

More specifically, as an example, the process according to WO 06/60544 for preparing a free-flowing and, if desired, prepolymerized supported catalyst system comprises the following steps:

a) Contacting a support material with a first composition which includes at least 5 mmol of an aluminoxane or of a mixture of aluminoxanes per g support material in a first solvent at a temperature of about 20°C followed by keeping the mixture at about 20°C for 0.15 to 2 hours, subsequently heating the resulting mixture to a temperature of 50 to 160°C and keeping the mixture at 50 to 160°C for 1 to 6 hours, optionally followed by removing all or part of the first solvent and/or optionally followed by one or more washing step(s) using a suitable solvent,

b) Suspending and/or dissolving, respectively, at least 0.5 mmole of a second portion of an aluminoxane or of a mixture of aluminoxanes per g support material and at least 0.1 mol% of the employed second portion of an aluminoxane or of a mixture of aluminoxanes per g support material of at least one metallocene of formula 1 and/or 1a in a second solvent or suspension medium at a temperature of 20 to 50°C, optionally followed by a preactivation time of 1 minute to 200 hours at a temperature of 20 to 30°,

c) Applying the mixture prepared in b) to the aluminoxane loaded support material produced in a), at a temperature of 10 to 100°C and a contact time of 1 minute to 24 hours,

d) Removing the major part of the solvent from the resulting mixture and

e) Optionally washing the resulting supported catalyst with a suitable solvent,

and/or drying the resulting supported catalyst at temperatures of 30 to 60°C,

and

f) Optionally prepolymerizing the resulting supported catalyst system with

one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

In a preferred embodiment, as an example, the process according to WO 06/60544 for preparing a free-flowing and, if desired, prepolymerized supported catalyst system comprises the following steps:

a) Contacting an optionally thermally pretreated silica support material with at least 10 mmol of an aluminoxane per g support material in toluene at a temperature of about 20°C followed by subsequently heating the resulting mixture to a temperature of 50 to 110°C and keeping the mixture at 50 to 110°C for 1 to 6 hours, optionally followed by removing all or part of the toluene, and/or optionally followed by one or more washing step(s) using a suitable solvent,

b) Suspending and/or dissolving, respectively, at least 0.5 mmole of a second portion of an aluminoxane per g support material and at least 0.1 mol% of the employed second portion of an aluminoxane or of a mixture of aluminoxanes per g support material of at least one metallocene of formula 1 and/or 1a in toluene at a temperature of 20 to 50°C, optionally followed by a preactivation time of 1 minute to 200 hours at a temperature of 20 to 30°,

c) Applying the mixture prepared in b) to the aluminoxane loaded support material produced in a), at a temperature of 10 to 100°C and a contact time of 1 minute to 24 hours,

d) Removing the major part of the toluene from the resulting mixture and

e) Optionally washing the resulting supported catalyst with a suitable solvent,

and/or drying the resulting supported catalyst at temperatures of 30 to 60°C,

and

f) Optionally prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

In a more preferred embodiment, as an example, the process according to WO 06/60544 for preparing a free-flowing and, if desired, prepolymerized supported catalyst system comprises the following steps:

a) Contacting an optionally thermally pretreated silica support material with a weight loss on dryness (LOD) of 0.5 wt.% or less and a weight loss on ignition (LOI) of 1.0 wt.% or greater with a first composition which includes at least 10 mmol of methylaluminoxane per g support material in toluene at a temperature of about 20°C followed by subsequently heating the resulting mixture to a temperature of 110°C and keeping the mixture at 110°C for 1 to 6 hours, optionally followed by removing all or part of the toluene, and/or optionally followed by one or more washing step(s) using a suitable solvent,

b) Suspending and/or dissolving, respectively, at least 1 mmole of a second portion of methylaluminoxane per g support material and at least 0.1 mol% of the employed second portion of methylaluminoxane per g support material of at least one metallocene of formula 1 and/or 1a in toluene at a temperature of 20 to 50°C, optionally followed by a preactivation time of 1 minute to 200 hours at a temperature of 20 to 30°,

c) Applying the mixture prepared in b) to the methylaluminoxane loaded support material produced in a), by passing the impregnation suspension or solution b) through the methylaluminoxane loaded support material in a direct flow or by using an incipient wetness impregnation technique, where the volume of the impregnation suspension or solution or the total liquid volume used in the impregnation step, respectively, does not exceed 250% of the total pore volume of the support material, at a temperature of 10 to 100°C and a contact time of 1 minute to 24 hours,

d) Removing the major part of the toluene from the resulting mixture and

e) Optionally washing the resulting supported catalyst with a suitable solvent,

and/or drying the resulting supported catalyst at temperatures of 30 to 60°C,

and

f) Optionally prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

In a particular preferred embodiment, as an example, the process according to WO 06/60544 for preparing a free-flowing and, if desired, prepolymerized supported catalyst system comprises the following steps:

a) Contacting an optionally thermally pretreated silica support material with a weight loss on dryness (LOD) of 0.3 wt.% or less and a weight loss on ignition (LOI) between 1.5 and 3.5 wt.%, with at least 10 mmol of methylaluminoxane per g support material in toluene at a temperature of about 20°C followed by subsequently heating the resulting mixture to a temperature of 110°C and keeping the mixture at 110°C for 1 to 6 hours, optionally followed by removing all or part of the toluene, and/or optionally followed by one or more washing step(s) using a suitable solvent,

b) Suspending and/or dissolving, respectively, at least 1 mmole of a second portion of methylaluminoxane per g support material and at least 0.1 mol% of the employed second portion of methylaluminoxane per g support material of at least one metallocene of formula 1a in toluene at a temperature of 20 to 50°C, optionally followed by a preactivation time of 1 minute to 200 hours at a temperature of 20 to 30°,

c) Applying the mixture prepared in b) to the methylaluminoxane loaded support material produced in a), by passing the impregnation suspension or solution b) through the aluminoxane loaded support material a) in a direct flow or by using an incipient wetness impregnation technique, where the volume of the impregnation suspension or solution or the total liquid volume used in the impregnation step, respectively, does not exceed 250% of the total pore volume of the support material, at a temperature of 10 to 100°C and a contact time of 1 minute to 24 hours,

d) Removing the major part of the toluene from the resulting mixture and

e) Optionally washing the resulting supported catalyst with a suitable solvent,

and/or drying the resulting supported catalyst at temperatures of 30 to 60°C,

and

f) Optionally prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

According to the present invention, for preparing a free-flowing and, if desired, prepolymerized supported catalyst system, in step b) of the catalyst preparations as mentioned above, instead of an aluminoxane or a mixture of aluminoxanes, at least one alkyl compound of elements of main Groups I to III of the Periodic Table, for example a magnesium alkyl, a lithium alkyl or an aluminum alkyl like trimethylaluminum, triethylaluminum, triisobutyllaluminum, triisopropylaluminum, trihexylaluminum, trioctylaluminum, tri-*n*-butylaluminum, tri-*n*-propylaluminum, triisoprene aluminum, dimethyl aluminum monochloride, aluminum monochloride, diisobutyl aluminum monochloride, methyl aluminum sesquichloride, ethyl aluminum sesquichloride, dimethyl aluminum hydride, aluminum hydride, diisopropyl aluminum hydride, dimethyl aluminum(trimethylsiloxide), dimethyl aluminum(triethylsiloxide), phenylalan, pentafluorophenylalan, and *o*-tolylalan, can be used. Preferred aluminum alkyls are trimethylaluminum, triethylaluminum, triisobutyllaluminum.

In an even further embodiment of the present invention a free flowing and, if desired, prepolymerized supported catalyst system is prepared comprising the following steps:

a) preparing a trialkylaluminium/borinic acid mixture in a suitable solvent or suspension medium

b) applying the trialkylaluminium/borinic acid mixture to a porous, preferably inorganic, if necessary thermally or chemically pretreated support, which was prior

treated with a base such as N,N-diethylbenzylamine, N,N-dimethylbenzylamine, N-benzyldimethylamine, N-benzyldiethylamine, N-benzylbutylamine, N-benzyl tertbutylamine, N-benzylisopropylamine, N-benzylmethylamine, N-benzylethylamine, N-benzyl-1-phenylethylamine, N-benzyl-2-phenylethylamine, N,N-dimethylbenzylamine, N,N-diethylbenzylamine, N-methyl-N-ethylbenzylamine, N-methyldibenzylamine and N-ethyldi(benzyl)amine,

c) removing the major part of solvent from the resulting mixture to obtain a supported cocatalyst,

d) preparing a metallocene/supported cocatalyst mixture in a suitable solvent or suspension medium, where the metallocene component has one of the above-described structures,

e) isolating the supported catalyst system and

f) if desired, prepolymerizing the resulting supported catalyst system with one or more olefinic monomer(s), to obtain a prepolymerized supported catalyst system.

Preferred solvents for the preparation of the metallocene/cocatalyst mixture are hydrocarbons and hydrocarbon mixtures, which are liquid at the selected reaction temperature and in which the individual components preferably dissolve. The solubility of the individual components is, however, not a prerequisite as long as it is ensured that the reaction product of metallocene and cocatalyst components is soluble in the solvent selected. Suitable solvents are alkanes such as pentane, isopentane, hexane, isohexane, heptane, octane and nonane, cycloalkanes such as cyclopentane and cyclohexane and aromatics such as benzene, toluene, ethylbenzene and diethylbenzene. Very particular preference is given to toluene, heptane and ethylbenzene.

For a preactivation, the metallocene in the form of a solid is dissolved in a solution of the cocatalyst in a suitable solvent. It is also possible to dissolve the metallocene separately in a suitable solvent and subsequently to combine this solution with the cocatalyst solution. Preference is given to using toluene. The preactivation time is from 1 minute to 200 hours. The preactivation can take place

at room temperature of 25 °C. In individual cases, the use of higher temperatures can reduce the required preactivation time and give an additional increase in activity. Elevated temperatures in this case refer to a range from 25 °C to 100 °C.

The preactivated solution or the metallocene/cocatalyst mixture is subsequently combined with an inert support material, usually silica gel, which is in the form of a dry powder or as a suspension in one of the above mentioned solvents. The support material is preferably used as powder. The preactivated metallocene/cocatalyst solution or the metallocene/cocatalyst mixture can be either added to the initially charged support material, or else the support material can be introduced into the initially charged solution.

The volume of the preactivated solution or the metallocene/cocatalyst mixture can exceed 100% of the total pore volume of the support material used or else be up to 100% of the total pore volume.

The temperature at which the preactivated solution or the metallocene/cocatalyst mixture is brought into contact with the support material can vary within the range from 0 °C to 100 °C. However, lower or higher temperatures are also possible.

While the solvent is completely or mostly removed from the supported catalyst system, the mixture can be stirred and, if desired, also heated. Preferably, both the visible portion of the solvent and the portion in the pores of the support material are removed. The removal of the solvent can be carried out in a conventional way using reduced pressure and/or purging with inert gas. During the drying process, the mixture can be heated until the free solvent has been removed, which usually takes from 1 to 3 hours at a preferred temperature of from 30 °C to 60 °C. The free solvent is the visible portion of the solvent in the mixture. For the purposes of the present invention, residual solvent is the portion present in the pores.

As an alternative to the complete removal of the solvent, the supported catalyst system can also be dried until only a certain residual solvent content is left, with the free solvent having been completely removed. Subsequently, the

supported catalyst system can be washed with a low-boiling hydrocarbon such as pentane or hexane and dried again.

The supported catalyst system prepared according to the present invention can be used either directly for the polymerization of olefins or be prepolymerized with one or more olefinic monomers, with or without the use of hydrogen as molar mass regulating agent, prior to use in a polymerization process. The procedure for the prepolymerization of supported catalyst systems is described in WO 94/28034.

As additive, it is possible to add, during or after the preparation of the supported catalyst system, a small amount of an olefin, preferably an alpha-olefin such as styrene or phenyldimethylvinylsilane as activity-increasing component or an antistatic, as described in U.S. Patent Application Ser. No. 08/365,280. The molar ratio of additive to metallocene component of formulas 1 or 1a is preferably from 1:1000 to 1000:1, very particularly preferably from 1:20 to 20:1.

The present invention also provides a process for preparing a polyolefin by polymerization of one or more olefins in the presence of the catalyst system of the present invention comprising at least one transition metal component of the formulas 1 or 1a. For the purposes of the present invention, the term polymerization refers to both homopolymerization and copolymerization and the term copolymerization includes terpolymerisation or copolymerisation of more than three different monomers.

Preference is given to polymerizing olefins of the formula R^m-CH=CH-R^n, where R^m and R^n are identical or different and are each a hydrogen atom or a radical having from 1 to 20 carbon atoms, in particular from 1 to 10 carbon atoms, and R^m and R^n together with the atoms connecting them can form one or more rings.

Suitable olefins are 1-olefins, e.g., ethene, propene, 1-butene, 1-pentene, 1-hexene, 4-methyl-1-pentene or 1-octene, styrene, dienes such as 1,3-butadiene, 1,4-hexadiene, vinylnorbornene, norbornadiene, ethylnorbornadiene and cyclic olefins such as norbornene, tetracyclododecene or methylnorbornene. In the process of the present invention, preference is given to homopolymerizing

propene or ethene or copolymerizing propene with ethene and/or one or more 1-olefins having from 4 to 20 carbon atoms, eg. 1-butene or hexene, and/or one or more dienes having from 4 to 20 carbon atoms, eg. 1,4-butadiene, norbornadiene, ethylidenenorbornene or ethylnorbornadiene. Very suitable copolymers are ethene-propene copolymers, propene-1-pentene copolymers and ethene-propene-1-butene, ethene-propene-1-pentene or ethene-propene-1,4-hexadiene terpolymers.

The polymerization is carried out at from -60 °C to 300 °C, preferably from 50 °C to 200 °C, very particularly preferably from 50 °C to 95 °C. The pressure is from 0.5 to 2000 bar, preferably from 5 to 100 bar.

The polymerization can be carried out in solution, in bulk, in suspension or in the gas phase, continuously or batchwise, in one or more stages. As an example, impact copolymers are preferably produced in more than one stage. The homopolymer or random copolymer content of such a polymer can be produced in (a) first stage(s) and the copolymer rubber content can be produced in (a) consecutive stage(s).

The supported catalyst system prepared according to the present invention can be used as sole catalyst component for the polymerization of olefins or preferably in combination with at least one alkyl compound of elements of main Groups I to III of the Periodic Table, for example an aluminum alkyl, magnesium alkyl or lithium alkyl or an aluminoxane. The alkyl compound is added to the monomer or suspension medium and serves to free the monomer of substances, which can impair the catalytic activity. The amount of alkyl compound added depends on the quality of the monomers used.

To prepare olefin polymers having a broad or bimodal molecular weight distribution or a broad or bimodal melting range, it is recommended to use a catalyst system comprising two or more different metallocenes and/or two or more different cocatalysts. Alternatively two or more different catalyst systems of the present invention can be used as a mixture.

As molar mass regulator and/or to increase the activity, hydrogen is added

if required.

The catalyst system may be supplied to the polymerization system as a solid or in the form of a paste or suspension in a hydrocarbon or may be treated with inert components, such as paraffins, oils, or waxes, to achieve better metering. If the catalyst system is to be metered into the reactor together with the monomer to be polymerized or the monomer mixture to be polymerized, the mixing unit and the metering line are preferably cooled.

Furthermore, an additive such as an antistatic or an alcohol can be used in the process of the present invention, for example to improve the particle morphology of the olefin polymer. In general it is possible to use all antistatics which are suitable in olefin polymerization processes. It is preferred to dose the antistatic directly into the polymerization system, either together with or separately from the catalyst system used.

The polymers prepared using the catalyst systems of the present invention display an uniform particle morphology and contain no fines. No agglomerates or deposits are obtained in the polymerization using the catalyst system of the present invention.

The catalyst systems of the present invention give polymers such as polypropylene having high molecular weight and cover a broad range of stereospecificity and regiospecificity.

The copolymers which can be prepared using the catalyst system based on metallocenes of formula 1 or 1a of the present invention have a significantly higher molar mass compared to the prior art. At the same time, such copolymers can be prepared using the catalyst system of the present invention at a high productivity and at industrially relevant process parameters without deposit formation.

The polymers prepared by the process of the present invention are suitable, in particular, for producing products such as fibers, filaments, injection-molded parts, films, sheets, caps, closures, bottles or large hollow bodies such as pipes with excellent properties.

EXAMPLES

General Procedures

The preparation and handling of the organometallic compounds were carried out under argon using Schlenk techniques or in a glove box. All solvents were purged with argon and dried over molecular sieves before use.

The metallocenes produced were characterized by ^{1}H-NMR spectroscopy using a Bruker DMX 500 spectrometer, operating at 500 MHz using $CDCl_3$ as the solvent.

The polymers produced were characterized by ^{1}H-NMR, ^{13}C-NMR, DSC, GPC, TREF/ATREF, Melt Flow Rate and IR spectroscopy.

1. Gel Permeation Chromatography (GPC), determination of Mw and Mw/Mn

A Waters Alliance/GPCV2000 equipped with a refractometer, a triple capillary on-line viscometer (Waters Corporation, 34 Maple Street, Milford, Massachusetts, 01757 USA) and a light scattering detector PD 2040 (Precision Detectors Inc., 34 Williams Way, Bellingham, MA, USA) was used for the determination of the molar mass data of the samples. 0.05 wt% solutions of the samples in 1,2,4-trichlorobenzene were analyzed at a temperature of 145 °C using a Mixed B light scattering quality column (Polymer Labs 1110-6100LS) and a Mixed B guard column (Polymer Labs 1110-1120). Weight average molar mass (Mw) and the ratio of weight average molar mass to number average molar mass (Mw/Mn) were calculated using the Cumulative Matching % Broad Standard procedure that is available in the Waters Millenium 3.2 GPC software module.

2. NMR Spectroscopy

Samples were prepared by weighing 0.32 g of polymer into 2.5 ml of a 1,2,4-trichlorobenzene/deuterobenzene-d6 (4:1 volume) mixture. Samples were

heated to 125°C and mixed until a homogeneous solution was formed (typically 1-4 hours). Spectra were obtained at 120°C on a Varian Inova 500 instrument (Varian Inc., 3120 Hansen Way, Palo Alto, CA, 94304, USA) operating at a ^{13}C-spectrometer frequency of 125.7 MHz and using a 10 mm probe. Spectra were obtained using 5000 scans employing a π/2 pulse of 10.0 μs, a recycle delay of 10.0 s and an acquisition time of 2.5 s. Waltz-16 decoupling remained on throughout the pulse sequence to gain the signal to noise enhancement due to the effects of nOe. Spectra were processed with 1 Hz of line broadening. The mmmm peak in the methyl region of the spectrum was used as an internal chemical shift reference and was set to 21.85 ppm.

3. 3. Differential Scanning Calorimetry (DSC), determination of the polymer melting point Tm

DSC measurements were carried out using a Mettler Toledo DSC 822e (Mettler-Toledo Inc., 1900 Polaris Parkway, Columbus, OH, 43240, USA). 4 mg of sample were weighed into a standard aluminum pan and subjected to the following temperature schedule:

The samples were heated from room temperature to 220 °C at a heating rate of 20 °C/min, maintained at this temperature for 5 min, then cooled down to – 55 °C at a cooling rate of 20 °C/min, maintained at the same temperature for 5 min, then heated to 220 °C at a heating rate of 20 °C/min. The melting point was determined from the second heating run as the temperature where the main peak was observed in the curve.

4. Analytical TREF (ATREF)

The TREF experiment is carried out on a TREF system built from a modified Waters 2000CV instrument (Waters Corporation, 34 Maple Street, Milford, MA, 01757 USA). The 2000CV instrument is maintained at 140°C in o-

dichlorobenzene (ODCB) solvent at 1 ml/min flowrate. To detect the polyolefin fractions eluting from the TREF column, the system uses a heated infrared IR4 detector (PolymerChar Company, Valencia Technology Park, P.O. Box 176, Valencia, VA, E-46980, PATERNA, Spain). For cooling and heating of the TREF column, the system uses a temperature-programmable HAAKE Phoenix II oil bath (Thermo Electron Corporation, 401 Millcreek Road, Marietta, OH 45750, USA). The TREF separation column is a stainless steel column of 100 mm long and 0.75 mm diameter packed with 20-micrometer cross-linked polystyrene beads. This TREF column is maintained at the 140°C temperature in the oil bath before the sample analyses. Polymer samples are dissolved in ODCB solvent at 140°C at a concentration of 2 mg/ml. One ml of the test sample of the resultant ODCB solution is injected into the TREF column by the auto-injection system of the Waters 2000CV instrument with a flowrate of ODCB set at 1ml/min. Following the sample injection, the ODCB flow is diverted away from the TREF column. As the sample is kept inside the column, the column is allowed to cool down in the oil bath from 140°C down to 0°C at the cooling rate of 1.5 °C/min. In this cooling step, the polymer molecules in the test sample are precipitated onto the packing beads in the TREF column. While the column is still at 0°C temperature, a flow of hot ODCB at 1 ml/min is re-introduced to the TREF column for 2 minutes to elute the soluble fraction of the polymer sample and detected by the IR detector set at 3.4 micrometer wavelength. Then, the temperature is raised at a heating rate of 2 °C/min while the ODCB flow is maintained at 1 ml/min through the TREF column to elute the higher melting polymer fractions which are being detected on-line by the IR4 detector.

5. Melt Flow Rate (MFR)

The MFR of the samples were determined according to ISO 1133 at 230 deg C. Two diffent loads were used: 2.16 kg and 5 kg. Values are reported as MFR(230/2.16) and MFR(230/5), respectively.

6. Productivity

The productivity of a catalyst is determined by dividing the produced mass of polypropylene by the mass of catalyst used and the reaction time.

7. Yield

The yield of a sample is determined by dividing the isolated amount of the desired product divided by the theoretical achievable amount of the product.

The following abbreviations are employed:
PP = polypropylene
MC = metallocene
Cat = supported catalyst system
h = hour

Synthesis of metallocenes:

Example 1:

Diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride

(4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene-1-yl)-chloro-diethylsilane

44.0 g (159 mmoles) of 4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene are dissolved in 334 ml toluene and 11 ml of 1,2-dimethoxyethane. Then 63.7 ml of an n-butyllithium solution (2.5 M in toluene) are added at room temperature and stirred for 1 hour at 80°C. After cooling to room temperature this solution is added

dropwise during 1.5 hours to a solution of 25.0 g (159 mmoles) of dichloro-diethyl-silane in 527 ml toluene and 17 ml of 1,2-dimethoxyethane at –40°C. The solution is slowly warmed to 20°C overnight and the solvent is removed in vacuum. 286 ml of toluene are added to the residue and the suspension is stirred for 30 minutes at room temperature. The suspension is filtered over a G3 fritted glass filter containing a bed of celite. The residue is washed with 100 ml of toluene and the resulting solution is dried in vacuum to yield 59.01 g (149 mmoles, 94 %) of [4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene-1-yl]-chloro-diethylsilane.

^{1}H-NMR (400 MHz, $CDCl_3$):

δ = 7.50-7.12 (m, 7H, arom-H), 6.84 (s, 1H, olefin-H), 3.80 (s, 1H, -CH), 2.75-2.53 (m, 2H, $-CH_2-$), 1.37 (s, 9H, tert-Bu), 1.20 (t, J=7.7 Hz, 3H, $-CH_3$), 1.02 (t, J=7.7 Hz, 3H, $-CH_3$), 0.90-0.77 (m, 5H, $-CH_2-$, $-CH_3$), 0.60-0.45 (m, 2H, $-CH_2-$) ppm.

(4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene-1yl)-(4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene-1yl)-diethyl-silane

45.3 g (173 mmoles) 4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene are dissolved in 541 ml toluene and 25 ml of THF and are treated with 72.6 ml of an n-butyllithium solution (2.5 M in toluene). After the addition is complete the solution is stirred for 1 hour at 80°C. The red solution is cooled to room temperature and a solution of 68.6 g (173 mmoles) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene-1-yl]-chloro-diethylsilane in 180 ml toluene is added. The reaction mixture is stirred for 16 h at 60°C. After cooling 100 ml of water are added and the phases that form are separated. The organic phase is washed with 125 ml of water, and the aqueous phase is extracted twice with a total of 150 ml of toluene. The combined organic phases are dried over magnesium sulfate. After separation of the magnesium sulfate, the solvent is removed in vacuum resulting in 110 g of an orange brown residue. To this residue 410 ml of heptane are added and the mixture is stirred for 1.5 hours at room temperature. The resulting colorless precipitate is filtered off, washed with 10 ml of heptane and dried in vacuum to

yield 15.24 g (24.5 mmoles, 14%) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene-1yl]-[4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene-1yl]-diethyl-silane.
^{1}H-NMR (400 MHz, $CDCl_3$):

δ = 7.50-7.07 (m, 14H, arom-H), 6.76 (s, 1 H, olefin-H), 6.75 (s, 1H, olefin-H), 3.66 (s, 1H, -CH), 3.56 (s, 1H, -CH), 2.4-2.27 (m, 2H, $-CH_2-$), 2.01 (s, 3H, $-CH_3$), 1.38 (s, 9H, t-Bu), 1.37 (s, 9H, tert-Bu), 1.07 (t, J=7.7 Hz, 3H, $-CH_3$), 0.85-0.67 (m, 10H, $-CH_2-$, $-CH_3$) ppm.

Diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride

8.29 g (13.3 mmoles) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene-1yl]-[4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene-1yl]-diethyl-silane are introduced into 83 mL of diethyl ether, and 10.6 mL of an n-butyllithium solution (2.5 *M* in toluene) are added at room temperature. After this addition is complete, the mixture is stirred overnight at this temperature. It is cooled to 0°C, and then 3.1 g (13.3 mmoles) of zirconium tetrachloride are added in portions. The suspension is stirred for two hours at room temperature. The precipitate that forms is separated by filtration through a G3 fritted glass filter and washed twice with 15 mL of diethyl ether. The residue is then dried in an oil-pump vacuum resulting in 7.92 g. This residue is dissolved in 1300 ml of dichloromethane and stirred for 15 minutes at room temperature. The precipitate is separated by filtration through a G3 fritted glass filter containing a bed of celite. The celite bed is washed with 20 ml of dichloromethane and the solvent is removed in vacuum to yield 5.85 g (7.5 mmoles, 56 %) of diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride with a rac:meso ratio of 2.4 : 1.
Rac:meso separation steps: 6.59 g of diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)-zirconium dichloride with a rac:meso ratio of 2.4 : 1 are introduced into 495 ml of acetone and stirred at room temperature for 1.5 hours. The suspension is filtered over a G3 fritted glass filter and the residue is dried in vacuum to yield 2.67 g (3.4 mmoles) of

diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride in a rac:meso ratio of 7:1. For further enrichment of the rac isomer 1.2 g of diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride in a rac:meso ratio of 7:1 are added to 36 ml of acetone and stirred for one hour at room temperature. The suspension is filtered over a G3 fritted glass filter and the residue is dried in vacuum to yield 1.06 g (1.35 mmoles) of diethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride in a rac:meso ratio > 10:1.

^{1}H-NMR (400 MHz, $CDCl_3$):

δ = 7.65-7.07 (m, 14H, arom-H), 7.03 (s, 1H, arom-H), 6.98 (s, 1H, arom-H), 2.77-2.69 (m, 1H, $-CH_2-$), 2.47-2.39 (m, 1H, $-CH_2-$), 2.22 (s, 3H, rac-CH_3), 1.98-1.75 (m, 4H, $-CH_2-$), 1.46 (t, J=8.0 Hz, 6H, $-CH_3$), 1.32 (s, 18H, tert-Bu), 1.07 (t, J=7.0 Hz, 3H, $-CH_3$) ppm.

Example 2

Dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(4'-tert-butyl-phenyl)-indenyl]zirconium dichloride

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane

In a flame dried 1000 ml roundbottom flask 38.7 g (140 mmole) 4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene were dissolved in 294 ml toluene and 9.3 ml dimethoxyethane. 56 ml n-Butyllithium (140 mmole, 2.5 M in toluene) were added dropwise and the resulting solution was stirred at 80°C for 1 h. In a separate flame dried 2000 ml roundbottom flask 17.0 ml (140 mmol) dimethyldichlorosilane were dissolved in 564 ml toluene and 14.5 ml dimethoxyethane and cooled to -40°C. The solution of the lithiated indene was added dropwise over a period of 1.5 h to the solution of dimethyldichlorosilane at -40°C. The mixture was allowed to come to room temperature while stirring overnight and then the solvent was removed in vacuo. 250 ml of toluene were added and the mixture was stirred overnight. The

lithium chloride was removed by filtration over a frit and washing the lithium chloride with 19 ml toluene. Removal of the solvent yielded 39.5 g (107 mmole, 76 %) of the product as an oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.45 (m, 4H, aromatic), 7.41 (m, 1H, aromatic), 7.26 (d, 1H, aromatic), 7.15 (m, 1H, aromatic), 6.84 (s, indenyl-C=C*H*), 3.73 (s, 1H, benzylic), 2.66, 2.55 (2 x m, 2H, -CH_2CH$_3$), 1.37 (s, 9H, C(CH_3)$_3$), 1.20 (t, 3H, CH_3), 0.40, 0.14 (2 x s, 6H, Si(CH_3)$_2$) ppm.

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(4'-tert-butyl-phenyl)-2-methyl-1H-inden-1-yl]-dimethyl-silane

In a flame dried 1000 ml roundbottom flask 28.0 g (107 mmol) 4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene were dissolved in 334 ml toluene and 15.1 ml THF. 44.8 ml (112.1 mmol, 1.05 eq.) n-Butyl lithium were added at room temperature and the mixture was heated to 80°C for 1 h. After cooling to room temperature a solution of 39.4 g (107 mmol) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane in 111 ml toluene was added at room temperature. The mixture was stirred for 10.5 h at 60°C and then given to 250 ml water. The phases were separated and the aqueous phase was extracted with 100 ml toluene. The combined organic phases were dried over magnesium sulfate and the solvent was removed in vacuo. The product was isolated by crystallization from heptane (5.63 g) and chromatography on sílica to give a combined yield of 24.4 g (41 mmole, 38 %). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.49 – 7.45, 7.36 – 7.10 (2 x m, 14H, aromatic), 6.84, 6.82 (2 x s, 2H, indenyl-C=C*H*), 3.87 – 3.75 (m, 2H, benzylic), 2.62 – 2.39 (m, 2H, CH_2CH$_3$), 2.22, 2.15 (2 x s, indenyl-CH_3), 1.38 (s, 18H, C(CH_3)$_3$), 1.25 – 1.12 (m, 8H, aliphatic + heptane), 0.87 (t, 3H, CH$_2$CH_3), 0.21, -0.23, -0.24, -0.25 (m, 6H, Si(CH_3)$_2$) ppm.

Dimethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride

In a flame dried round bottom flask 1.5 g (2.5 mmol) [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(4'-tert-butyl-phenyl)-2-methyl-1H-inden-1-yl]-dimethyl-silane were dissolved in 15 ml diethylether. 2.0 ml (5 mmol, 2.5 M in toluene) n-Butyl lithium were added and the solution was stirred at room temperature overnight. At 0°C 590 mg (2.5 mmol) zirconium tetrachloride were added in portions. Stirring was continued for 2 h at room temperature and the suspension was filtered over a frit. The residue was washed with 2 ml diethylether and dried in vacuo. Extraction with dichloromethane yielded 230 mg (0.3 mmol, 12 %) of the complex as an orange solid with a rac/meso-ratio of about 1:2. The isomers were separated in a subsequent step to obtain selective catalysts for propylene polymerization. ^{1}H-NMR (400 MHz, $CDCl_3$) [mixture of rac and meso]: δ = 7.65-7.07 (m, 14H, aromatic), 7.01, 6.97, 6.88 – 6.84 (2 x s, 1 x m, 2H, indenyl-C=C*H*) 2.81 - 2.72 (m, 2H, CH_2CH_3), 2.42, 2.24 (2 x s, 3H, indenyl-CH_3), 1.46, 1.32, 1.25, 1.07, 0.90 (5 x m, 26H, CH_2CH_3, $C(CH_3)_3$, $Si(CH_3)_2$) ppm.

Example 3

Dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconium dichloride

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(1-naphthyl)-2-methyl-1H-inden-1-yl]-dimethyl-silane

In a flame dried 1000 ml roundbottom flask 13.7 g (53 mmol) 2-methyl-4-(1-naphthyl)-1H-indene were dissolved in 233 ml toluene and 13.7 ml THF. 22 ml (55 mmol, 2.5 M in toluene) n-Butyl lithium were added at room temperature and the mixture was heated to 80°C for 1 h. After cooling to room temperature a solution of 19.5 g (53 mmol) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane in 55 ml toluene was added at room temperature. The mixture was stirred for 8 h at 60°C and then given to 150 ml water. The phases were separated and the aqueous phase was extracted with 100 ml toluene. The combined organic phases were dried over magnesium sulfate and the solvent was removed in

vacuo. The product was isolated by chromatography on sílica to give a yield of 13.3 g (23 mmole, 43 %). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.64 – 7.41, 7.37 – 7.11 (2 x m, 17H, aromatic), 6.89, 6.81 (2 x s, 2H, indenyl-C=C*H*), 3.95 – 3.78 (m, 2H, benzylic), 2.62 – 2.40 (m, 2H, CH_2CH_3), 2.21, 2.14 (2 x s, 3H, indenyl-CH_3), 1.37 (s, 9H, $C(CH_3)_3$), 1.24 – 1.11 (m, 8H, aliphatic + heptane), 0.88 (t, 3H, CH_2CH_3), 0.22, -0.22, -0.23, -0.24 (m, 6H, $Si(CH_3)_2$) ppm.

Dimethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(1-naphthyl)indenyl)zirconium dichloride

In a flame dried round bottom flask 13.3 g (23 mmol) [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4'-(1-naphthyl)-2-methyl-1H-inden-1-yl]-dimethyl-silane were dissolved in 266 ml diethylether. 18.4 ml (46 mmol, 2.5 M in toluene) n-Butyl lithium were added and the solution was stirred at room temperature overnight. At 0°C 5.4 g (23 mmol) zirconium tetrachloride were added in portions. Stirring was continued for 2 h at room temperature and the suspension was filtered over a frit. The residue was washed with 20 ml diethylether and dried in vacuo. Extraction with dichloromethane yielded 9.8 g (13 mmol, 57 %) of the complex as an orange solid with a rac/meso-ratio of about 2:1. The isomers were separated in a subsequent step to obtain selective catalysts for propylene polymerization.
^{1}H-NMR (400 MHz, $CDCl_3$) [mixture of rac and meso]: δ = 7.89-7.01 (m, 17H, aromatic), 6.99, 6.98, 6.87 – 6.83 (2 x s, 1 x m, 2H, indenyl-C=C*H*), 2.83 - 2.74 (m, 2H, CH_2CH_3), 2.45, 2.21 (2 x s, 3H, indenyl-CH_3), 1.48, 1.35, 1.24, 1.06, 0.93 (5 x m, 17H, CH_2CH_3, $C(CH_3)_3$, $Si(CH_3)_2$) ppm.

Example 4

Dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(3',5'-dimethylphenyl)-indenyl]zirconium dichloride

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(3',5'-dimethyl-phenyl)-2-methyl-1H-inden-1-yl]-dimethyl-silane

In a flame dried 1000 ml roundbottom flask 23.4 g (100 mmol) 2-methyl-4-(3',5'-dimethyl-phenyl)-1H-indene were dissolved in 400 ml toluene and 23.4 ml THF. 40 ml (100 mmol, 2.5 M in toluene) n-Butyl lithium were added at room temperature and the mixture was heated to 80°C for 1 h. After cooling to room temperature a solution of 36.9 g (100 mmol) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane in 100 ml toluene was added at room temperature. The mixture was stirred for 9 h at 60°C and then given to 300 ml water. The phases were separated and the aqueous phase was extracted with 250 ml toluene. The combined organic phases were dried over magnesium sulfate and the solvent was removed in vacuo. The product was isolated by chromatography on sílica to give a yield of 29.8 g (53 mmole, 53 %). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.55 – 7.42, 7.36 – 7.12 (2 x m, 13H, aromatic), 6.86, 6.80 (2 x s, 2H, indenyl-C=C*H*), 3.88 – 3.79 (m, 2H, benzylic), 2.64 – 2.42 (m, 2H, CH_2CH_3), 2.33 (s, 6H, Ph-CH_3), 2.20, 2.13 (2 x s, 3H, indenyl-CH_3), 1.37 (s, 9H, $C(CH_3)_3$), 1.22 – 1.10 (m, 6H, aliphatic + heptane), 0.89 (t, 3H, CH_2CH_3), 0.27, -0.16, -0.21, -0.25 (m, 6H, $Si(CH_3)_2$) ppm.

Dimethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(3',5'-dimethyl-phenyl)indenyl)zirconium dichloride

In a flame dried round bottom flask 29.8 g (53 mmol) [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(3',5'-dimethyl-phenyl)-2-methyl-1H-inden-1-yl]-dimethyl-silane were dissolved in 600 ml diethylether. 42.4 ml (106 mmol, 2.5 M in toluene) n-Butyl lithium were added and the solution was stirred at room temperature overnight. At 0°C 12.4 g (53 mmol) zirconium tetrachloride were added in portions. Stirring was continued for 2 h at room temperature and the suspension was filtered over a frit. The residue was washed with 50 ml diethylether and dried in vacuo. Extraction with dichloromethane, removal of the solvent and fractional crystallization from toluene and yielded 11.2 g (15 mmol, 29 %) of the complex as an orange solid with a rac/meso-ratio of about 11:1. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.90 - 7.11 (m, 13H, aromatic), 6.93, 6.89 (2 x s, 2H,

indenyl-C=C*H*), 2.81 - 2.76 (m, 2H, C*H*$_2$CH$_3$), 2.34 (s, 6H, Ph-C*H*$_3$), 2.21 (s, 3H, indenyl-C*H*$_3$), 1.35, 1.33, 1.23 (2 x s, 1 x m, 24H, CH$_2$C*H*$_3$, C(C*H*$_3$)$_3$, Si(C*H*$_3$)$_2$) ppm.

Example 5

Di-n-propylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(4'-tert-butyl-phenyl)-indenyl]zirconium dichloride

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-di-n-propyl-silane

In a flame dried 1000 ml roundbottom flask 38.7 g (140 mmole) 4-(4'-tert-butyl-phenyl)-2-ethyl-1H-indene were dissolved in 294 ml toluene and 9.3 ml dimethoxyethane. 17 ml n-Butyllithium (140 mmole, 2.5 M in toluene) were added dropwise and the resulting solution was stirred at 80°C for 1 h. In a separate flame dried 2000 ml roundbottom flask 25.9 g (140 mmol) di-n-propyldichlorosilane were dissolved in 564 ml toluene and 14.5 ml dimethoxyethane and cooled to -40°C. The solution of the lithiated indene was added dropwise over a period of 1.5 h to the solution of di-n-propyldichlorosilane at -40°C. The mixture was allowed to come to room temperature while stirring overnight and then the solvent was removed in vacuo. 250 ml of toluene were added and the mixture was stirred overnight. The lithium chloride was removed by filtration over a frit and washing the lithium chloride with 21 ml toluene. Removal of the solvent yielded 59.5 g (140 mmole, 100 %) of the product as an oil. ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 7.44 (m, 4H, aromatic), 7.40 (m, 1H, aromatic), 7.27 (d, 1H, aromatic), 7.16 (m, 1H, aromatic), 6.85 (s, indenyl-C=C*H*), 3.74 (s, 1H, benzylic), 2.65, 2.54 (2 x m, 2H, ind-C*H*$_2$CH$_3$), 1.40 (m, 4H, SiC*H*$_2$CH$_2$CH$_3$), 1.36 (s, 9H, C(C*H*$_3$)$_3$), 1.30 (m, 4H, SiCH$_2$C*H*$_2$CH$_3$), 1.20 (t, 3H, ind-CH2C*H*$_3$), 0.96 (t, 6H, SiCH$_2$CH$_2$C*H*$_3$) ppm.

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(4'-tert-butyl-phenyl)-2-methyl-1H-inden-1-yl]-di-n-propyl-silane

In a flame dried 1000 ml roundbottom flask 26.2 g (100 mmol) 4-(4'-tert-butyl-phenyl)-2-methyl-1H-indene were dissolved in 445 ml toluene and 26.2 ml THF. 40 ml (100 mmol, 1.0 eq., 2.5 M in toluene) n-Butyl lithium were added at room temperature and the mixture was heated to 80°C for 1 h. After cooling to room temperature a solution of 42.5 g (100 mmol) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane in 100 ml toluene was added at room temperature. The mixture was stirred for 12 h at 60°C and then given to 250 ml water. The phases were separated and the aqueous phase was extracted with 100 ml toluene. The combined organic phases were dried over magnesium sulfate and the solvent was removed in vacuo. The product was isolated by chromatography on silica to give a yield of 32.4 g (49.8 mmole, 50 %). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.51 – 7.44, 7.37 – 7.11 (2 x m, 14H, aromatic), 6.85, 6.83 (2 x s, 2H, indenyl-C=C*H*), 3.88 – 3.76 (m, 2H, benzylic), 2.63 – 2.40 (m, 2H, ind-CH_2CH$_3$), 2.22, 2.15 (2 x s, indenyl-CH_3), 1.38, 1.37 (2 x s, 18H, C(CH_3)$_3$), 1.25 – 0.96 (m, 8H, aliphatic), 0.87 (t, 3H, CH$_2$CH_3), 0.33, 0,27 (2 x s, 4H, Si(CH_2CH$_2$CH$_3$)$_2$) ppm.

Di-n-propylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-tert-butyl-phenyl)indenyl)zirconium dichloride

In a flame dried round bottom flask 6.5 g (10 mmol) [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[4-(4'-tert-butyl-phenyl)-2-methyl-1H-inden-1-yl]-di-n-propyl-silane were dissolved in 130 ml diethylether. 8.0 ml (20 mmol, 2.5 M in toluene) n-Butyl lithium were added and the solution was stirred at room temperature overnight. At 0°C 2.33 g (10 mmol) zirconium tetrachloride were added in portions. Stirring was continued for 2 h at room temperature and the suspension was filtered over a frit. The residue was washed with 20 ml diethylether and dried in vacuo. Extraction with hot toluene and fractional crystallization yielded 2.3 g (2.8 mmol, 28 %) of the complex as an orange solid with a rac/meso-ratio of about 33:1. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.64 - 7.08 (m, 14H, aromatic), 6.94, 6.89 (2 x s, 2H,

indenyl-C=C*H*) 2.80 - 2.71 (m, 2H, C*H*$_2$CH$_3$), 2.24 (s, 3H, indenyl-C*H*$_3$), 1.46 – 0.88 (m, 35H, CH$_2$C*H*$_3$, C(C*H*$_3$)$_3$, Si(C*H*$_2$C*H*$_2$C*H*$_3$)$_2$) ppm.

Example 6

Dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4,5-benzoindenyl]zirconium dichloride

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[2-methyl-4,5-benzo-1H-inden-1-yl-dimethyl-silane

In a flame dried 1000 ml roundbottom flask 18.0 g (100 mmol) 2-methyl-4,5-benzo-1H-indene were dissolved in 300 ml toluene and 18 ml THF. 40 ml (100 mmol, 2.5 M in toluene) n-Butyl lithium were added at room temperature and the mixture was heated to 80°C for 1 h. After cooling to room temperature a solution of 36.9 g (100 mmol) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane in 100 ml toluene was added at room temperature. The mixture was stirred for 13 h at 60°C and then given to 300 ml water. The phases were separated and the aqueous phase was extracted with 250 ml toluene. The combined organic phases were dried over magnesium sulfate and the solvent was removed in vacuo. The product was isolated by chromatography on silica to give a yield of 24.9 g (49 mmole, 49 %). ^{1}H-NMR (400 MHz, CDCl$_3$): δ = 7.81 - 7.12 (m, 13H, aromatic), 6.90, 6.81 (2 x s, 2H, indenyl-C=C*H*), 3.79 – 3.70 (m, 2H, benzylic), 2.63 – 2.41 (m, 2H, C*H*$_2$CH$_3$), 2.18, 2.09 (2 x s, 3H, indenyl-C*H*$_3$), 1.37 (s, 9H, C(C*H*$_3$)$_3$), 0.89 (t, 3H, CH$_2$C*H*$_3$), 0.23, -0.19, -0.21, -0.25 (m, 6H, Si(C*H*$_3$)$_2$) ppm.

Dimethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4,5-benzoindenyl)zirconium dichloride

In a flame dried round bottom flask 24.9 g (49 mmol) [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[2-methyl-4,5-benzo-1H-inden-1-yl-dimethyl-silane were dissolved in 600 ml diethylether. 39.2 ml (98 mmol, 2.5 M in toluene) n-Butyl

lithium were added and the solution was stirred at room temperature overnight. At 0°C 11.4 g (49 mmol) zirconium tetrachloride were added in portions. Stirring was continued for 3 h at room temperature and the suspension was filtered over a frit. The residue was washed with 60 ml diethylether and dried in vacuo. Extraction with dichloromethane, removal of the solvent and fractional crystallization from toluene and yielded 9.1 g (13.5 mmol, 28 %) of the complex as an orange solid with a rac/meso-ratio of about 19:1. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.83 - 7.07 (m, 13H, aromatic), 6.95, 6.87 (2 x s, 2H, indenyl-C=C*H*), 2.77 - 2.71 (m, 2H, CH_2CH_3), 2.30 (s, 3H, indenyl-CH_3), 1.35, 1.33, 1.23 (2 x s, 1 x m, 18H, CH_2CH_3, $C(CH_3)_3$, $Si(CH_3)_2$) ppm.

Example 7

Dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(4'-methyl-phenyl)-indenyl]zirconiumdichloride

[4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[2-methyl-4-(4'-methyl-phenyl)-1H-inden-1-yl-dimethyl-silane

In a flame dried 1000 ml roundbottom flask 22 g (100 mmol) 2-methyl-4-(4'-methylphenyl)-1H-indene were dissolved in 374 ml toluene and 22 ml THF. 40 ml (100 mmol, 2.5 M in toluene) n-Butyl lithium were added at room temperature and the mixture was heated to 80°C for 1 h. After cooling to room temperature a solution of 36.9 g (100 mmol) of [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-chloro-dimethyl-silane in 100 ml toluene was added at room temperature. The mixture was stirred for 13 h at 60°C and then given to 250 ml water. The phases were separated and the aqueous phase was extracted with 250 ml toluene. The combined organic phases were dried over magnesium sulfate and the solvent was removed in vacuo. The product was isolated by chromatography on silica to give a yield of 35.4 g (64 mmole, 64 %). ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.69 - 7.19 (m, 14H, aromatic), 6.81, 6.69 (2 x s, 2H, indenyl-C=C*H*), 3.85 – 3.71 (m, 2H, benzylic), 2.74 – 2.51 (m, 2H, CH_2CH_3), 2.35 (s, 3H, Ph-CH_3), 2.21, 2.11 (2 x s,

3H, indenyl-CH_3), 1.36 (s, 9H, $C(CH_3)_3$), 0.87 (t, 3H, CH_2CH_3), 0.24, -0.20, -0.22, -0.25 (m, 6H, $Si(CH_3)_2$) ppm.

Dimethylsilandiyl(2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl)(2-methyl-4-(4'-methyl-phenyl)-indenyl)zirconium dichloride

In a flame dried round bottom flask 27.6 g (50 mmol) [4-(4'-tert-butyl-phenyl)-2-ethyl-1H-inden-1-yl]-[2-methyl-4-(4'-methyl-phenyl)-1H-inden-1-yl-dimethyl-silane were dissolved in 552 ml diethylether. 40 ml (100 mmol, 2.5 M in toluene) n-Butyl lithium were added and the solution was stirred at room temperature overnight. At 0°C 11.7 g (50 mmol) zirconium tetrachloride were added in portions. Stirring was continued for 3 h at room temperature and the suspension was filtered over a frit. The residue was washed with 55 ml diethylether and dried in vacuo. Extraction with dichloromethane, removal of the solvent and fractional crystallization from toluene and yielded 8.9 g (12.5 mmol, 25 %) of the complex as an yellow solid with a rac/meso-ratio of > 50:1. ^{1}H-NMR (400 MHz, $CDCl_3$): δ = 7.70 - 7.21 (m, 14H, aromatic), 6.93, 6.91 (2 x s, 2H, indenyl-C=C*H*), 2.81 - 2.75 (m, 2H, CH_2CH_3), 2.33 (s, 3H, Ph-CH_3), 2.28 (s, 3H, indenyl-CH_3), 1.35, 1.34, 1.24 (2 x s, 1 x m, 18H, CH_2CH_3, $C(CH_3)_3$, $Si(CH_3)_2$) ppm.

Comparative Example 8:

Dimethylsilanediylbis(2-methylindenyl)zirconium dichloride

Preparation of Dimethylbis(2-methylindenyl)silane

8.0 g (61.4 mmoles) of 2-methylindene were introduced into 175 mL of toluene and 13 mL of THF, and 24.6 mL of *n*-butyllithium (2.5 *M* in toluene) were added without interruption at room temperature. After this addition was complete, the mixture was heated to 80°C and stirred at this temperature for one hour. It was allowed to cool to 40°C, then 3.96 g (30.7 mmoles) of dimethyldichlorosilane were slowly added dropwise. After this addition, the reaction solution was stirred for three hours at 60°C and then overnight at room temperature. 70 mL of water were

added and the phases that form were separated. The organic phase was washed with 100 mL of water, and the aqueous phase was extracted three times with a total of 100 mL of toluene. The combined organic phases were dried over magnesium sulfate. After separation of the magnesium sulfate, the solvent was removed and the residue was purified by column chromatography. The desired product was isolated in a yield of 8.16 g (84%) (purity 99%).

^{1}H-NMR (400 MHz, $CDCl_3$):

7.55-7.12 (m, 8H, arom-H), 6.40 (s, br, 2H, olefin-H indene), 3.51, 3.48 (each s, each 1H, SiC-H), 2.09, 2.04 (each s, each 3H, CH_3), 1.71 (s, 6H, CH_3), 0.08 (s, 6H, $SiMe_2$).

Dimethylsilanediylbis(2-methylindenyl)zirconium dichloride

A solution of 5.0 g (15.8 mmoles) of dimethylbis(2-methylindenyl)silane in 45 mL of tetrahydrofuran was treated with 12.6 mL of an *n*-butyllithium solution (2.5 *M* in hexane) and stirred for 16 hours at room temperature. The reaction solution was cooled to 0°C and 1.84 g (7.9 mmoles) of zirconium tetrachloride were added in portions. After this addition, the solution was heated to room temperature and stirred for two hours at this temperature. The precipitate that forms was filtered through a G3 fritted glass filter, and the residue was washed once with 10 mL of diethyl ether. The residue was then dried in a vacuum, and the desired product was obtained in a yield of 1.89 g (50%) with a rac:meso ratio close to 1:1. The isomers must be separated in a subsequent step to obtain selective catalysts for propylene polymerization.

^{1}H-NMR (400 MHz, $CDCl_3$):

7.75-6.85 (m, 10H, arom-H), 2.24 (s, 6H, CH_3), 1.25 (s, 6H, aliph-H).

Comparative Example 9:

Dimethylsilanediylbis(2-methyl-4,5-benzoindenyl)zirconium dichloride

Dimethylbis(2-methyl-4,5-benzoindenyl)silane

A solution of 7.0 g (38.8 mmoles) of the isomeric mixture of 2-methyl-4,5-benzoindene and 2-methyl-6,7-benzoindene in 65 mL of tetrahydrofuran was treated with 15.6 mL of an *n*-butyllithium solution (2.5 *M* in hexane) and heated under reflux for one hour. The resulting red solution was then added dropwise at room temperature to a solution of 2.51 g (19.4 mmoles) of dimethyldichlorosilane in 10 mL of THF, and the resulting solution was heated under reflux for 5-6 hours. The reaction solution was then cooled to room temperature and poured into ice water. The aqueous phase was repeatedly extracted with 60 mL of diethyl ether. After the organic phase has been dried with magnesium sulfate, the solvent was removed and the residue was purified by column chromatography. The desired product was isolated in a yield of 4.85 g (60%).

^{1}H-NMR (400 MHz, $CDCl_3$):

8.01-7.36 (m, 12H, arom-H), 7.21 (s, br, 2H, olefin-H indene), 3.96 (s, 2H, SiC-H), 2.43 (s, 6H, CH_3), -0.22 (s, 6H, $SiMe_2$).

Dimethylsilanediylbis(2-methyl-4,5-benzoindenyl)zirconium dichloride

A solution of 3.0 g (7.2 mmoles) of dimethylbis(2-methyl-4,5-benzo-indenyl)silane in 30 mL of tetrahydrofuran was treated with 5.8 mL of an *n*-butyllithium solution (2.5 *M* in hexane) and stirred for 16 hours at room temperature. The reaction solution was cooled to 0°C and 1.68 g (7.2 mmoles) of zirconium tetrachloride were added in portions. After this addition, the solution was warmed to room temperature and stirred for two hours at this temperature. The precipitate that forms was filtered through a G3 fritted glass filter and the residue was washed once with 5 mL of diethyl ether. The residue was then dried in a vacuum, and the desired product was obtained in a yield of 2.32 g (56%) with a rac:meso ratio of about 1:1. The isomers must be separated in a subsequent step to obtain selective catalysts for propylene polymerization.

^{1}H-NMR (400 MHz, $CDCl_3$):

7.85-7.10 (m, 14H, arom-H), 2.25 (s, 6H, CH_3), 1.30 (s, 6 H, CH_3).

Comparative Example 10:

Dimethylsilanediylbis(2-methyl-4-(4'-*tert*-butylphenyl)indenyl)zirconiumdichloride

Dimethylbis(2-methyl-4-(4'-*tert*-butylphenyl)indenyl)silane

8.0 G (30.5 mmoles) of 2-methyl-4-(4'-*tert*-butylphenyl)-1-indene were introduced into 180 mL of toluene and 10 mL of THF, then 12.4 mL of *n*-butyllithium solution (2.5 *M* in toluene) were added without interruption at room temperature. After this addition was complete, the mixture was heated to 80°C and stirred at this temperature for one hour. It was allowed to cool to 40°C, then 2.0 g (15.3 mmoles) of dimethyldichlorosilane were slowly added dropwise. After this addition, the reaction solution was stirred for three hours at 60°C and then overnight at room temperature. 80 mL of water were added and the phases that form were separated. The organic phase was washed with 80 mL of water, and the aqueous phase was extracted three times with a total of 80 mL of toluene. The combined organic phases were dried over magnesium sulfate. After separation of the magnesium sulfate, the solvent was removed and the residue was purified by column chromatography. The desired product was isolated in a yield of 7.27 g (80%) (purity 97%).

^{1}H-NMR (400 MHz, $CDCl_3$):

7.73-7.12 (m, 16H, arom-H), 6.75 (s, br, 2H, olefin-H indene), 3.76 (s, 2H, SiC-H), 2.17 (s, 6H, CH_3), -0.20 (m, 6H,$SiMe_2$).

Dimethylsilanediylbis(2-methyl-4-(4'-*tert*-butylphenyl)indenyl)zirconiumdichloride

143 G (0.54 moles) of 2-methyl-4-(4'-*tert*-butylphenyl)-1-indene were introduced into 2.4 L of toluene and 143 mL of tetrahydrofuran, and 234 mL of an *n*-butyllithium solution (2.5 *M* in toluene) were added without interruption at room temperature. After this addition was complete, the mixture was heated to 80°C and stirred for one hour at this temperature. It was allowed to cool to 40°C, then 33.6 g (0.26 moles) of dimethyldichlorosilane were added dropwise to this reaction solution. The reaction solution was stirred for three hours at 60°C. It was cooled

to room temperature, and then 218 mL of an *n*-butyllithium solution (2.5 *M* in toluene) were added dropwise. After this addition was complete, the solution was heated to 80°C and stirred for one hour at this temperature. It was allowed to cool to room temperature, then 71.1 g (0.305 moles) of zirconium tetrachloride were added in portions. The solution was stirred for two hours at 45°C and the precipitate that forms was separated by filtration through a G3 fritted glass filter and then carefully washed with 700-mL portions of tetrahydrofuran. The residue was dried in an oil-pump vacuum, and the product was obtained in a yield of 155 g (80%) and with a rac:meso ratio of 1:1. The isomers must be separated in an additional step to obtain selective catalysts for propylene polymerization.

^{1}H-NMR (400 MHz, $CDCl_3$):

7.63-6.85 (m, 16H, arom-H), 2.44 (s, 3H, meso-CH_3), 2.24 (s, 3H, rac-CH_3), 1.46 (s, 1.5H, meso-$SiMe_2$), 1.33-1.29 (m, 21H, *tert*-butyl, rac-$SiMe_2$), 1.23 (s, 1.5H, meso-CH_3).

Comparative Example 11:

Dimethylsilanediyl(2-methyl-4-(4'-*tert*-butylphenyl)indenyl)(2-isopropyl-4-(4'-*tert*-butylphenyl)indenyl)zirconium dichloride

Dimethylsilanediyl(2-methyl-4-(4'-*tert*-butylphenyl)-1-indene)(2-isopropyl-4-(4'-*tert*-butylphenyl)-1-indene)

16.8 G (57.7 mmoles) of 2-isopropyl-4-(4'-*tert*-butylphenyl)-1-indene were introduced into 131 mL of toluene and 5.0 mL of THF, and 21.5 mL of an *n*-butyllithium solution (2.68 *M* in toluene) were added without interruption at room temperature. After this addition was complete, the mixture was heated to 80°C and stirred for one hour at this temperature. It was then allowed to cool to room temperature. The resulting reaction solution was added dropwise to a solution of 20.5 g (57.7 mmoles) of (2-methyl-4-(4'-*tert*-butylphenyl)-1-indenyl)dimethylchlorosilane in 246 mL of toluene over a period of one hour. The mixture was stirred overnight at room temperature. Then 60 mL of water were

added and the phases which form were separated. The organic phase was washed with 100 mL of water and the combined aqueous phases were extracted twice with a total of 100 mL of toluene. The combined organic phases were dried over magnesium sulfate. After filtering off the magnesium sulfate, the solvent was removed and the residue was dried in an oil pump vacuum. The desired product was isolated in a yield of 31.6 g (90%) (purity: 90%).

^{1}H-NMR (400 MHz, $CDCl_3$):

7.51–7.1 (m, 14H, arom-H), 6.71, 6.62 (each s, each 1H, olefin-H-indene), 3.35, 3.31 (each s, each 2H, CH_2-H), 2.65 (m, 1H, CH-isopropyl), 2.41 (s, 3H CH_3-H), 1.35, 1.33 (each s, each 9H, *tert*-butyl), 1.15 (d, 6H, isopropyl-CH_3), 0.2, 0.0 (each d, each 3H, $SiCH_3$).

Dimethylsilanediyl(2-methyl-4-(4'-*tert*-butylphenyl)indenyl)(2-isopropyl-4-(4'-*tert*-butylphenyl)indenyl)zirconium dichloride

36.6 G (60 mmoles) of dimethylsilanediyl(2-methyl-4-(4'-*tert*-butylphenyl)-1-indene)(2-isopropyl-4-(4'-*tert*-butylphenyl)-1-indene) were introduced into 366 ml of diethyl ether, and 44.9 mL of an *n*-butyllithium solution (2.68 *M* in toluene) were added without interruption at room temperature. After this addition was complete, the mixture was stirred over night at this temperature. It was then cooled to 0°C and 14.0 g (60 mmoles) of zirconium tetrachloride were added in portions. The mixture was allowed to warm to room temperature and was stirred for another two hours at this temperature. The precipitate that forms was separated by filtration through a G3 fritted glass filter and was washed with two 50 mL portions of tetrahydrofuran and with one 70 mL portion of pentane. The residue was dried in an oil-pump vacuum, and the product was obtained in a yield of 23.5 g (50%) and with a rac:meso ratio of about 1:1. The isomers must be separated in a subsequent step to obtain selective catalysts for propylene polymerization.

^{1}H-NMR (400 MHz, $CDCl_3$):

7.7-6.9 (m, 14H, arom-H), 3.26 (m, 1H, CH-isopropyl), 2.23 (s, 3H, CH_3), 1.31 (s, 18H, *tert*-butyl), 1.33, 1.32 (each s, each 3H, Si-CH_3), 1.08, 1.03 (each d,

each 3H, isopropyl-CH_3).

Preparation of methylaluminoxane treated silica:

Example 12:

To a stirred suspension of 293 g of silica (Grace XPO2107, dried at 180°C and 1 mbar for 16 hours, LOD < 0.5 wt% and LOI = 2.6 wt%) in 1500 mL of toluene is added slowly 300 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation) at room temperature. During the addition the temperature must not exceed 30°C. After the addition is complete, the mixture is stirred for two hours at room temperature and separated by filtration. The residue is washed with two 1500 mL portions of toluene and three 1500 mL portions of isohexane and dried in vacuum to constant weight. The methylaluminoxane treated silica is obtained as a free-flowing powder in a yield of 408 g.

Preparation of supported metallocene catalysts:

Example 13:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 282 mg of *rac*-diethylsilandiyl(2-ethyl-4-(4'-*tert*-butyl-phenyl)-indenyl)(2-methyl-4-(4'-*tert*-butyl-phenyl)indenyl)zirconium dichloride (prepared in Example 1) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to

give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 11.8 g.

Example 14:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 282 mg of *rac*-dimethylsilanediyl[2-ethyl-4-(4-tert-butyl-phenyl)-indenyl][2-methyl-4-(4-tert-butyl-phenyl)-indenyl]zirconium dichloride (prepared in Example 2) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 9.6 g.

Example 15:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 269 mg of *rac*-dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconium dichloride (prepared in Example 3) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 10.2 g.

Example 16:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 262 mg of *rac*-dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(3',5'-dimethylphenyl)-indenyl]zirconium dichloride (prepared in Example 4) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in

toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 10.5 g.

Example 17:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 292 mg of *rac*-di-n-propylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(4'-tert-butyl-phenyl)-indenyl]zirconium dichloride (prepared in Example 5) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 10.2 g.

Example 18:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 242 mg of *rac*-dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4,5-benzoindenyl]zirconium dichloride (prepared in Example 6) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 10.0 g.

Example 19:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 256 mg of *rac*-dimethylsilanediyl[2-ethyl-4-(4'-tert-butyl-phenyl)-indenyl][2-methyl-4-(4'-methyl-phenyl)-indenyl]zirconiumdichloride (prepared in Example 7) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene

(Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 10.5 g.

Comparative Example 20:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 171 mg of *rac*-dimethylsilanediyl-bis-(2-methylindenyl)-zirconium dichloride (prepared in Comparative Example 8) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing reddish powder in a yield of 12.2 g.

Comparative Example 21:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 207 mg of *rac*-dimethylsilanediyl-bis-(2-methyl-4,5-benzoindenyl)-zirconium dichloride (prepared in Comparative Example 9) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 11.5 g.

Comparative Example 22:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 267 mg of *rac*-dimethylsilanediyl-bis-(2-methyl-4-(4'-*tert*-butylphenyl)-1-indenyl)-zirconium dichloride (prepared in Comparative Example 10) are mixed with 27 mL of toluene

and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 11.9 g.

Comparative Example 23:

10.0 G of the methylaluminoxane treated silica prepared in Example 12 are placed in a fritted glass filter as a column with a smooth surface. A minimal amount of toluene is added and the treated silica is carefully stirred with a spatula to remove any air pockets in the column. The excess toluene is removed by filtration leaving a smooth surface. In a separate flask 277 mg of *rac*-dimethylsilanediyl(2-methyl-4-(4'-*tert*-butylphenyl)indenyl)(2-isopropyl-4-(4'-*tert*-butylphenyl)indenyl)zirconium dichloride (prepared in Comparative Example 11) are mixed with 27 mL of toluene and 13.6 mL of a 30 wt-% solution of methylaluminoxane in toluene (Albemarle Corporation). The slurry is stirred at room temperature for one hour to give an orange solution. This solution is then carefully added on top of the methylaluminoxane treated silica and slowly filtered off within approximately 30 minutes. When the surface of the colored solution reaches the top of the silica, the filtration process is stopped and the filter cake is carefully and thoroughly stirred by means of a spatula. The catalyst is then allowed to rest for one hour. The residual solvent is filtered off and the catalyst is washed twice with isohexane (20 mL) and dried in a nitrogen purge to constant weight. The catalyst is obtained as free-flowing orange powder in a yield of 11.9 g.

Polymerizations:

Polymerization Procedure (batch propylene homo- and co-polymerization):

A dry and nitrogen purged 5 dm^3 autoclave equipped with a stirrer is charged with if desired 100 g of metallocene polymer seed bed. Optionally, a certain amount of hydrogen is metered in. Triisobutylaluminum (1 cm^3 of a 10 wt.-% solution in heptane), liquid propylene (one-half of the total amount used for the run), and optionally, a certain amount of ethylene are metered in and the mixture is stirred for at least 5 minutes (stirrer speed 200 rpm) at 20 °C. Then supported metallocene catalyst, suspended in 5 cm^3 of white oil, is injected with liquid propylene (one-half of total amount used for the run). The reactor is heated to the internally measured run temperature (65, 60 or 30 °C) within 11 minutes. The polymerization reaction is allowed to proceed at the run temperature for either 15 or 60 minutes. During the 60 min copolymerization runs the reactor pressure was maintained by continuous feeding of ethylene and propylene. The polymerization is stopped by releasing the monomer and cooling down the reactor. The polymer is discharged and dried under reduced pressure.

The following examples were carried out according to the polymerization procedure described above:

Table 1: Polymerisations

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]
1	13	-	1837	-	105	65	60	623	5,930
2	13	50	1836	-	25	65	60	560	22,400
3	13	-	1820	60	75	65	15	200	10,670
4	13	-	1760	120	75	65	15	200	10,670
5	13	-	1700	180	75	65	15	250	13,300
6	13	-	1640	240	75	30	15	103	5,500
7	13	-	1580	300	25	30	15	33	5,760
8	13	-	1550	330	25	30	15	40	6,400

9	13	-	55	100	50	60	60		
10	13	-	55	125	50	60	60		
11	13	-	55	142	50	60	60		
12	14	-	1835	-	100	65	60	550	5,500
13	14	50	1832	-	30	65	60	612	20,400
14	14	-	1825	60	70	65	15	200	11,500
15	14	-	1750	120	70	65	15	220	12,550
16	14	-	1680	180	70	65	15	230	13,000
17	14	-	1600	240	70	30	15	96	5,500
18	14	-	1550	300	30	30	15	40	5,300
19	14	-	1600	330	30	30	15	44	5,800
20	14	-	55	100	50	60	60		
21	14	-	55	142	50	60	60		
22	15	-	1800	-	100	65	60	480	5,100
23	15	50	1750	-	30	65	60	550	18,300
24	15	-	1820	60	70	65	15	187	10,700
25	15	-	1780	120	70	65	15	163	9,300
26	15	-	1695	180	70	65	15	180	10,400
27	15	-	1690	240	70	30	15	84	4,800
28	15	-	1750	300	30	30	15	36	4,800
29	15	-	1690	330	30	30	15	34	4,500
30	15	-	55	100	50	60	60		
31	15	-	55	142	50	60	60		
32	16	-	1810	-	100	65	60	520	5,200
33	16	50	1800	-	30	65	60	570	19,100
34	16	-	1800	60	70	65	15	200	11,400
35	16	-	1790	120	70	65	15	205	11,700
36	16	-	1720	180	70	65	15	217	12,400
37	16	-	1750	240	70	30	15	98	5,600
38	16	-	1710	300	30	30	15	36	4,800
39	16	-	1740	330	30	30	15	34	4,500
40	17	-	1750	-	100	65	60	580	5,800
41	17	50	1830	-	25	65	60	550	22,000
42	17	-	1850	60	65	65	15	177	10,870
43	17	-	1800	120	65	65	15	180	11,100
44	17	-	1760	180	65	65	15	205	12,600
45	17	-	1720	240	65	30	15	83	5,100
46	17	-	1725	300	25	30	15	33	5,250
47	17	-	1710	330	25	30	15	39	6,280
48	18	-	1830	-	100	65	60	480	4,990
49	18	50	1835	-	25	65	60	385	15,400
50	18	-	1825	60	60	65	15	119	7,900
51	18	-	1810	120	60	65	15	112	7,500
52	18	-	1750	180	60	65	15	152	10,100
53	18	-	1740	240	60	30	15	62	4,100
54	18	-	1710	300	25	30	15	27	4,310
55	18	-	1650	330	25	30	15	31	4,960
56	19	-	1832	-	100	65	60	532	5,320
57	19	50	1833	-	25	65	60	505	20,200
58	19	-	1825	60	50	65	15	116	9,280
59	19	-	1780	120	50	65	15	116	9,280
60	19	-	1700	180	50	65	15	148	11,840

61	19	-	1717	240	50	30	15	54	4,320
62	19	-	1695	300	30	30	15	33	4,410
63	19	-	1680	330	30	30	15	41	5,466
64	Comp 20	-	1837	-	100	65	60	210	2,100
65	Comp 20	50	1834	-	65	65	60	194	5,970
66	Comp 20	-	55	100	50	60	60		waxy material
67	Comp 20	-	55	125	50	60	60		waxy material
68	Comp 20	-	55	142	50	60	60		waxy material
69	Comp 21	-	1838	-	101	65	60	369	3,650
70	Comp 21	50	1837	-	82	65	60	525	6,400
71	Comp 21	-	55	100	50	60	60		waxy material
72	Comp 21	-	55	125	50	60	60		waxy material
73	Comp 21	-	55	142	50	60	60		waxy material
74	Comp 22	-	1830	-	105	65	60	517	4,920
75	Comp 22	50	1830	-	56	65	60	667	11,910
76	Comp 22	-	55	142	50	60	60		
77	Comp 23	-	1836	-	104	65	60	215	2,070
78	Comp 23	50	1834	-	61	65	60	581	9,520
79	Comp 23	-	1200	25	50	60	60	140	2,800
80	Comp 23	-	1200	38	50	60	60	130	2,600
81	Comp 23	-	1184	75	50	60	60	160	3,200
82	Comp 23	-	1115	110	50	60	60	190	3,800

Table 2: Polymer Properties

Poly. Example	Catalyst From Example	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
1	13	-	152	0.27	0.75	809.0	3.3	0.5
2	13	-	153	2.9	8.5	337.0	2.8	0.5
3	13	2.3	134	1.1	3.0	452.8	2.9	
4	13	4.8	115	1.3	4.2	372.0	3.3	
5	13	10.2	89	0.7	1.8	463.5	2.9	
10	13	47.5	amor-phous	3.2	9.1	315.0	3.0	
11	13	55.0	amor-phous	15.1	48.9	167.5	2.9	
12	14	-	152	0.28	0.85	794.0	3.2	0.4
13	14	-	152	3.0	8.7	327.0	2.9	0.5
14	14	2.2	135	1.2	3.2	442.4	2.9	

15	14	4.7	116	1.3	4.0	382.0	3.2	
16	14	9.9	90	0.75	2.0	440.0	3.0	
20	14	33.7	amor-phous	2.3	7.0	355.0	2.9	
21	14	54.2	amor-phous	13.2	47.2	175.3	2.8	
22	15	-	151	0.15	0.5	902.0	3.1	0.5
23	15	-	152	1.9	6.0	385.0	2.9	0.5
24	15	2.5	132	0.7	2.0	471.0	3.1	
25	15	5.2	114	0.9	3.2	385.0	3.6	
26	15	11.2	82	0.5	1.4	581.0	3.5	
31	15	52.7	amor-phous	10.0	34.1	189.7	3.2	
32	16	-	154	0.27	0.75	739.0	2.9	0.5
33	16	-	155	2.9	8.5	327.5	2.9	0.5
34	16	1.8	139	1.1	3.0	439.0	3.2	
35	16	4.0	124	1.3	4.2	361.3	2.8	
36	16	9.2	92	0.7	1.8	453.2	2.7	
40	17	-	152	0.25	0.77	796.0	3.1	0.5
41	17	-	152	3.1	8.9	309.0	2.9	0.5
42	17	2.1	135	1.0	3.1	438.9	2.8	
43	17	4.9	117	1.2	4.1	390.5	3.1	
44	17	11.0	85	0.7	1.9	455.0	3.0	
48	18	-	149	3.0	8.9	523.0	3.0	
49	18	-	150	21.1	62.9	237.5	2.8	
50	18	1.8	135	1.5	5.1	388.9	3.8	
51	18	4.3	116	3.2	10.1	230.5	2.7	

52	18	10.2	78	11.9	35.9	180.0	3.1	
56	19	-	150	0.4	1.3	798.0	3.0	0.5
57	19	-	151	3.2	10.5	319.0	2.6	0.5
58	19	2.3	131	1.5	3.9	442.3	2.8	
59	19	4.8	112	1.0	3.4	361.0	3.5	
60	19	10.2	76	0.6	1.9	474.5	3.7	
64	Comp 20	-	147	14	44	184.9	2.7	1.2
65	Comp 20	-	148	29	98	166.3	2.6	
66	Comp 20	39.5	amor-phous	n.m.	n.m	< 20		
68	Comp 20	53.7	amor-phous	n.m	n.m	< 20		
69	Comp 21	-	144	4.3	14	317.1	2.6	1.0
70	Comp 21	-	146	64	200	145.8	2.2	1.0
71	Comp 21	32.5	amor-phous	n.m.	n.m	< 20		
73	Comp 21	45.7	amor-phous	n.m	n.m	< 20		
74	Comp 22		151	0.35	1.8	730.0	4.0	
75	Comp 22		151	4.3	12	215.5	3.9	
76	Comp 22	49.5	amor-phous	25.4	81.0	169.7	3.3	
77	Comp 23	-	153	1.2	4.0	386.7	2.8	1.2
78	Comp 23	-	155	45.3	152	146.3	2.4	1.0
79	Comp 23	1.5	142	0.36	1.62	461.3	2.84	
80	Comp 23	2.2	140	0.28	1.4	488.1	2.67	
81	Comp 23	3.8	125	0.1	0.55	531.6	2.81	
82	Comp 23	5.9	108	0.01	0.07	725.4	2.81	

Analysis of Results

While the invention of the present application is so exceptional that it shows unexpected improvements over the whole class of Metallocenes, the applicants note that true comparisons of the effect of this invention must be evaluated upon metallocenes of similar structure of the indenyl group at other than the 2 position. Therefore, while part of this analysis will make aggregate comparisons between the several inventive examples and the comparative examples, individual catalyst comparisons should only be made when the substitutions in all positions of the indenyl groups other than the 2 position are the same to ensure a proper comparison of apples to apples. Therefore, individual catalyst comparisons should only be made between inventive examples 13, 14 and 17 (ethyl and methyl substituents in the 2 positions and t-butyl-phenyl substituents in the 4 positions of the indenyl groups) to comparative examples 22 and 23 (methyl or isopropyl substituents in the 2 positions and t-butyl-phenyl substituents in the 4 positions of the indenyl groups). Individual catalyst comparisons with the comparative examples 20 and 21 are not possible because in these cases the substitutions in all positions of the indenyl groups other than the 2 position are not the same as the catalyst from comparative example 20 has no substitution in the 4 positions of the indenylligands and the catalyst from comparative example 21 carries a cyclic system bridging the positions 4 and 5 of the indenylligands.

Table 1 and Table 2 represent the raw data presented by test run; the remaining tables 3 - 12 break that data out by the ratio of propylene to ethylene or if the polymer is a propylene homopolymer whether hydrogen was used in the polymerization process.

Propylene homopolymers

Analysis 1: Production of Propylene polymers without the ethylene comonomer and in the absence of hydrogen.

Table 3 shows the results of seven experimental Metallocene catalysts conforming to the requirements of the invention compared to four comparative examples. In the aggregate, the catalysts of the present invention showed a 70% increase in productivity while at the same time showing a 89% increase in Molecular Weight and more than a two degree Celcius increase in melting point (significant when the range of melting points for homopolymer polypropylene is 144 to 154 degree Celsius). Further the catalysts of the current invention produced products with an aggregate MFR 2.16 of just about 13% of that of the comparative products and an aggregate MFR 5 of just about 12% of the comparative examples. This dramatic drop in MFR indicates a dramatic increase of Molecular Weight (89%) and opens full access to application fields like film, pipe or sheets, where a high Molecular Weight is mandatory.

The individual catalyst comparisons between inventive samples 13, 14 and 17 and comparative examples 22 and 23 are just as dramatic. When examples 13, 14 and 17 are compared to comparative examples 22 and 23, all inventive examples exhibit significantly lower xylene solubles, lower MFR 2.16, MFR 5 rates and increases in Molecular Weight. Specifically for MFR 2.16, the inventive examples 13, 14 and 17 show a reduction of 23%, 20%, and 29% of the original value of example 22. For the MFR 5, the inventive examples 13, 14 and 17 show a respective reduction of 58%, 53% and 57% of the original value of example 22. For the molecular weight, the inventive examples 13, 14 and 17 show a respective increase of 11%, 9% and 9% over the original value. Even more surprisingly is that the inventive examples 13, 14 and 17 showed these dramatic improvements in product properties at significantly higher productivity levels of 20%, 12% and 18%.

When examples 13, 14 and 17 are compared to comparative example 23, all three inventive examples exhibit significantly lower MFR 2.16, MFR 5 rates and increases in Molecular Weight. Specifically for MFR 2.16, the inventive examples 13, 14 and 17 show a respective reduction of about 78% of the original value of example 23. For MFR 5, inventive examples 13, 14 and 17 show a respective reduction of about 80% of the original value of example 23. For the molecular weight, the inventive examples 13, 14 and 17 show a respective increase of 109%, 105% and 106% over the original value. Productivity was also massively enhanced, respectively by a 186%, 166% and 180% increase over the original value of example 23.

Analysis 2: Production of Propylene polymers without the ethylene comonomer and in the presence of hydrogen.

Table 4 shows the results of seven experimental Metallocene catalysts conforming to the requirements of the invention compared to four comparative examples. However, in this case, hydrogen was added during the polymerization process to enhance catalyst productivity and to regulate the Molecular Weight. In the aggregate, the catalysts of the present invention showed more than a 133% increase in productivity while at the same time showing more than a 90% increase in Molecular Weight and almost a two degree Celcius increase in melting point (significant when the range of melting points for homopolymer polypropylene is 146 to 155). Further the catalysts of the current invention produced products with an aggregate MFR 2.16 of only 15% of that of the comparative products and an aggregate MFR 5 of only 14% of the comparative examples.

The individual catalyst comparisons between inventive samples 13, 14 and 17 and comparative examples 22 and 23 again are dramatic.

When examples 13, 14 and 17 are compared to comparative example 22, all three inventive examples exhibit significantly lower MFR 2.16, MFR 5 rates and increases in Molecular Weight. Specifically for MFR 2.16, the inventive examples 13, 14 and 17 show a respective reduction of 33%, 30%, and 28% of the original value of example 22. For the MFR 5, the inventive examples 13, 14 and 17 show a respective reduction of 29%, 27% and 26% of the original value of example 22. For the molecular weight, the inventive examples 13, 14 and 17 show a respective increase of 56%, 52% and 43% over the comparative value. Even more surprisingly is that the inventive examples showed these dramatic improvements in product properties at increased productivity levels of 88%, 71% and 85% over the comparative value.

When examples 13, 14 and 17 are compared to comparative example 23, all three inventive examples exhibit significantly lower MFR 2.16, MFR 5 rates and increases in Molecular Weight. Specifically for MFR 2.16, the inventive examples 13, 14 and 17 show a respective reduction of 93% to 94% of the original value of comparative example 23. For MFR 5, inventive examples 13, 14 and 17 show a respective reduction of about 94% of the original value of example 23. For the molecular weight, the inventive examples 13, 14 and 17 show a respective increase of 130%, 124% and 111% over the original value. Productivity was also significantly enhanced, respectively by a 135%, 114% and 131% increase over the comparative value.

Propylene/Ethylene Copolymers

The properties of products made from the inventive catalysts were tested at various levels of an ethylene/propylene mix to form copolymers. With the introduction of a new variable, the propylene to ethylene ratio, far fewer datapoints were taken for the copolymers made with the comparative catalysts at each ratio

because resources became limited. In each case the inventive catalysts from example 13, 14 and 15 have been tested and in most cases, the full set of inventive catalysts from examples 13 to 19 have been tested. Due to the high productivity of the inventive catalysts, only 15 minutes polymerization time has been applied, while the low productivity of the comparative examples required a 60 minutes polymerization time. Consequently, not identical polymerisation conditions exclude in most cases a direct comparison of the polymerisations based on inventive catalysts and comparative catalysts. Moreover, individual catalyst comparisons with the comparative examples 20 and 21 are not possible because in these cases the substitutions in all positions of the indenyl groups other than the 2 position are not the same as the catalyst from comparative example 20 has no substitution in the 4 positions of the indenylligands and the catalyst from comparative example 21 carries a cyclic system bridging the positions 4 and 5 of the indenylligands.

Analysis 3: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 30 and in the absence of hydrogen.

In this case, all inventive catalysts(examples 13 to 19) and one comparative catalyst (example 23), were tested, the results being presented in Table 5. However, as noted before, due to the high productivity of the inventive catalysts, only 15 minutes polymerization time has been applied, while the low productivity of the comparative example required a 60 minutes polymerization time. Consequently, not identical polymerization conditions exclude a direct comparison of the polymerisations based on inventive catalysts and comparative catalyst, but are provided for informational purposes only.

Overall, the polymers based on the inventive metallocenes show an extremely high productivity, a similar incorporation of the ethylene comonomer (content of 1.8 to 2.5 wt.% ethylene), a low MFR 2,16 level (0.7 to 1.5) resp. MFR 5 level (2.0 to 5.1) and a high Molecular Weight (389 to 471) and open full access

to application fields like film, pipe or sheets, where a high Molecular Weight, low MFR and a low content of catalyst residues (achieved by the high catalyst productivity) are mandatory.

Analysis 4: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 15 and in the absence of hydrogen.

In this case, all inventive catalysts (examples 13 to 19) and one comparative catalyst (example 23), were tested, the results being presented in Table 6. However, as noted before, due to the high productivity of the inventive catalysts, only 15 minutes polymerization time has been applied, while the low productivity of the comparative example required a 60 minutes polymerization time. Consequently, not identical polymerization conditions exclude a direct comparison of the polymerisations based on inventive catalysts and comparative catalyst but are provided for informational purposes only.

Overall, the polymers based on the inventive metallocenes show an extremely high productivity, a similar incorporation of the ethylene comonomer (content of 4.0 to 5.2 wt.% ethylene), a low MFR 2,16 level (0.9 to 3.2) resp. MFR 5 level (3.2 to 10.1) and a high Molecular Weight (231 to 385) and open full access to application fields like film, pipe or sheets, where a high Molecular Weight, low MFR and a low content of catalyst residues (achieved by the high catalyst productivity) are mandatory.

Analysis 5: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 9.5 and in the absence of hydrogen.

In this case, all inventive catalysts (examples 13 to 19) and one comparative catalyst (example 23), were tested, the results being presented in Table 7. However, as noted before, due to the high productivity of the inventive

catalysts, only 15 minutes polymerization time has been applied, while the low productivity of the comparative example required a 60 minutes polymerization time. Consequently, not identical polymerisation conditions exclude a direct comparison of the polymerizations based on inventive catalysts and comparative catalyst but are provided for informational purposes only.

Overall, the polymers based on the inventive metallocenes 13 to 17 and 19 show an extremely high productivity, a similar incorporation of the ethylene comonomer (content of 9.2 to 11.2 wt.% ethylene), a low MFR 2,16 level (0.5 to 0.75) resp. MFR 5 level (1.4 to 2.0) and a high Molecular Weight (440 to 581) and open full access to application fields like film, pipe or sheets, where a high Molecular Weight, low MFR and a low content of catalyst residues (achieved by the high catalyst productivity) are mandatory. In addition, copolymers based on catalyst from example 18 open opportunities in the fields of fibre and injection molding applications where slightly higher MFR´s and slightly lower Molecular Weights combined with a high catalyst productivity and and an excellent comonomer incorporation is required.

Analysis 6: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 7and in the absence of hydrogen.

In this case, all inventive catalysts (examples 13 to 19) were tested, the productivity results presented in Table 8 are provided for informational purposes only.

Analysis 7: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 5 resp. 5.6 and in the absence of hydrogen.

In this case, all inventive catalysts (examples 13 to 19) were tested, the productivity results presented in Table 9 are provided for informational purposes only.

Analysis 8: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 0.55 and in the absence of hydrogen.

In this case, the inventive catalysts from examples 13 to 15 and two comparative catalysts from comparative examples 20 and 21 were tested, the results being presented in Table 10. However, individual catalyst comparisons with the comparative examples 20 and 21 are not possible because in these cases the substitutions in all positions of the indenyl groups other than the 2 position are not the same as the catalyst from comparative example 20 has no substitution in the 4 positions of the indenylligands and the catalyst from comparative example 21 carries a cyclic system bridging the positions 4 and 5 of the indenylligands, but are provided for informational purposes only.

Overall, the polymers based on the inventive metallocenes 13 to 15 clearly show the superior performance of the concept of the invention. While the polymerizations based on state of the art catalysts, based on metallocenes from examples 20 and 21, result in polymers with waxy consistency and extremely low molecular weight which makes the measurement of MFR values impossible, the propylene/ethylene rubber produced with catalyst from example 14 shows still a reasonable high Molecular Weight and low MFR values. Due to capacity limitations, the originally planned polymerization examples 9 and 30 have not been performed.

Analysis 9: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 0.44 and in the absence of hydrogen.

In this case, the inventive catalyst from example 13 and two comparative catalysts from comparative examples 20 and 21 were tested, the results being presented in Table 11. However, individual catalyst comparisons with the comparative examples 20 and 21 are not possible because in these cases the substitutions in all positions of the indenyl groups other than the 2 position are not the same, as the catalyst from comparative example 20 has no substitution in the 4 positions of the indenylligands and the catalyst from comparative example 21 carries a cyclic system bridging the positions 4 and 5 of the indenylligands, but are provided for informational purposes only.

Nevertheless, the polymer based on the inventive metallocene 13 clearly shows the superior performance of the concept of the invention. While the polymerizations based on state of the art catalysts, based on metallocenes from examples 20 and 21, result in polymers with waxy consistency where the measurement of MFR and Molecular Weight was no longer possible, the propylene/ethylene rubber produced with catalyst from example 13 shows still a reasonable high Molecular Weight and low MFR values.

Analysis 10: Production of propylene/ethylene copolymers with a propylene/ethylene ratio of approximately 0.39 and without the presence of hydrogen.

In this case, the inventive catalysts from examples 13 to 15 and three comparative catalysts from comparative examples 20, 21 and 22 were tested, the results being presented in Table 12. The polymerizations based on the inventive catalysts 13 and 14 can be compared with the results from the polymerizations based on the comparative catalyst 22. However, individual catalyst comparisons with the comparative examples 20 and 21 are not possible because in these cases the substitutions in all positions of the indenyl groups other than the 2 position are not the same as the catalyst from comparative example 20 has no substitution in the 4

positions of the indenylligands and the catalyst from comparative example 21 carries a cyclic system bridging the positions 4 and 5 of the indenylligands, but are provided for informational purposes only.

Overall, the polymers based on the inventive metallocenes 13 to 15 clearly show the superior performance of the concept of the invention. While the polymerizations based on state of the art catalysts, based on metallocenes from examples 20 and 21, result in polymers with waxy consistency and extremely low molecular weight (< 20) which makes the measurement of MFR values impossible, the propylene/ethylene rubber produced with catalysts from examples 13, 14 and 15 show still reasonable Molecular Weight and MFR values.

The direct comparison of polymers produced with catalysts 13 and 14 with the polymer produced using the non inventive catalyst from comparative example 22 shows, that the ethylene content of the comparison example is due to worse ethylene incorporation behaviour about 5% lower than the high incorporations found for the catalysts 13 and 14 which should lead to higher Molecular Weights and lower MFR values of the polymer of the comparative example. But this is not the case.

When examples 13 and14 are compared to comparative example 22, all inventive examples exhibit significantly lower MFR 2.16 and MFR 5 rates. Specifically for MFR 2.16, the inventive examples 13 and 14 show a respective reduction of more than 40% and 48% of the original value of the comparative example 22. For MFR 5, inventive examples 13 and 14 show a respective reduction of 40 to 42% of the original value of example 22. For the Molecular Weight, the inventive examples 13 and 14 show similar values from 167.5 to 175.3.

Table 3: Propylene homo polymerizations without hydrogen

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
1	13	-	1837	-	105	65	60	623	5,930	152	0.27	0.75	809.0	3.3	0.5
12	14	-	1835	-	100	65	60	550	5,500	152	0.28	0.85	794.0	3.2	0.4
22	15	-	1800	-	100	65	60	480	5,100	151	0.15	0.5	902.0	3.1	0.5
32	16	-	1810	-	100	65	60	520	5,200	154	0.27	0.75	739.0	2.9	0.5
40	17	-	1750	-	100	65	60	580	5,800	152	0.25	0.77	796.0	3.1	0.5
48	18	-	1830	-	100	65	60	480	4,990	149	3.0	8.9	523.0	3.0	
56	19	-	1832	-	100	65	60	532	5,320	150	0.4	1.3	798.0	3.0	0.5
64	Comp 20	-	1837	-	100	65	60	210	2,100	147	14	44	184.9	2.7	1.2
69	Comp 21	-	1838	-	101	65	60	369	3,650	144	4.3	14	317.1	2.6	1.0
74	Comp 22	-	1830	-	105	65	60	517	4,920	151	0.35	1.8	730.0	4.0	
77	Comp 23	-	1836	-	104	65	60	215	2,070	153	1.2	4.0	386.7	2.8	1.2
						Average Experimental			5406	151	0.66	1.97	765.9		
						Average Comparative			3185	149	4.96	15.95	404.7		

Table 4: Propylene homo polymerizations with hydrogen

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
2	13	50	1836	-	25	65	60	560	22,400	153	2.9	8.5	337.0	2.8	0.5
13	14	50	1832	-	30	65	60	612	20,400	152	3.0	8.7	327.0	2.9	0.5
23	15	50	1750	-	30	65	60	550	18,300	152	1.9	6.0	385.0	2.9	0.5
33	16	50	1800	-	30	65	60	570	19,100	155	2.9	8.5	327.5	2.9	0.5
41	17	50	1830	-	25	65	60	550	22,000	152	3.1	8.9	309.0	2.9	0.5
49	18	50	1835	-	25	65	60	385	15,400	150	21.1	62.9	237.5	2.8	
57	19	50	1833	-	25	65	60	505	20,200	151	3.2	10.5	319.0	2.6	0.5
65	Comp 20	50	1834	-	65	65	60	194	5,970	148	29	98	166.3	2.6	
70	Comp 21	50	1837	-	82	65	60	525	6,400	146	64	200	145.8	2.2	1.0
75	Comp 22	50	1830	-	56	65	60	667	11,910	151	4.3	12	215.5	3.9	
78	Comp 23	50	1834	-	61	65	60	581	9,520	155	45.3	152	146.3	2.4	1.0
						Average Experimental			19686	152	5.4	16.3	320.3		
						Average Comparative			8450	150	35.7	115.5	168.5		

Table 5: Propylene/Ethylene Ratio ~ 30, Production of Propylene/Ethylene Random Co-polymers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
3	13	-	1820	60	75	65	15	200	10,670	2.3	134	1.1	3.0	452.8	2.9	
14	14	-	1825	60	70	65	15	200	11,500	2.2	135	1.2	3.2	442.4	2.9	
24	15	-	1820	60	70	65	15	187	10,700	2.5	132	0.7	2.0	471.0	3.1	
34	16	-	1800	60	70	65	15	200	11,400	1.8	139	1.1	3.0	439.0	3.2	
42	17	-	1850	60	65	65	15	177	10,870	2.1	135	1.0	3.1	438.9	2.8	
50	18	-	1825	60	60	65	15	119	7,900	1.8	135	1.5	5.1	388.9	3.8	
58	19	-	1825	60	50	65	15	116	9,280	2.3	131	1.5	3.9	442.3	2.8	
79	Comp 23	-	1200	25	50	60	60	140	2,800	1.5	142	0.36	1.62	461.3	2.84	
80	Comp 23	-	1200	38	50	60	60	130	2,600	2.2	140	0.28	1.4	488.1	2.67	

Table 6: Propylene/Ethylene Ratio ~ 15, Production of Propylene/Ethylene Random Co-polymers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
4	13	-	1760	120	75	65	15	200	10,670	4.8	115	1.3	4.2	372.0	3.3	
15	14	-	1750	120	70	65	15	220	12,550	4.7	116	1.3	4.0	382.0	3.2	
25	15	-	1780	120	70	65	15	163	9,300	5.2	114	0.9	3.2	385.0	3.6	
35	16	-	1790	120	70	65	15	205	11,700	4.0	124	1.3	4.2	361.3	2.8	
43	17	-	1800	120	65	65	15	180	11,100	4.9	117	1.2	4.1	390.5	3.1	
51	18	-	1810	120	60	65	15	112	7,500	4.3	116	3.2	10.1	230.5	2.7	
59	19	-	1780	120	50	65	15	116	9,280	4.8	112	1.0	3.4	361.0	3.5	
81	Comp 23	-	1184	75	50	60	60	160	3,200	3.8	125	0.1	0.55	531.6	2.81	

Table 7: Propylene/Ethylene Ratio ~ 9.5, Production of Propylene/Ethylene Random Co-polymers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
5	13	-	1700	180	75	65	15	250	13,300	10.2	89	0.7	1.8	463.5	2.9	
16	14	-	1680	180	70	65	15	230	13,000	9.9	90	0.75	2.0	440.0	3.0	
26	15	-	1695	180	70	65	15	180	10,400	11.2	82	0.5	1.4	581.0	3.5	
36	16	-	1720	180	70	65	15	217	12,400	9.2	92	0.7	1.8	453.2	2.7	
44	17	-	1760	180	65	65	15	205	12,600	11.0	85	0.7	1.9	455.0	3.0	
52	18	-	1750	180	60	65	15	152	10,100	10.2	78	11.9	35.9	180.0	3.1	
60	19	-	1700	180	50	65	15	148	11,840	10.2	76	0.6	1.9	474.5	3.7	
82	Comp 23	-	1115	110	50	60	60	190	3,800	5.9	108	0.01	0.07	725.4	2.81	

Table 8: Propylene/Ethylene Ratio ~ 7, Production of Propylene/Ethylene Random Co-polymers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
6	13	-	1640	240	75	30	15	103	5,500							
17	14	-	1600	240	70	30	15	96	5,500							
27	15	-	1690	240	70	30	15	84	4,800							
37	16	-	1750	240	70	30	15	98	5,600							
45	17	-	1720	240	65	30	15	83	5,100							
53	18	-	1740	240	60	30	15	62	4,100							
61	19	-	1717	240	50	30	15	54	4,320							

Table 9: Propylene/Ethylene Ratio ~ 5.0 for the experiments where 330 gms ethylene have been used and ~ 5.6 for the experiments where 300 gms ethylene have been used, Production of Propylene/Ethylene Random Co-polymers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
7	13	-	1580	300	25	30	15	33	5,760							
8	13	-	1550	330	25	30	15	40	6,400							
18	14	-	1550	300	30	30	15	40	5,300							
19	14	-	1600	330	30	30	15	44	5,800							
28	15	-	1750	300	30	30	15	36	4,800							
29	15	-	1690	330	30	30	15	34	4,500							
38	16	-	1710	300	30	30	15	36	4,800							
39	16	-	1740	330	30	30	15	34	4,500							
46	17	-	1725	300	25	30	15	33	5,250							
47	17	-	1710	330	25	30	15	39	6,280							
54	18	-	1710	300	25	30	15	27	4,310							
55	18	-	1650	330	25	30	15	31	4,960							
62	19	-	1695	300	30	30	15	33	4,410							
63	19	-	1680	330	30	30	15	41	5,466							

Table 10: Propylene/Ethylene Ratio 0.55, Production of Propylene/Ethylene Rubbers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
9	13	-	55	100	50	60	60									
20	14	-	55	100	50	60	60			33.7	amorphous	2.3	7.0	355.0	2.9	
30	15	-	55	100	50	60	60									
66	Comp 20	-	55	100	50	60	60		waxy material	39.5	amorphous	n.m.	n.m	< 20		
71	Comp 21	-	55	100	50	60	60		waxy material	32.5	amorphous	n.m.	n.m	< 20		

Table 11: Propylene/Ethylene Ratio 0.44, Production of Propylene/Ethylene Rubbers

Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
10	13	-	55	125	50	60	60			47.5	amorphous	3.2	9.1	315.0	3.0	
67	Comp 20	-	55	125	50	60	60		waxy material							
72	Comp 21	-	55	125	50	60	60		waxy material							

Table 12: Propylene/Ethylene Ratio 0.39, Production of Propylene/Ethylene Rubbers

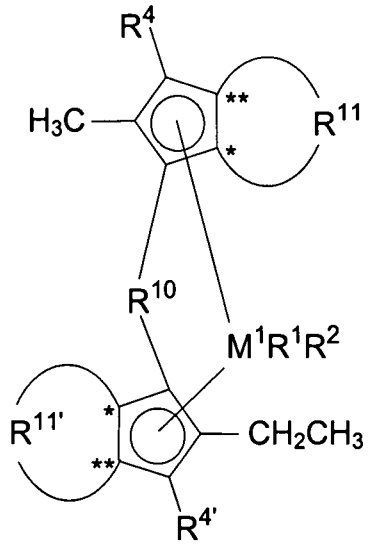
Poly. Example	Catalyst From Example	H2 [mg]	C3 [g]	C2 [g]	Catalyst [mg]	Polym. Temp. [°C]	Polym. Time [min]	Yield [g]	Productivity [g polymer / g catalyst*hour]	C2 [wt%]	Tm [deg C]	MFR 2.16 [g/10']	MFR 5 [g/10']	Mw [kg/mol]	Mw/Mn	XS [wt%]
11	13	-	55	142	50	60	60			55.0	amorphous	15.1	48.9	167.5	2.9	
21	14	-	55	142	50	60	60			54.2	amorphous	13.2	47.2	175.3	2.8	
31	15	-	55	142	50	60	60			52.7	amorphous	10.0	34.1	189.7	3.2	
68	Comp 20	-	55	142	50	60	60		waxy material	53.7	amorphous	n.m	n.m	< 20		
73	Comp 21	-	55	142	50	60	60		waxy material	45.7	amorphous	n.m	n.m	< 20		
76	Comp 22	-	55	142	50	60	60			49.5	amorphous	25.4	81.0	169.7	3.3	

While the above description contains many specifics, these specifics should not be construed as limitations, but merely as exemplifications of preferred embodiments thereof. Those skilled in the art will envision many other embodiments within the scope and spirit of the inventions as defined by the claims appended hereto.

WHAT IS CLAIMED IS:

1. A process for olefin polymerization comprising:

contacting one or more olefin with a catalyst system under polymerization reaction conditions, wherein said catalyst system includes at least one metallocene component of the general Formula 1 below,



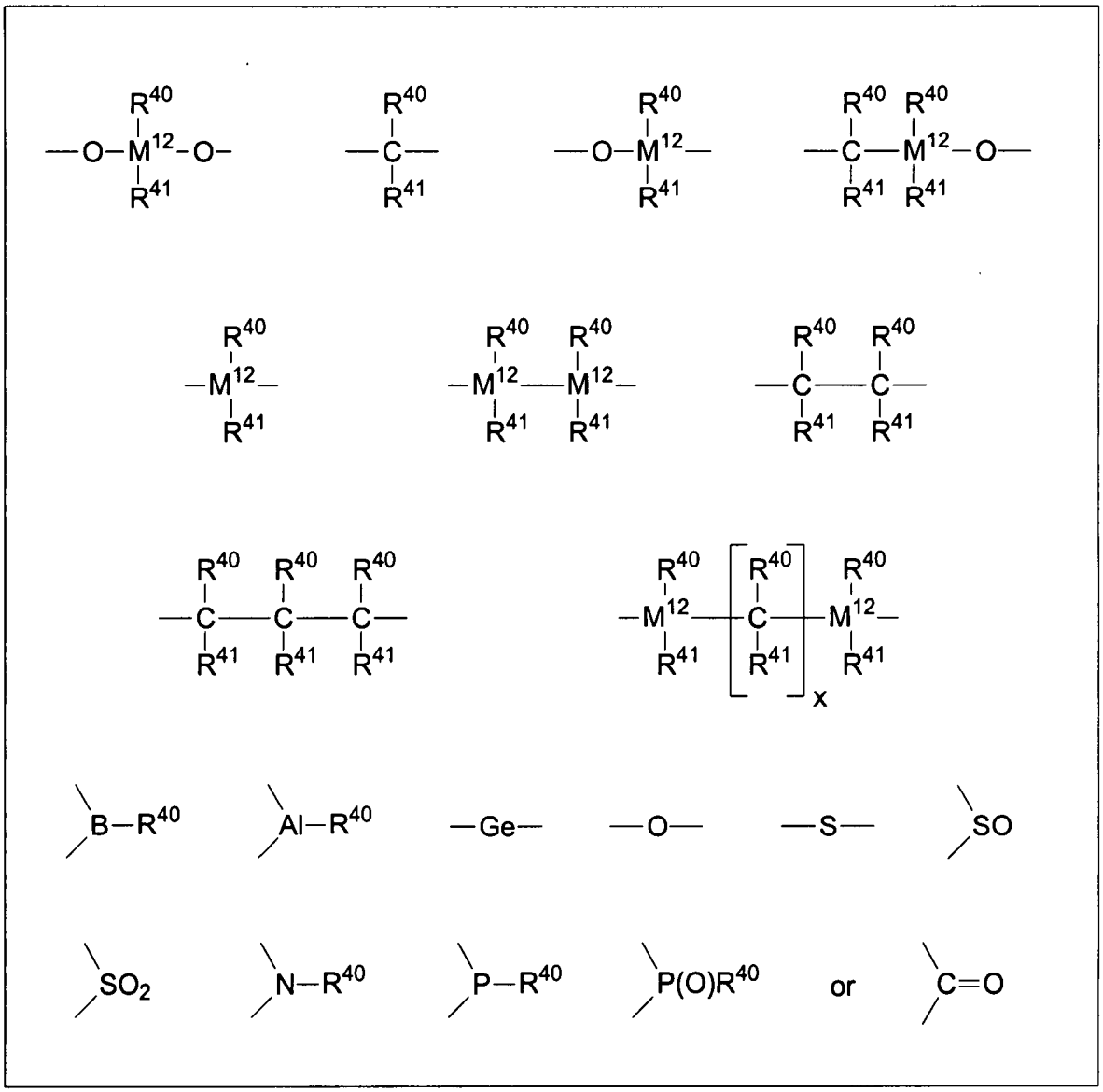
(Formula 1)

where M^1 is a metal of Group IVb of the Periodic Table of the Elements,

R^1 and R^2 are identical or different and are each a hydrogen atom, an alkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an OH group, a halogen atom, or a NR_2^{32} group, where R^{32} is an alkyl group of from 1 to about 10 carbon atoms or an aryl group of from 6 to about 14 carbon atoms and R^1 and R^2 may form one or more ring system(s),

R^4 and $R^{4'}$ are each a hydrogen atom,

R^{10} is a bridging group wherein R^{10} is selected from:



where

R^{40} and R^{41}, even when bearing the same index, can be identical or different and are each selected from the group consisting of a hydrogen atom, an alkyl group having from 1 to about 30 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, a fluoroalkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, a substituted or unsubstituted alkylsilyl, alkyl(aryl)silyl or

arylsilyl group and an arylalkenyl group of from 8 to about 40 carbon atoms or wherein R^{40} and R^{41} together with the atoms connecting them form one or more cyclic systems or wherein R^{40} and/or R^{41} contain additional hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, Cl and Br,

x is an integer from 1 to 18,

M^{12} is silicon, germanium or tin, and

R^{10} may also link two units of the formula 1 to one another, and

R^{11} and $R^{11'}$ are identical or different and are each a divalent C_2-C_{40} group which together with the cyclopentadienyl ring forms a further saturated or unsaturated ring system having a ring size of from 5 to 7 atoms, with or without heteroatoms selected from the group consisting of Si, Ge, N, P, O and S within the ring system fused onto the cyclopentadienyl ring, and wherein the symbols * and ** denote chemical bonds joining R^{11} and $R^{11'}$ to the cyclopentadienyl ring.

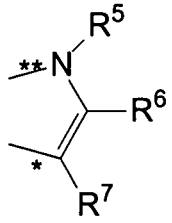
2 . The process of claim 1 wherein R^{10} is $R^{40}R^{41}Si=$, $R^{40}R^{41}Ge=$, R^{40} $R^{41}C=$ or $-(R^{40}R^{41}C-CR^{40}R^{41})-$,

where R^{40} and R^{41} are identical or different and are each a hydrogen atom, a hydrocarbon group of from 1 to about 30 carbon atoms, in particular an alkyl group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 14 carbon atoms, an alkylaryl group of from 7 to about 14 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl or an arylsilyl group.

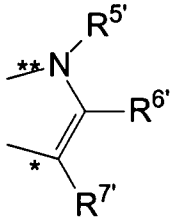
3. The process of claim 1 wherein the bridging unit R^{10} is $R^{40}R^{41}Si=$ or $R^{40}R^{41}Ge=$,

where R^{40} and R^{41} are identical or different and are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, cyclopentyl, cyclopentadienyl, cyclohexyl, phenyl, naphthyl, benzyl, trimethylsilyl or 3,3,3-trifluoropropyl.

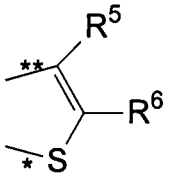
4. The process of claim 1 wherein the groups R^{11} and $R^{11'}$ are identical or different and are each a divalent group selected from those given in Formulae 1 α, β, γ, δ, ϕ, and ν and Formulae 1 α', β', γ', δ', ϕ', and ν', respectively:



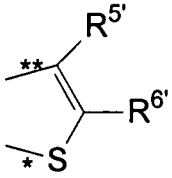
Formula 1α



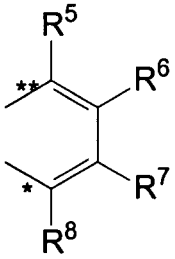
Formula 1α'



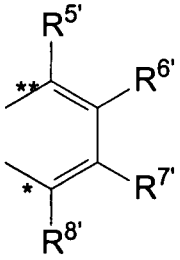
Formula 1β



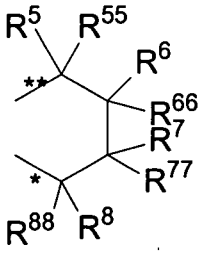
Formula 1β'



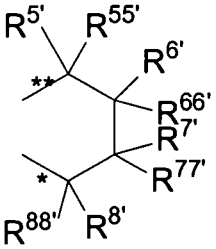
Formula 1γ



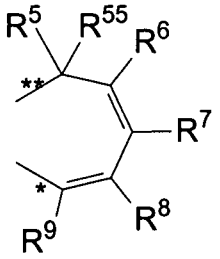
Formula 1γ'



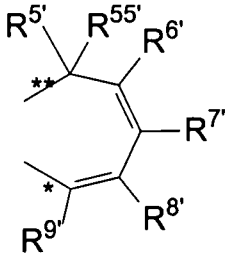
Formula 1δ



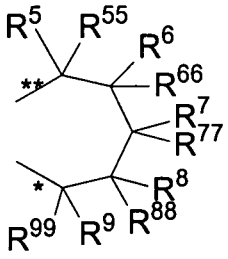
Formula 1δ'



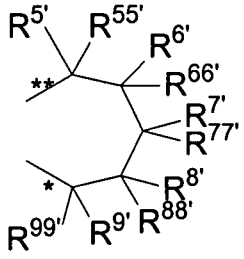
Formula 1ϕ



Formula 1ϕ'



Formula 1ν



Formula 1ν'

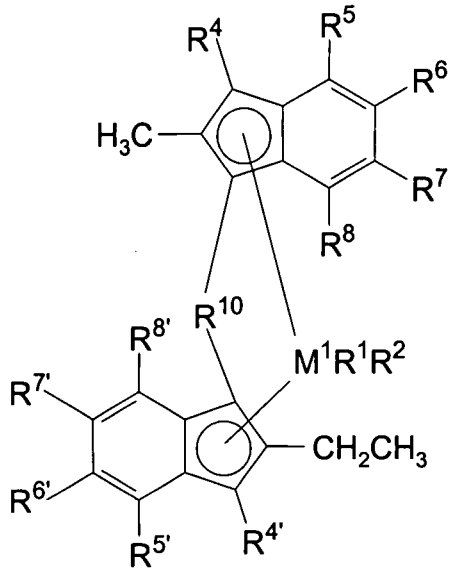
wherein R^5, R^6, R^7, R^8, and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ as well as R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are identical or different and are each selected from the group consisting of a hydrogen atom, a linear, cyclic or branched hydrocarbon group with or without heteroatoms selected from Si, B, Al, O, S, N, P, F, Cl and Br, said hydrocarbon group being selected from an alkyl group of from 2 to about 20 carbon atoms, an alkenyl group of from 2 to about 20 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, an arylalkenyl group of from 8 to about 40 carbon atoms, a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group and an arylsilyl group, wherein two adjacent radicals R^5, R^6 or $R^{5'}$, $R^{6'}$ or R^6, R^7 or $R^{6'}$, $R^{7'}$ or R^7, R^8 or $R^{7'}$, $R^{8'}$ or R^8, R^9 or $R^{8'}$, $R^{9'}$ as well as R^{55}, R^{66} or $R^{55'}$, $R^{66'}$ or R^{66}, R^{77} or $R^{66'}$, $R^{77'}$ or R^{77}, R^{88} or $R^{77'}$, $R^{88'}$ or R^{88}, R^{99} or $R^{88'}$, $R^{99'}$ in each case may optionally form a saturated or unsaturated hydrocarbon ring system.

5. The process of claim 4 wherein R^{11} and $R^{11'}$ are identical or different and R^{11} is a divalent group according to Formula 1γ and $R^{11'}$ is selected from the divalent groups in Formulae 1α', β', and γ' or R^{11} and $R^{11'}$ are identical or different and are divalent groups according to Formula 1α and 1α' or Formula 1β and 1β' or Formula 1γ and 1γ' or Formula 1δ and 1δ' or Formula 1ϕ and 1ϕ' or Formula 1ν and 1ν', respectively.

6. The process of claim 4 wherein R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are each a hydrogen atom and R^5, R^6, R^7, R^8 and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms, which may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br. The two adjacent radicals R^5/R^6 and also $R^{5'}/R^{6'}$ may form a hydrocarbon ring system or R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

7. The process of claim 4 wherein R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are each a hydrogen atom and R^5, R^6, R^7, R^8 and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms. The two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ together may form a ring system or R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

8. The process of claim 1 wherein the metallocene component is represented as Formula 1a below:



Formula 1a

wherein M^1, R^1, R^2, R^4, $R^{4'}$ and R^{10} have the meaning set forth above with respect to Formula 1 and

(i) wherein R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 1 to about 20 carbon atoms, an alkenyl group of from 2 to about 20 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group. The groups may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br, and / or two adjacent radicals R^5, R^6 or R^6, R^7 or R^7, R^8 and also $R^{5'}$, $R^{6'}$ or $R^{6'}$, $R^{7'}$ or $R^{7'}$, $R^{8'}$ in each case may form a hydrocarbon ring system

or

(ii) wherein R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon

atoms, an arylalkyl, alkaryl or aryl group of from 6 to about 40 carbon atoms, optionally including one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br, and/or the two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ can form a saturated or unsaturated hydrocarbon ring system.

9. The process of claim 8 wherein R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms and/or the two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ together may form a saturated or unsaturated ring system.

10. The process of claim 8 wherein R^6, R^7, R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 1 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group, and wherein two adjacent radicals R^6, R^7 or R^7, R^8 as well as $R^{6'}$, $R^{7'}$ or $R^{7'}$, $R^{8'}$ in each case may form a hydrocarbon ring system, wherein the groups may optionally contain one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br, and wherein R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms, optionally containing one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br.

11. The process of claim 8 wherein R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of

from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms, which may optionally contain one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br, and wherein R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

12. The process of claim 8 wherein R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms, R^5 and $R^{5'}$ are identical or different and are each selected from naphthyl, 4-methyl-phenyl, 4-biphenyl, 4-ethyl-phenyl, 4-n-propyl-phenyl, 4-isopropyl-phenyl, 4-tert-butyl-phenyl, 4-sec-butyl-phenyl, 4-cyclohexyl-phenyl, 4-trimethylsilyl-phenyl, 4-adamantyl-phenyl, 4-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_1-C_{10}-alkyl)-phenyl, 3-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_6-C_{20}-aryl)phenyl, 3,5-di-(C_1-C_{10}-alkyl)-phenyl, 3,5-di-(C_1-C_{10}-fluroalkyl)-phenyl and 3,5-(C_6-C_{20}-aryl)phenyl.

13. The process of claim 8 wherein

M1 is zirconium,

R^1 and R^2 are identical and are methyl, chlorine or phenolate,

R^4 and $R^{4'}$ are hydrogen,

R^{10} is $R^{40}R^{41}Si=$ or $R^{40}R^{41}Ge=$, where R^{40} and R^{41} are identical or different and are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, cyclopentyl, cyclopentadienyl, cyclohexyl, phenyl, naphthyl, benzyl, trimethylsilyl or 3,3,3-trifluoropropyl, and

R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms,

R^5 and $R^{5'}$ are identical and are selected from naphthyl, 4-methyl-phenyl, 4-biphenyl, 4-ethyl-phenyl, 4-n-propyl-phenyl, 4-isopropyl-phenyl, 4-tert-butyl-phenyl,

4-sec-butyl-phenyl, 4-cyclohexyl-phenyl, 4-trimethylsilyl-phenyl, 4-adamantyl-phenyl, 4-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_1-C_{10}-alkyl)-phenyl, 3-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_6-C_{20}-aryl)phenyl, 3,5-di-(C_1-C_{10}-alkyl)-phenyl, 3,5-di-(C_1-C_{10}-fluroalkyl)-phenyl and 3,5-(C_6-C_{20}-aryl)phenyl.

14. The process of claim 1 wherein the metallocene component is a compound selected from the group consisting of

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-indenyl][2-methyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-indenyl][2-methyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-indenyl][2-methyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-indenyl][2-methyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-indenyl][2-methyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-indenyl][2-methyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-indenyl][2-methyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-indenyl][2-methyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-indenyl][2-methyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-indenyl][2-methyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-indenyl][2-methyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-indenyl][2-methyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-indenyl][2-methyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl][2-methyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-indenyl][2-methyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-indenyl][2-methyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-indenyl][2-methyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-indenyl][2-methyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-indenyl][2-methyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-indenyl][2-methyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-indenyl][2-methyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-indenyl][2-methyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-indenyl][2-methyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-indenyl][2-methyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-indenyl][2-methyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-indenyl][2-methyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-indenyl][2-methyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-indenyl][2-methyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl][2-methyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-indenyl][2-methyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl] zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl] zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

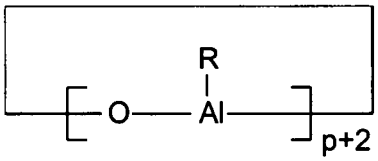
Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl] zirconiumdichloride and

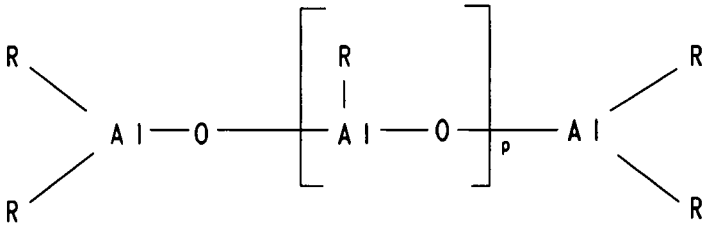
Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride.

15. The process of claim 1 wherein the catalyst system further includes at least one of an aluminoxane, a Lewis acid and an ionic compound capable of converting the metallocene into a cationic compound.

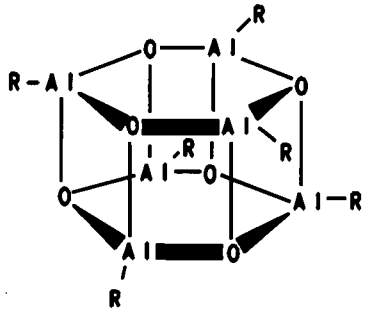
16. The process of claim 1 wherein the catalyst system further includes an aluminoxane having one of the formulas A, B, or C:



(Formula A)



(Formula B)



(Formula C)

wherein R in the formulas (A), (B), or (C) can be identical or different and are each a C_1 -C_{20} group such as an alkyl group of from 1 to about 6 carbon atoms, an aryl group of from 6 to about 18 carbon atoms, benzyl or hydrogen, and p is an integer from 2 to 50.

17. The process of claim 1 wherein the catalyst system further includes a Lewis acid having the formula

$$M^2X^1X^2X^3$$

where M^2 is B, Al or Ga, X^1, X^2 and X^3 are the same or different and each are a hydrogen atom, an alkyl group of from 1 to about 20 carbon atoms, an aryl group of from 6 to about 15 carbon atoms, alkylaryl, arylalkyl, haloalkyl or haloaryl each having from 1 to 10 carbon atoms in the alkyl radical and from 6-20 carbon atoms in the aryl radical or fluorine, chlorine, bromine or iodine.

18. The process of claim 1 wherein the catalyst system includes an ionic compound containing a non-coordinating anion selected from tetrakis(pentafluorophenyl)borate, tetraphenylborate, SbF_6^-, $CF_3SO_3^-$ and ClO_4^-.

19. The process of claim 1 wherein the catalyst system further includes a particulate porous catalyst support selected from inorganic oxides, inorganic salts, hydrotalcites, talc and finely divided polymer powders.

20. The process of claim 1 wherein the olefin has the formula

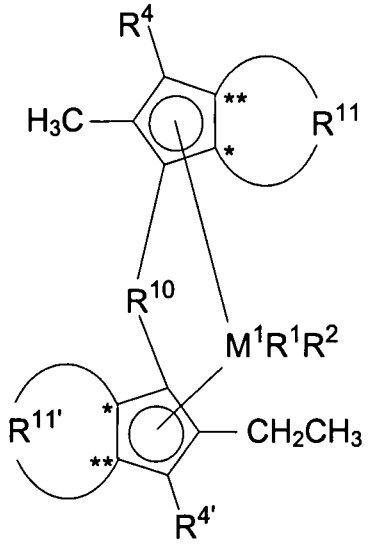
$$R^m\text{-}CH=CH\text{-}R^n,$$

where R^m and R^n are identical or different and are each a hydrogen atom or a radical having from 1 to 20 carbon atoms, wherein R^m and R^n together with the atoms connecting them optionally can form one or more rings.

21. The process of claim 1 wherein the olefin includes ethylene and/or propylene.

22. The process of claim 1 wherein the polymerization reaction conditions include a temperature of from about -60 °C to about 300 °C and a pressure of from about 0.5 to about 2000 bar, and wherein the polymerization can be carried out in solution, in bulk, in suspension or in the gas phase, continuously or batchwise, in one or more stages.

23. A catalyst composition comprising a bridged metallocene component of the general Formula 1 below,



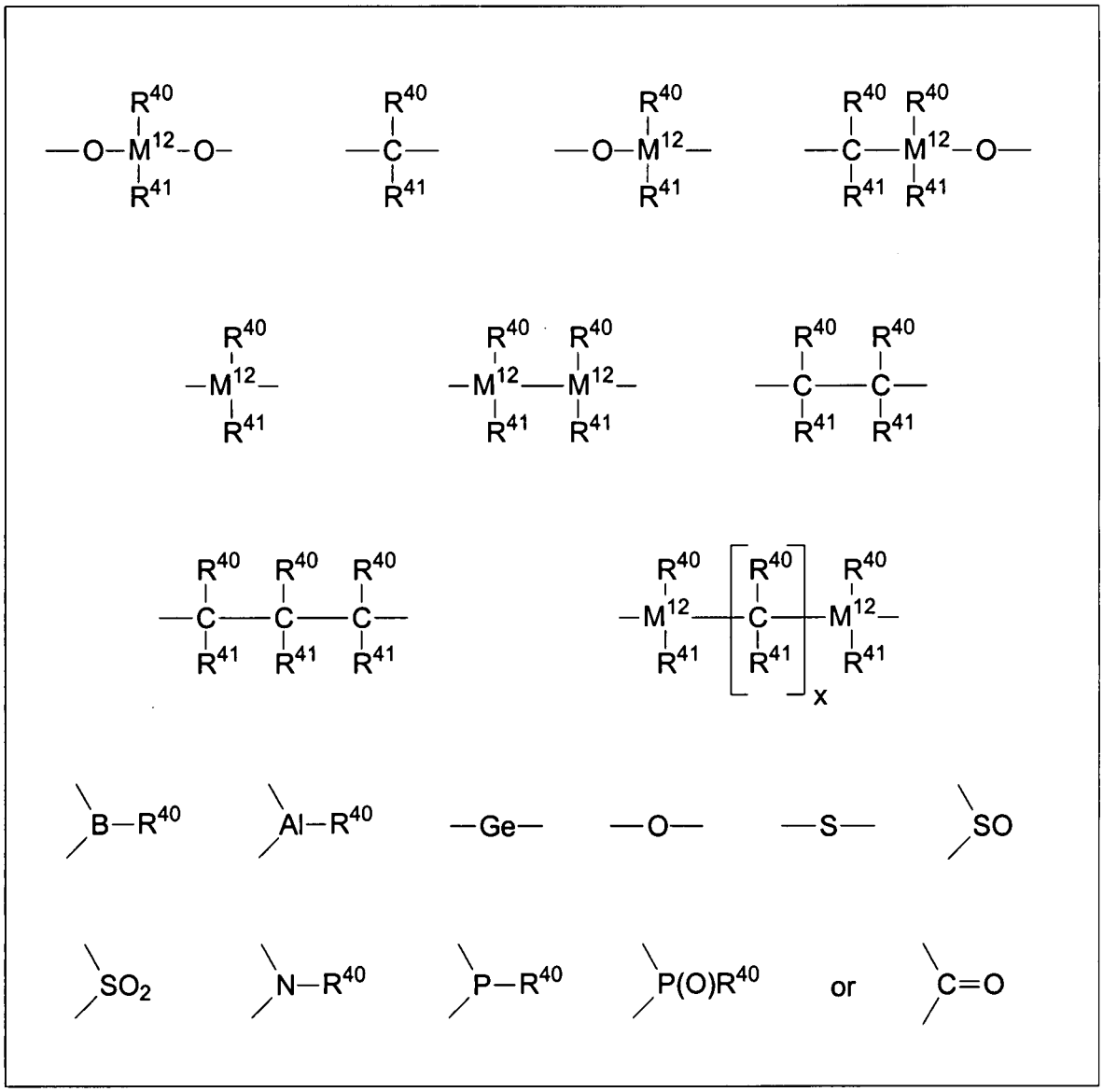
(Formula 1)

where M^1 is a metal of Group IVb of the Periodic Table of the Elements,

R^1 and R^2 are identical or different and are each a hydrogen atom, an alkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an OH group, a halogen atom, or a NR_2^{32} group, where R^{32} is an alkyl group of from 1 to about 10 carbon atoms or an aryl group of from 6 to about 14 carbon atoms and R^1 and R^2 may form one or more ring system(s),

R^4 and $R^{4'}$ are each a hydrogen atom,

R^{10} is a bridging group wherein R^{10} is selected from:



where

R^{40} and R^{41}, even when bearing the same index, can be identical or different and are each selected from the group consisting of a hydrogen atom, an alkyl group having from 1 to about 30 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, a fluoroalkyl group of from 1 to about 10 carbon atoms, an alkoxy group of from 1 to about 10 carbon atoms, an aryloxy group of from 6 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, a substituted or unsubstituted alkylsilyl, alkyl(aryl)silyl or

arylsilyl group and an arylalkenyl group of from 8 to about 40 carbon atoms or wherein R^{40} and R^{41} together with the atoms connecting them form one or more cyclic systems or wherein R^{40} and/or R^{41} contain additional hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, Cl and Br,

x is an integer from 1 to 18,

M^{12} is silicon, germanium or tin, and

R^{10} may also link two units of the formula 1 to one another, and

R^{11} and $R^{11'}$ are identical or different and are each a divalent C_2-C_{40} group which together with the cyclopentadienyl ring forms a further saturated or unsaturated ring system having a ring size of from 5 to 7 atoms, with or without heteroatoms selected from the group consisting of Si, Ge, N, P, O and S within the ring system fused onto the cyclopentadienyl ring, and wherein the symbols * and ** denote chemical bonds joining R^{11} and $R^{11'}$ to the cyclopentadienyl ring.

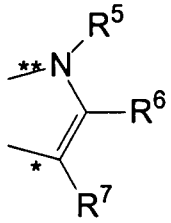
24. The catalyst composition of claim 23 wherein R^{10} is $R^{40}R^{41}Si=$, $R^{40}R^{41}Ge=$, R^{40} $R^{41}C=$ or $-(R^{40}R^{41}C-CR^{40}R^{41})-$,

where R^{40} and R^{41} are identical or different and are each a hydrogen atom, a hydrocarbon group of from 1 to about 30 carbon atoms, in particular an alkyl group of from 1 to about 10 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 14 carbon atoms, an alkylaryl group of from 7 to about 14 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl or an arylsilyl group.

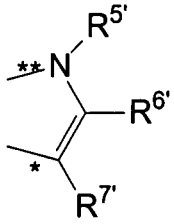
25. The catalyst composition of claim 23 wherein the bridging unit R^{10} is $R^{40}R^{41}Si=$ or $R^{40}R^{41}Ge=$,

where R^{40} and R^{41} are identical or different and are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, cyclopentyl, cyclopentadienyl, cyclohexyl, phenyl, naphthyl, benzyl, trimethylsilyl or 3,3,3-trifluoropropyl.

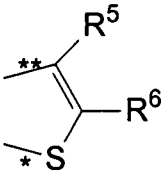
26. The catalyst composition of claim 23 wherein the groups R^{11} and $R^{11'}$ are identical or different and are each a divalent group selected from those given in Formulae 1 α, β, γ, δ, ϕ, and ν and Formulae 1 α', β', γ', δ', ϕ', and ν', respectively:



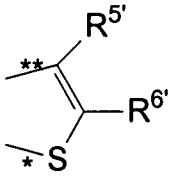
Formula 1α



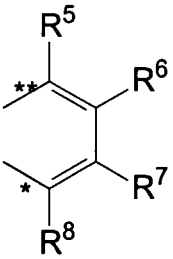
Formula 1α'



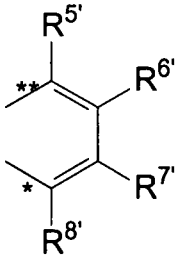
Formula 1β



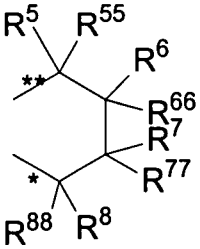
Formula 1β'



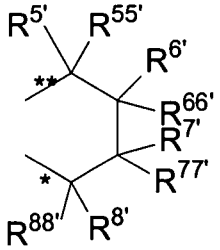
Formula 1γ



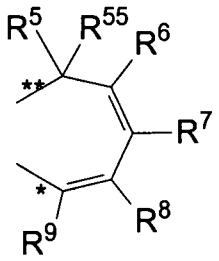
Formula 1γ'



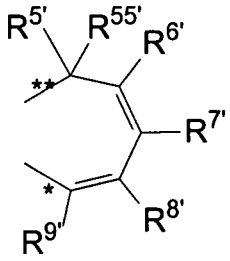
Formula 1δ



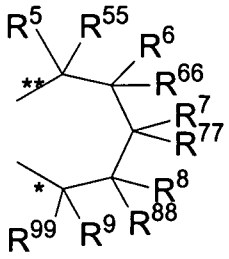
Formula 1δ'



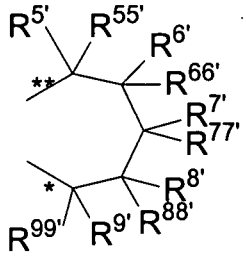
Formula 1ϕ



Formula 1ϕ'



Formula 1ν



Formula 1ν'

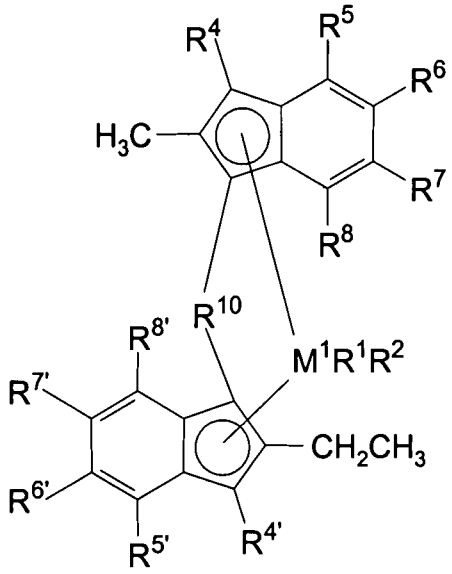
wherein R^5, R^6, R^7, R^8, and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ as well as R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are identical or different and are each selected from the group consisting of a hydrogen atom, a linear, cyclic or branched hydrocarbon group with or without heteroatoms selected from Si, B, Al, O, S, N, P, F, Cl and Br, said hydrocarbon group being selected from an alkyl group of from 2 to about 20 carbon atoms, an alkenyl group of from 2 to about 20 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, an arylalkenyl group of from 8 to about 40 carbon atoms, a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group and an arylsilyl group, wherein two adjacent radicals R^5, R^6 or $R^{5'}$, $R^{6'}$ or R^6, R^7 or $R^{6'}$, $R^{7'}$ or R^7, R^8 or $R^{7'}$, $R^{8'}$ or R^8, R^9 or $R^{8'}$, $R^{9'}$ as well as R^{55}, R^{66} or $R^{55'}$, $R^{66'}$ or R^{66}, R^{77} or $R^{66'}$, $R^{77'}$ or R^{77}, R^{88} or $R^{77'}$, $R^{88'}$ or R^{88}, R^{99} or $R^{88'}$, $R^{99'}$ in each case may optionally form a saturated or unsaturated hydrocarbon ring system.

27. The catalyst composition of claim 26 wherein R^{11} and $R^{11'}$ are identical or different and R^{11} is a divalent group according to Formula 1γ and $R^{11'}$ is selected from the divalent groups in Formulae 1α', β', and γ' or R^{11} and $R^{11'}$ are identical or different and are divalent groups according to Formula 1α and 1α' or Formula 1β and 1β' or Formula 1γ and 1γ' or Formula 1δ and 1δ' or Formula 1φ and 1φ' or Formula 1ν and 1ν', respectively.

28. The catalyst composition of claim 26 wherein R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are each a hydrogen atom and R^5, R^6, R^7, R^8 and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms, which may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br. The two adjacent radicals R^5/R^6 and also $R^{5'}/R^{6'}$ may form a hydrocarbon ring system or R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

29. The catalyst composition of claim 26 wherein R^{55}, R^{66}, R^{77}, R^{88} and R^{99} and also $R^{55'}$, $R^{66'}$, $R^{77'}$, $R^{88'}$ and $R^{99'}$ are each a hydrogen atom and R^5, R^6, R^7, R^8 and R^9 and also $R^{5'}$, $R^{6'}$, $R^{7'}$, $R^{8'}$ and $R^{9'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms. The two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ together may form a ring system or R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

30. The catalyst composition of claim 23 wherein the metallocene component is represented as Formula 1a below:



Formula 1a

wherein M^1, R^1, R^2, R^4, $R^{4'}$ and R^{10} have the meaning set forth above with respect to Formula 1 and

(i) wherein R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 1 to about 20 carbon atoms, an alkenyl group of from 2 to about 20 carbon atoms, an aryl group of from 6 to about 40 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group. The groups may contain one or more hetero atoms like Si, B, Al, O, S, N or P, and / or may contain halogen atoms like F, Cl or Br, and / or two adjacent radicals R^5, R^6 or R^6, R^7 or R^7, R^8 and also $R^{5'}$, $R^{6'}$ or $R^{6'}$, $R^{7'}$ or $R^{7'}$, $R^{8'}$ in each case may form a hydrocarbon ring system

or

(ii) wherein R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched alkyl group of from 1 to about 10 carbon

atoms, an arylalkyl, alkaryl or aryl group of from 6 to about 40 carbon atoms, optionally including one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br, and/or the two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ can form a saturated or unsaturated hydrocarbon ring system.

31. The catalyst composition of claim 30 wherein R^5, R^6, R^7 and R^8 and also $R^{5'}$, $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 40 carbon atoms and/or the two adjacent radicals R^5, R^6 and also $R^{5'}$, $R^{6'}$ together may form a saturated or unsaturated ring system.

32. The catalyst composition of claim 30 wherein R^6, R^7, R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a linear, cyclic or branched hydrocarbon group, for example an alkyl group of from 1 to about 10 carbon atoms, an alkenyl group of from 2 to about 10 carbon atoms, an aryl group of from 6 to about 20 carbon atoms, an arylalkyl group of from 7 to about 40 carbon atoms, an alkylaryl group of from 7 to about 40 carbon atoms, or an arylalkenyl group of from 8 to about 40 carbon atoms or a substituted or unsubstituted alkylsilyl group, an alkyl(aryl)silyl group or an arylsilyl group, and wherein two adjacent radicals R^6, R^7 or R^7, R^8 as well as $R^{6'}$, $R^{7'}$ or $R^{7'}$, $R^{8'}$ in each case may form a hydrocarbon ring system, wherein the groups may optionally contain one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br, and wherein R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms, optionally containing one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br.

33. The catalyst composition of claim 30 wherein R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom, a substituted or unsubstituted alkylsilyl or arylsilyl group, a linear, cyclic or branched

alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms, which may optionally contain one or more hetero atoms selected from the group consisting of Si, B, Al, O, S, N, P, F, Cl and Br, and wherein R^5 and $R^{5'}$ are identical or different and are each a substituted or unsubstituted aryl group of from 6 to about 40 carbon atoms.

34. The catalyst composition of claim 30 wherein R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms, R^5 and $R^{5'}$ are identical or different and are each selected from naphthyl, 4-methyl-phenyl, 4-biphenyl, 4-ethyl-phenyl, 4-n-propyl-phenyl, 4-isopropyl-phenyl, 4-tert-butyl-phenyl, 4-sec-butyl-phenyl, 4-cyclohexyl-phenyl, 4-trimethylsilyl-phenyl, 4-adamantyl-phenyl, 4-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_1-C_{10}-alkyl)-phenyl, 3-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_6-C_{20}-aryl)phenyl, 3,5-di-(C_1-C_{10}-alkyl)-phenyl, 3,5-di-(C_1-C_{10}-fluroalkyl)-phenyl and 3,5-(C_6-C_{20}-aryl)phenyl.

35. The catalyst composition of claim 30 wherein

M1 is zirconium,

R^1 and R^2 are identical and are methyl, chlorine or phenolate,

R^4 and $R^{4'}$ are hydrogen,

R^{10} is $R^{40}R^{41}Si=$ or $R^{40}R^{41}Ge=$, where R^{40} and R^{41} are identical or different and are methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, cyclopentyl, cyclopentadienyl, cyclohexyl, phenyl, naphthyl, benzyl, trimethylsilyl or 3,3,3-trifluoropropyl, and

R^6, R^7 and R^8 and also $R^{6'}$, $R^{7'}$ and $R^{8'}$ are identical or different and are each a hydrogen atom or a linear, cyclic or branched alkyl group of from 1 to about 10 carbon atoms, or an aryl group of from 6 to about 10 carbon atoms,

R^5 and $R^{5'}$ are identical and are selected from naphthyl, 4-methyl-phenyl, 4-biphenyl, 4-ethyl-phenyl, 4-n-propyl-phenyl, 4-isopropyl-phenyl, 4-tert-butyl-phenyl,

4-sec-butyl-phenyl, 4-cyclohexyl-phenyl, 4-trimethylsilyl-phenyl, 4-adamantyl-phenyl, 4-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_1-C_{10}-alkyl)-phenyl, 3-(C_1-C_{10}-fluoroalkyl)-phenyl, 3-(C_6-C_{20}-aryl)phenyl, 3,5-di-(C_1-C_{10}-alkyl)-phenyl, 3,5-di-(C_1-C_{10}-fluroalkyl)-phenyl and 3,5-(C_6-C_{20}-aryl)phenyl.

36. The catalyst composition of claim 23 wherein the metallocene component is a compound selected from the group consisting of

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-indenyl][2-methyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-indenyl][2-methyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-indenyl][2-methyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-indenyl][2-methyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-indenyl][2-methyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-indenyl][2-methyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-indenyl][2-methyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-indenyl][2-methyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-indenyl][2-methyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-indenyl][2-methyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-indenyl][2-methyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-indenyl][2-methyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-indenyl][2-methyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl][2-methyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-indenyl][2-methyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-indenyl][2-methyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-indenyl][2-methyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-indenyl][2-methyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-indenyl][2-methyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-indenyl][2-methyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-indenyl][2-methyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-indenyl][2-methyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-indenyl][2-methyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-indenyl][2-methyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-indenyl][2-methyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-indenyl][2-methyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-indenyl][2-methyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-indenyl][2-methyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-indenyl][2-methyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl][2-methyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-indenyl][2-methyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-6-methyl-indenyl][2,6-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl] zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-6-methyl-indenyl][2,6-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(1-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(2-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl] zirconiumdichloride,

Dimethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(1-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(1-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(2-naphthyl)-7-methyl-indenyl][2,7-dimethyl-4-(2-naphthyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-methyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-methyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-biphenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-ethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-ethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-n-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-n-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-i-propyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-i-propyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-t-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-t-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-sec-butyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-sec-butyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-cyclohexyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-cyclohexyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-trimethylsilyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-trimethylsilyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(4-adamantyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(4-adamantyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3-biphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3-biphenyl)-indenyl]zirconiumdichloride,

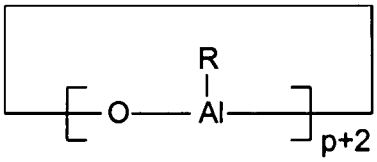
Diethylsilanediyl[2-ethyl-4-(3,5-dimethyl-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-dimethyl-phenyl)-indenyl]zirconiumdichloride,

Diethylsilanediyl[2-ethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-di-(trifluoromethyl)-phenyl)-indenyl] zirconiumdichloride and

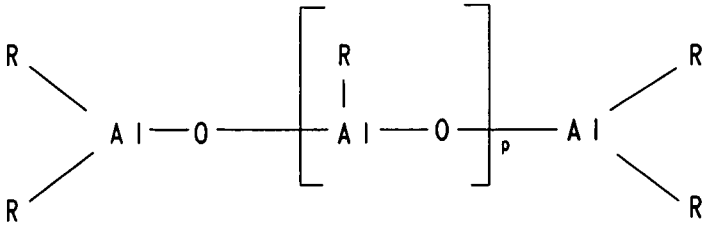
Diethylsilanediyl[2-ethyl-4-(3,5-terphenyl)-7-methyl-indenyl][2,7-dimethyl-4-(3,5-terphenyl)-indenyl]zirconiumdichloride.

37. The catalyst composition of claim 23 further comprising at least one of an aluminoxane, a Lewis acid and an ionic compound capable of converting the metallocene into a cationic compound.

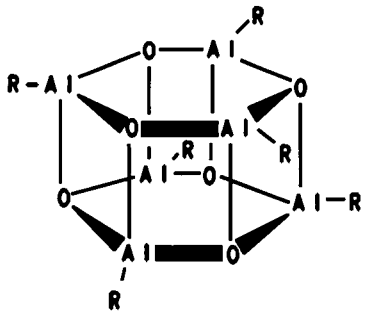
38. The catalyst composition of claim 23 further comprising an aluminoxane having one of the formulas A, B, or C:



(Formula A)



(Formula B)



(Formula C)

wherein R in the formulas (A), (B), or (C) can be identical or different and are each a C_1 -C_{20} group such as an alkyl group of from 1 to about 6 carbon atoms, an aryl group of from 6 to about 18 carbon atoms, benzyl or hydrogen, and p is an integer from 2 to 50.

39. The catalyst composition of claim 23 further comprising a Lewis acid having the formula

$$M^2X^1X^2X^3$$

where M^2 is B, Al or Ga, X^1, X^2 and X^3 are the same or different and each are a hydrogen atom, an alkyl group of from 1 to about 20 carbon atoms, an aryl group of from 6 to about 15 carbon atoms, alkylaryl, arylalkyl, haloalkyl or haloaryl each having from 1 to 10 carbon atoms in the alkyl radical and from 6-20 carbon atoms in the aryl radical or fluorine, chlorine, bromine or iodine.

40. The catalyst composition of claim 23 further comprising an ionic compound containing a non-coordinating anion selected from tetrakis(pentafluorophenyl)borate, tetraphenylborate, SbF_6^-, $CF_3SO_3^-$ and ClO_4^-.

41. The catalyst composition of claim 23 further comprising a particulate porous catalyst support selected from inorganic oxides, inorganic salts, hydrotalcites, talc and finely divided polymer powders.