[0013] A method of polymerizing ethylene, and optionally an alpha-olefin comonomer(s), in a polymerization process conducted in a polymerization reactor, the method comprising contacting ethylene, and optionally alpha-olefin comonomer(s), with the Ziegler-Natta catalyst system in a polymerization reactor to give a semicrystalline polyethylene polymer.

[0013a] In one aspect, there is provided a method of polymerizing ethylene, and optionally 0, 1, or more alpha-olefin comonomers, in a gas phase or liquid phase polymerization process conducted in a gas phase or liquid phase polymerization reactor, the method comprising contacting ethylene, and optionally 0, 1, or more alpha-olefin comonomers, a Ziegler-Natta catalyst system to give a semicrystalline polyethylene polymer; wherein the Ziegler-Natta catalyst system comprises a nucleating effective amount of a compound (B1) calcium 1R,2S-*cis*-cyclohexane-1,2-dicarboxylate, wherein the molar ratio of calcium to (1R,2S)-*cis*-cyclohexane-1,2-dicarboxylate is 1:1 and (D) a Ziegler-Natta catalyst.

[0014] The semicrystalline polyethylene polymer made by the method of polymerizing.

[0015] A manufactured article comprising the semicrystalline polyethylene polymer.

DRAWING(S)

[0016] Figure (FIG.) 1 contains a DSC exotherm plot of heat flow versus time for a test sample CE(C) of a semicrystalline polyethylene polymer at 122° C.

DETAILED DESCRIPTION

[0017] The Introduction, Summary and Abstract are incorporated here by reference.

[0018] Certain inventive embodiments are described below as numbered aspects for easy cross-referencing. Additional embodiments are described elsewhere herein.

[0019] Aspect 1. An activator-nucleator formulation comprising, alternatively consisting essentially of, alternatively consisting of, an activating effective amount of (A) an alkylaluminum(chloride) compound of formula (I): $Al((C_1\text{-}C_6)alkyl)_m(chloro)_n$ (I), wherein subscript m is an integer from 1 to 3, subscript n is an integer from 2 to 0, the sum of subscripts m + n = 3, and each chloro is a chlorine atom (compound (A)); and a nucleating effective amount of a compound (B) selected from at least one of compounds (B1) to (B3): (B1) calcium (1R,2S)-*cis*-cyclohexane-1,2-dicarboxylate (1:1); (B2) calcium stearate (1:2), and (B3) zinc stearate (1:2). The activator-nucleator formulation may be free of a polyolefin, alternatively may be free of any polymer.

[0020] Aspect 2. The activator-nucleator formulation of aspect 1, wherein the compound (A) is the alkylaluminum(chloride) compound of formula (I) characterized by any one of limitations (i) to (iii): (i) subscript m is 3 and subscript n is 0; (ii) each $(C_1\text{-}C_6)$alkyl is ethyl, butyl, or hexyl; and (iii) each $(C_1\text{-}C_6)$alkyl is ethyl. In some aspects the alkylaluminum(chloride compound of formula (I) is characterized by any one of limitations

(iv) to (xi): (iv) both (i) and (ii); (v) both (i) and (iii); (vi) subscript m is 2 and subscript n is 1; (vii) both (ii) and (vi); (viii) both (iii) and (vi); (ix) subscript m is 1 and subscript n is 2; (x) both (ii) and (ix); (xi) both (iii) and (ix).

[0021] Aspect 3. The activator-nucleator formulation of aspect 1 or 2, wherein the compound (B) is any one of limitations (i) to (iii): (i) (B1) calcium (1R,2S)-*cis*-cyclohexane-1,2-dicarboxylate (1:1); (ii) (B2) calcium stearate (1:2); and (iii) (B3) zinc stearate (1:2). In some aspects compound (B) is any one of limitations (iv) to (vii): (iv) both (i) and (ii); (v) both (i) and (iii); (vi) both (ii) and (iii); (vii) each of (i), (ii), and (iii).

CLAIMS

1. A method of polymerizing ethylene, and optionally 0, 1, or more alpha-olefin comonomers, in a gas phase or liquid phase polymerization process conducted in a gas phase or liquid phase polymerization reactor, the method comprising contacting ethylene, and optionally 0, 1, or more alpha-olefin comonomers, a Ziegler-Natta catalyst system to give a semicrystalline polyethylene polymer; wherein the Ziegler-Natta catalyst system comprises a nucleating effective amount of a compound (B1) calcium 1R,2S-*cis*-cyclohexane-1,2-dicarboxylate, wherein the molar ratio of calcium to (1R,2S)-*cis*-cyclohexane-1,2-dicarboxylate is 1:1 and (D) a Ziegler-Natta catalyst.

2. The method of claim 1 wherein the Ziegler-Natta catalyst system is a spray-dried Ziegler-Natta catalyst system further comprising at least one of a carrier material and an organic modifier that is tetrahydrofuran.

3. The method of claim 2 comprising the gas phase polymerization of the ethylene and the (C_3-C_{20})alpha-olefin in the presence of molecular hydrogen gas (H_2) and, optionally, an induced condensing agent (ICA) in one, two or more gas phase polymerization reactors under polymerizing conditions, thereby making the semicrystalline polyethylene polymer; wherein the polymerizing conditions comprise a reaction temperature from 80 degrees (°) to 110° Celsius (C.); a molar ratio of the molecular hydrogen gas to the ethylene (H_2/C_2 molar ratio) from 0.001 to 0.050; and a molar ratio of the comonomer to the ethylene (Comonomer/C_2 molar ratio) from 0.005 to 0.10.

4. The method of any one of claims 1 to 3 wherein the (D) Ziegler-Natta catalyst is made from a Ziegler-Natta procatalyst system comprising an activating effective amount of (A) an alkylaluminum(chloride) compound of formula (I): $Al((C_1$-$C_6)alkyl)_m(chloro)_n$ (I), wherein subscript m is an integer from 1 to 3, subscript n is an integer from 2 to 0, the sum of subscripts m + n = 3, and each chloro is a chlorine atom (compound (A)); the compound (B1); and (C) a Ziegler-Natta procatalyst.

5. A semicrystalline polyethylene polymer made by the method of polymerizing of any one of claims 1 to 4.

6. A manufactured article comprising the semicrystalline polyethylene polymer of claim 5.

7. The method of claim 1 comprising the liquid phase polymerization process conducted in a liquid phase polymerization reactor.

8. The method of claim 7 wherein the liquid phase polymerization process is a slurry phase polymerization process and the liquid phase polymerization reactor is a slurry phase polymerization reactor.

9. A semicrystalline polyethylene polymer made by the method of polymerizing of claim 7 or 8.

10. A manufactured article comprising the semicrystalline polyethylene polymer of claim 9.