CLAIMS

1. An olefin polymerization process, the process comprising:

contacting a catalyst composition with an olefin monomer and an olefin comonomer under polymerization conditions to produce an olefin polymer, wherein the catalyst composition comprises catalyst component I, catalyst component II, catalyst component III, an activator, and an optional co-catalyst, wherein:

catalyst component I comprises an unbridged zirconium or hafnium based metallocene compound and/or an unbridged zirconium and/or hafnium based dinuclear metallocene compound;

catalyst component II comprises a bridged zirconium based metallocene compound with a fluorenyl group, and with no aryl groups on the bridging group; and

catalyst component III comprises a bridged zirconium or hafnium based metallocene compound with a fluorenyl group, and an aryl group on the bridging group.

2. The process of claim 1, wherein the catalyst composition comprises:

an unbridged zirconium based metallocene compound containing two cyclopentadienyl groups, two indenyl groups, or a cyclopentadienyl and an indenyl group;

a bridged zirconium based metallocene compound with a cyclopentadienyl group and a fluorenyl group, and with no aryl groups on the bridging group;

a bridged zirconium or hafnium based metallocene compound with a cyclopentadienyl group and fluorenyl group, and a phenyl group on the bridging group;

an activator-support comprising a solid oxide treated with an electron-withdrawing anion; and

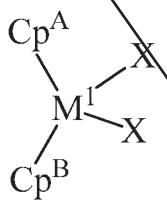
an organoaluminum compound.

3. The process of claim 2, wherein the organoaluminum compound comprises trimethylaluminum, triethylaluminum, tri-n-propylaluminum, tri-n-butylaluminum, triisobutylaluminum, tri-n-hexylaluminum, tri-n-octylaluminum, diisobutylaluminum

hydride, diethylaluminum ethoxide, diethylaluminum chloride, or any combination thereof.

4. The process of claim 2, wherein the activator-support comprises fluorided alumina, chlorided alumina, bromided alumina, sulfated alumina, fluorided silica-alumina, chlorided silica-alumina, bromided silica-alumina, sulfated silica-alumina, fluorided silica-zirconia, chlorided silica-zirconia, bromided silica-zirconia, sulfated silica-zirconia, fluorided silica-titania, fluorided silica-coated alumina, sulfated silica-coated alumina, phosphated silica-coated alumina, or any combination thereof.

5. The process of claim 1, wherein catalyst component I comprises an unbridged metallocene compound having formula (**A**):



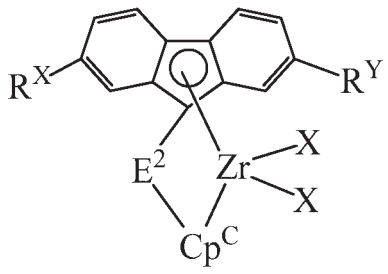
(**A**); wherein:

M^1 is Zr or Hf;

Cp^A and Cp^B independently are a substituted or unsubstituted cyclopentadienyl or indenyl group; and

each X independently is a monoanionic ligand.

6. The process of claim 1, wherein catalyst component II comprises a bridged metallocene compound having formula (**B**):



(**B**); wherein:

Cp^C is a substituted cyclopentadienyl, indenyl, or fluorenyl group;

each X independently is a monoanionic ligand;

R^X and R^Y independently are H, a halide, a C_1 to C_{36} hydrocarbyl group, a C_1 to C_{36} halogenated hydrocarbyl group, a C_1 to C_{36} hydrocarboxy group, or a C_1 to C_{36} hydrocarbylsilyl group; and

E^2 is a bridging group selected from:

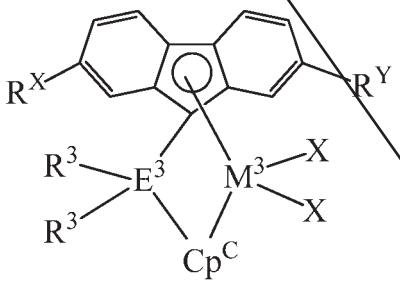
a bridging group having the formula $>E^AR^AR^B$, wherein E^A is C, Si, or Ge, and R^A and R^B independently are H or a C_1 to C_{18} hydrocarbyl group,

a bridging group having the formula $—CR^CR^D—CR^ER^F—$, wherein R^C, R^D, R^E, and R^F independently are H or a C_1 to C_{18} hydrocarbyl group, or

a bridging group having the formula $—SiR^GR^H—E^5R^IR^J—$, wherein E^5 is C or Si, and R^G, R^H, R^I, and R^J independently are H or a C_1 to C_{18} hydrocarbyl group,

wherein R^A, R^B, R^C, R^D, R^E, R^F, R^G, R^H, R^I, and R^J are not aryl groups.

7. The process of claim 1, wherein catalyst component III comprises a bridged metallocene compound having formula (**C**):



(**C**); wherein:

M^3 is Zr or Hf;

Cp^C is a substituted cyclopentadienyl, indenyl, or fluorenyl group;

each X independently is a monoanionic ligand;

R^X and R^Y independently are H, a halide, a C_1 to C_{36} hydrocarbyl group, a C_1 to C_{36} halogenated hydrocarbyl group, a C_1 to C_{36} hydrocarboxy group, or a C_1 to C_{36} hydrocarbylsilyl group;

E^3 is C, Si, or Ge; and

each R^3 independently is H or a C_1 to C_{18} hydrocarbyl group, wherein at least one R^3 is an aryl group having up to 18 carbon atoms.

8. The process of claim 1, wherein the activator comprises an aluminoxane compound, an organoboron or organoborate compound, an ionizing ionic compound, or any combination thereof.

9. The process of claim 1, wherein the activator comprises an activator-support, the activator-support comprising a solid oxide treated with an electron-withdrawing anion.

10. The process of claim 1, wherein the co-catalyst comprises an organoaluminum compound, an organozinc compound, an organomagnesium compound, an organolithium compound, or any combination thereof.

11. The process of claim 1, wherein the process is conducted in a batch reactor, slurry reactor, gas-phase reactor, solution reactor, high pressure reactor, tubular reactor, autoclave reactor, or a combination thereof.

12. The process of claim 1, wherein the olefin monomer comprises ethylene, and the olefin comonomer comprises 1-butene, 1-hexene, 1-octene, or a mixture thereof.

13. The process of claim 1, wherein the olefin polymer has:
a melt index in a range from about 0.005 to about 10 g/10 min;
a ratio of HLMI/MI in a range from about 50 to about 500;
a density in a range from about 0.915 g/cm^3 to about 0.965 g/cm^3;
a non-bimodal molecular weight distribution; and
a ratio of Mw/Mn in a range from about 10 about 40.

14. A catalyst composition comprising:
catalyst component I comprising an unbridged zirconium or hafnium based metallocene compound and/or an unbridged zirconium and/or hafnium based dinuclear metallocene compound;

catalyst component II comprising a bridged zirconium based metallocene compound with a fluorenyl group, and with no aryl groups on the bridging group;

catalyst component III comprising a bridged zirconium or hafnium based metallocene compound with a fluorenyl group, and an aryl group on the bridging group;

an activator; and

optionally, a co-catalyst.

15. The composition of claim 14, wherein:

a weight percentage of catalyst component I is in a range from about 20 to about 50%;

a weight percentage of catalyst component II is in a range from about 5 to about 30%; and

a weight percentage of catalyst component III is in a range from about 20 to about 50%; wherein the weight percentages are based on the total weight of catalyst components I, II, and III.

16. An olefin polymer having a melt index in a range from about 0.005 to about 10 g/10 min, a ratio of HLMI/MI in a range from about 50 to about 500, a density in a range from about 0.915 g/cm^3 to about 0.965 g/cm^3, and a non-bimodal molecular weight distribution.

17. The polymer of claim 16, wherein:

a ratio of Mw/Mn of the polymer is in a range from about 10 about 40; and

a ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 30 to about 90.

18. The polymer of claim 17, wherein the polymer has:

a reverse comonomer distribution; and

a unimodal molecular weight distribution.

19. The polymer of claim 17, wherein:

the melt index is in a range from about 0.01 to about 2 g/10 min;

the ratio of HLMI/MI is in a range from about 50 to about 200;

the density is in a range from about 0.925 g/cm^3 to about 0.955 g/cm^3;

the ratio of Mw/Mn is in a range from about 15 about 30; and

the ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 40 to about 70.

20. An article comprising the polymer of claim 16.

CLAIMS

1. An olefin polymer having a melt index in a range from about 0.005 to about 10 g/10 min, a ratio of HLMI/MI in a range from about 50 to about 500, a density in a range from about 0.915 g/cm^3 to about 0.965 g/cm^3, a reverse comonomer distribution, and a non-bimodal molecular weight distribution.

2. The polymer of claim 1, wherein:
a ratio of Mw/Mn of the polymer is in a range from about 10 to about 40; and

a ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 30 to about 90.

3. The polymer of claim 2, wherein the polymer has:
a unimodal molecular weight distribution.

4. The polymer of claim 2, wherein:
the melt index is in a range from about 0.01 to about 2 g/10 min;

the ratio of HLMI/MI is in a range from about 50 to about 200;

the density is in a range from about 0.925 g/cm^3 to about 0.955 g/cm^3;

the ratio of Mw/Mn is in a range from about 15 about 30; and

the ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 40 to about 70.

5. An article comprising the polymer of claim 1.

6. The polymer of claim 1, wherein the polymer is an ethylene/1-butene copolymer, an ethylene/1-hexene copolymer, or an ethylene/1-octene copolymer.

7. The polymer of claim 6, wherein:
the melt index is in a range from about 0.01 to about 2 g/10 min;

the ratio of HLMI/MI is in a range from about 50 to about 200; and

a ratio of Mw/Mn of the polymer is in a range from about 10 to about 40.

8. An article comprising the polymer of claim 7.

9. The polymer of claim 7, wherein:

the ratio of Mw/Mn is in a range from about 10 to about 30;

a ratio of Mz/Mw is in a range from about 3.5 to about 9;

a ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 30 to about 90; and

a ratio of the number of short chain branches (SCB) per 1000 total carbon atoms of the polymer at D10 to the number of SCB per 1000 total carbon atoms of the polymer at D50 is in a range from about 1.2 to about 10.

10. The polymer of claim 9, wherein:
the ratio of Mz/Mw is in a range from about 4 to about 8;

the ratio of the number of short chain branches (SCB) per 1000 total carbon atoms of the polymer at D10 to the number of SCB per 1000 total carbon atoms of the polymer at D50 is in a range from about 2 to about 5;

the density is in a range from about 0.925 g/cm^3 to about 0.955 g/cm^3; and

the polymer has a unimodal molecular weight distribution.

11. An olefin polymer having a melt index in a range from about 0.005 to about 10 g/10 min, a ratio of HLMI/MI in a range from about 50 to about 500, a density in a range from about 0.915 g/cm^3 to about 0.965 g/cm^3, a non-bimodal molecular weight distribution, and less than about 0.008 long chain branches (LCB) per 1000 total carbon atoms.

12. The polymer of claim 11, wherein:
a ratio of Mw/Mn of the polymer is in a range from about 10 to about 40; and

a ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 30 to about 90.

13. The polymer of claim 12, wherein the polymer has:
a reverse comonomer distribution; and

a unimodal molecular weight distribution.

14. The polymer of claim 12, wherein:
the melt index is in a range from about 0.01 to about 2 g/10 min;

the ratio of HLMI/MI is in a range from about 50 to about 200;

the density is in a range from about 0.925 g/cm^3 to about 0.955 g/cm^3;

the ratio of Mw/Mn is in a range from about 15 about 30; and

the ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 40 to about 70.

15. An article comprising the polymer of claim 11.

16. The polymer of claim 11, wherein the polymer is an ethylene/1-butene copolymer, an ethylene/1-hexene copolymer, or an ethylene/1-octene copolymer.

17. The polymer of claim 16, wherein:
the melt index is in a range from about 0.01 to about 2 g/10 min;

the ratio of HLMI/MI is in a range from about 50 to about 200; and

a ratio of Mw/Mn of the polymer is in a range from about 10 to about 40.

18. An article comprising the polymer of claim 17.

19. The polymer of claim 17, wherein:
the ratio of Mw/Mn is in a range from about 10 to about 30;

a ratio of Mz/Mw is in a range from about 3.5 to about 9;

a ratio of the molecular weight of the polymer at D15 to the molecular weight of the polymer at D85 is in a range from about 30 to about 90;

a ratio of the number of short chain branches (SCB) per 1000 total carbon atoms of the polymer at D10 to the number of SCB per 1000 total carbon atoms of the polymer at D50 is in a range from about 1.2 to about 10; and

the polymer has less than about 0.005 LCB per 1000 total carbon atoms.

20. The polymer of claim 19, wherein:
the ratio of Mz/Mw is in a range from about 4 to about 8;

the ratio of the number of short chain branches (SCB) per 1000 total carbon atoms of the polymer at D10 to the number of SCB per 1000 total carbon atoms of the polymer at D50 is in a range from about 2 to about 5;

the density is in a range from about 0.925 g/cm^3 to about 0.955 g/cm^3; and

the polymer has a unimodal molecular weight distribution.