

CLAIMS

1. An ethylene/1-hexene copolymer that has a density from 0.9541 to 0.9600 gram per cubic centimeter (g/cm^3), as measured by ASTM D792-13, a molecular mass dispersity $\mathfrak{D}_M$ (wherein $\mathfrak{D}_M = M_w/M_n$) from greater than 2.0 to 3.5, as measured by Gel Permeation Chromatography (GPC) Method; and a Z-average molecular weight (M_z) from 80,000 to 240,000 grams per mole (g/mol), as measured by the GPC Method.
2. The ethylene/1-hexene copolymer of claim 1 characterized by any one of limitations (i) to (vii): (i) a density from 0.9541 to 0.9583 g/cm^3 , as measured by ASTM D792-13; (ii) a $\mathfrak{D}_M$ from 2.5 to 3.0, as measured by the GPC Method; (iii) a M_z from 110,000 to 240,000 g/mol , as measured by the GPC Method; (iv) both limitations (i) and (ii); (v) both limitations (i) and (iii); (vi) both limitations (ii) and (iii); and (vii) each of limitations (i) to (iii).
3. The ethylene/1-hexene copolymer of claim 1 or 2 characterized by a melt index (" I_2 ") from 1.5 to 40 grams per 10 minutes (g/10 min.), as measured by ASTM D1238-13 (190°C. , 2.16 kg, " I_2 ").
4. The ethylene/1-hexene copolymer of any one of claims 1 to 3 characterized by any one of limitations (i) to (vii): (i) a melt flow rate from 4 to 25 g/10 min. , as measured by ASTM D1238-13 (190°C. , 5.0 kg, " I_5 "); (ii) a high-load melt flow rate ("HLMFR") from 20 to 200 g/10 min. , as measured by ASTM D1238-13 (190°C. , 21.6 kg, " I_{21} "); (iii) a flow rate ratio, I_{21}/I_2 , of 15 to 20, wherein I_{21} and I_2 are measured by ASTM D1238-13 (190°C. , 21.6 kg and 2.16 kg, respectively); (iv) a flow rate ratio, I_{21}/I_5 , of 4 to 10, wherein I_{21} and I_5 are measured by ASTM D1238-13 (190°C. , 21.6 kg and 5.0 kg, respectively); (v) both limitations (i) and (ii); (vi) both limitations (iii) and (iv); and (vii) each of limitations (i) to (iv).
5. The ethylene/1-hexene copolymer of any one of claims 1 to 4 characterized by any one of limitations (i) to (iii): (i) an environmental stress crack resistance (ESCR) F50 of greater than 11 hours, as measured according to ASTM D1693-15 in 10 weight percent (wt%) Igepal CO-630 in water at 50°C. ; (ii) a 2% Flexural Secant Modulus from 930 to 1140 megapascals (MPa), as measured according to ASTM D790-17; and (iii) both (i) and (ii).
6. A method of making the ethylene/1-hexene copolymer of any one of claims 1 to 5, the method comprising contacting ethylene and 1-hexene with the single hafnocene catalyst in a single gas phase reactor operating a single gas phase polymerization process to give the ethylene/1-hexene copolymer, wherein the polymerization reaction is conducted under effective gas phase polymerization conditions, and wherein the hafnocene catalyst is made by contacting bis(n-propylcyclopentadienyl)hafnium dichloride or bis(n-propylcyclopentadienyl)hafnium dimethyl with an activator.

7. The method of claim 6 characterized by any one of limitations (i) to (viii): (i) externally-sourced (from outside the reactor) molecular hydrogen gas (H_2) is not added into the polymerization reactor and is not present during the contacting step of the method; (ii) the method further comprises adding externally-sourced H_2 gas into the polymerization reactor during the contacting step of the method; (iii) the method further comprises a (C_4) or (C_8 -20)alpha-olefin (second comonomer) and makes an ethylene/1-hexene/(C_4) or (C_8 -20)alpha-olefin copolymer, which contains monomeric constituent units that are derived from ethylene, comonomeric constituent units that are derived from 1-hexene, and comonomeric constituent units that are derived from the (C_4) or (C_8 -20)alpha-olefin; (iv) the method is free of any monomer and comonomer except the ethylene and 1-hexene and makes an ethylene/1-hexene copolymer having constitutional units consisting of ethylenic and 1-hexenic units; (v) both (i) and (iii); (vi) both (ii) and (iii); (vii) both (i) and (iv); and (viii) both (ii) and (iv).
8. The method of claim 6 or 7 comprising a gas phase polymerization optionally in the presence of added external molecular hydrogen gas (H_2), optionally in the presence of an induced condensing agent (ICA); a reaction temperature from 60 degrees ($^{\circ}$) to 120 $^{\circ}$ Celsius (C.), and a molar ratio of the molecular hydrogen gas to the ethylene (H_2/C_2 molar ratio) from 0.001 to 0.050.
9. An ethylene/1-hexene copolymer made by the method of claim 6, 7, or 8.
10. A manufactured article comprising a shaped form of the ethylene/1-hexene copolymer of claim 9.