CLAIMS

1. An ethylene polymer having a density from about 0.930 to about 0.948 g/cm^3, a zero-shear viscosity greater than about 5 x 10^5 Pa-sec, a CY-a parameter in a range from about 0.01 to about 0.40, a peak molecular weight (Mp) in a range from about 30,000 to about 130,000 g/mol, and a reverse comonomer distribution.

2. The polymer of claim 1, wherein the ethylene polymer has a density in a range from about 0.933 to about 0.946 g/cm^3.

3. The polymer of claim 1, wherein the ethylene polymer has:
a natural draw ratio (NDR) in a range from about 400 to about 525 %; and
a single point notched constant tensile load (SP-NCTL) of at least 8,000 hours.

4. The polymer of claim 1, wherein the ethylene polymer has:
a HLMI in a range from about 1 to about 20 g/10 min;
a ratio of Mw/Mn in a range from about 5 to about 25;
a ratio of Mz/Mw in a range from about 4.5 to about 7.5; and
a Mn in a range from about 8,000 to about 60,000 g/mol.

5. The polymer of claim 1, wherein the ethylene polymer has:
a density in a range from about 0.935 to about 0.946 g/cm^3;
a zero-shear viscosity in a range from about 7.5 x 10^5 to about 1 x 10^9 Pa-sec;
a CY-a parameter in a range from about 0.08 to about 0.35; and
a Mp in a range from about 35,000 to about 120,000 g/mol.

6. The polymer of claim 1, wherein a relationship between natural draw ratio (NDR, %) and density (g/cm^3) of the ethylene polymer is defined by the equation:

$$NDR < 7800(density) - 6800.$$

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

8. An article comprising the ethylene polymer of claim 1.

9. An ethylene polymer having a density from about 0.930 to about 0.948 g/cm^3, a single point notched constant tensile load (SP-NCTL) of at least 6,500 hours, and a natural draw ratio (NDR) of less than or equal to about 525 %.

10. The polymer of claim 9, wherein the ethylene polymer has:

a density in a range from about 0.933 to about 0.946 g/cm^3;

a natural draw ratio (NDR) in a range from about 400 to about 525 %; and

a single point notched constant tensile load (SP-NCTL) of at least 9,000 hours.

11. The polymer of claim 9, wherein the ethylene polymer has:

a HLMI in a range from 0 to about 50 g/10 min;

a ratio of Mw/Mn in a range from about 10 to about 50;

a ratio of Mz/Mw in a range from about 2.4 to about 8; and

a Mn in a range from about 5,000 to about 25,000 g/mol.

12. The polymer of claim 9, wherein a relationship between natural draw ratio (NDR, %) and density (g/cm^3) of the ethylene polymer is defined by the equation:

$$NDR < 13404(density) - 12050.$$

13. The polymer of claim 9, wherein the ethylene polymer is an ethylene/1-butene copolymer, an ethylene/1-hexene copolymer, or an ethylene/1-octene copolymer.

14. An article comprising the ethylene polymer of claim 9.

15. A catalyst composition comprising:

catalyst component I comprising an unbridged Group IV transition metal based metallocene compound;

catalyst component II comprising a bridged Group IV transition metal based metallocene compound with a fluorenyl group;

catalyst component III comprising a titanium or chromium half-metallocene compound;

an activator; and

optionally, a co-catalyst.

16. The composition of claim 15, wherein the activator comprises an aluminoxane compound, an organoboron or organoborate compound, an ionizing ionic compound, or any combination thereof.

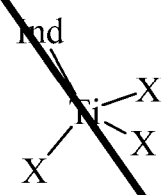
17. An olefin polymerization process, the process comprising contacting the catalyst composition of claim 15 with an olefin monomer and an optional olefin

comonomer in a polymerization reactor system under polymerization conditions to produce an olefin polymer, wherein the catalyst composition comprises:

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

a bridged metallocene compound with a cyclopentadienyl group and fluorenyl group, and an alkenyl substituent on the cyclopentadienyl group and/or on the bridging group;

a half-metallocene compound having formula (**IIIA**) or formula (**IIIB**):



(**IIIA**)

$Cr(Cp^C)(X)(X)(L)_n$ (**IIIB**); wherein:

Ind is an indenyl group;

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

each X independently is a monoanionic ligand; and

each L is a neutral ligand, and integer n is 0, 1 or 2;

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

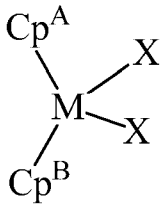
an organoaluminum compound.

18. The process of claim 17, wherein:

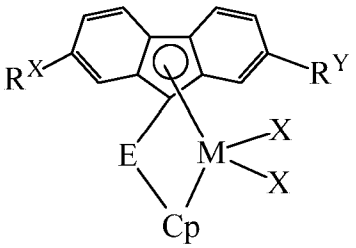
the activator-support comprises a fluorided solid oxide and/or a sulfated solid oxide;

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;

catalyst component I comprises an unbridged metallocene compound having formula (**I**) and catalyst component II comprises a bridged metallocene compound having formula (**II**):



(**I**)



(**II**); wherein:

each M independently is Zr or Hf;

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

Cp is a cyclopentadienyl 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 is a bridging group.

19. The process of claim 17, wherein the polymerization reactor system comprises a slurry reactor, gas-phase reactor, solution reactor, or a combination thereof.

20. The process of claim 17, wherein the catalyst composition is contacted with ethylene and an olefin comonomer comprising 1-butene, 1-hexene, 1-octene, or a mixture thereof.

CLAIMS

The invention claimed is:

1. An ethylene polymer having a density from about 0.930 to about 0.948 g/cm^3, a zero-shear viscosity greater than about 5×10^5 Pa-sec, a CY-a parameter in a range from about 0.01 to about 0.40, a peak molecular weight (Mp) in a range from about 30,000 to about 130,000 g/mol, a bimodal molecular weight distribution, and a reverse comonomer distribution.

2. The polymer of claim 1, wherein the ethylene polymer has a density in a range from about 0.933 to about 0.946 g/cm^3.

3. The polymer of claim 1, wherein the ethylene polymer has:
a natural draw ratio (NDR) in a range from about 400 to about 525%; and

a single point notched constant tensile load (SP-NCTL) of at least 8,000 hours.

4. The polymer of claim 1, wherein the ethylene polymer has:
a HLMI in a range from about 1 to about 20 g/10 min;

a ratio of Mw/Mn in a range from about 5 to about 25;

a ratio of Mz/Mw in a range from about 4.5 to about 7.5; and

a Mn in a range from about 8,000 to about 60,000 g/mol.

5. The polymer of claim 1, wherein the ethylene polymer has:
a density in a range from about 0.935 to about 0.946 g/cm^3;

a zero-shear viscosity in a range from about 7.5×10^5 to about 1×10^9 Pa-sec;

a CY-a parameter in a range from about 0.08 to about 0.35; and

a Mp in a range from about 35,000 to about 120,000 g/mol.

6. The polymer of claim 1, wherein a relationship between natural draw ratio (NDR, %) and density (g/cm^3) of the ethylene polymer is defined by the equation:

$$NDR<7800(density)-6800.$$

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

8. An article comprising the ethylene polymer of claim 1.

9. An ethylene polymer having a density from about 0.930 to about 0.948 g/cm^3, a bimodal molecular weight distribution, a single point notched constant tensile load (SP-NCTL) of at least 6,500 hours, and a natural draw ratio (NDR) of less than or equal to about 525%.

10. The polymer of claim 9, wherein the ethylene polymer has:
a density in a range from about 0.933 to about 0.946 g/cm^3;

a natural draw ratio (NDR) in a range from about 400 to about 525%; and

a single point notched constant tensile load (SP-NCTL) of at least 9,000 hours.

11. The polymer of claim 9, wherein the ethylene polymer has:
a HLMI in a range from 0 to about 50 g/10 min;

a ratio of Mw/Mn in a range from about 10 to about 50;

a ratio of Mz/Mw in a range from about 2.4 to about 8; and

a Mn in a range from about 5,000 to about 25,000 g/mol.

12. The polymer of claim 9, wherein a relationship between natural draw ratio (NDR, %) and density (g/cm^3) of the ethylene polymer is defined by the equation:

$$NDR<13404(density)-12050.$$

13. The polymer of claim 9, wherein the ethylene polymer is an ethylene/l-butene copolymer, an ethylene/l-hexene copolymer, or an ethylene/l-octene copolymer.

14. An article comprising the ethylene polymer of claim 9.

15. The polymer of claim 1, wherein the ethylene polymer has:
a density in a range from about 0.935 to about 0.946 g/cm^3;

a zero-shear viscosity in a range from about 7.5×10^5 to about 1×10^9 Pa-sec;

a CY-a parameter in a range from about 0.08 to about 0.35;

a Mp in a range from about 40,000 to about 110,000 g/mol; and

a ratio of Mw/Mn in a range from about 7 to about 20.

16. The polymer of claim 15, wherein the ethylene polymer is an ethylene/l-butene copolymer, an ethylene/l-hexene copolymer, or an ethylene/l-octene copolymer.

17. An article comprising the ethylene polymer of claim 16.

18. The polymer of claim 9, wherein the ethylene polymer has:

a density in a range from about 0.935 to about 0.946 g/cm^3;

a Mn in a range from about 5,000 to about 25,000 g/mol;

a natural draw ratio (NDR) in a range from about 400 to about 525%; and

a single point notched constant tensile load (SP-NCTL) of at least 9,000 hours.

19. The polymer of claim 18, wherein the ethylene polymer is an ethylene/l-butene copolymer, an ethylene/l-hexene copolymer, or an ethylene/l-octene copolymer.

20. An article comprising the ethylene polymer of claim 19.