METHOD OF CHANGING MELT RHEOLOGY PROPERTY OF BIMODAL POLYETHYLENE POLYMER

FIELD

[0001] Ethylene polymerization process, and bimodal polyethylene polymers made thereby.

INTRODUCTION

[0002] Patent application publications and patents in or about the field include US20170355790A1, US20170362353A1, US6063877, US7157531B2, and US9221936B2. Literature includes Montree Namkajorn et al., *Condensed Mode Cooling for Ethylene Polymerization: Part III. The Impact of Induced Condensing Agents on Particle Morphology and Polymer Properties*, Macromolecular Chemistry and Physics, 2016, vol. 217, pp. 1521-1528; and Ahmad Mirzaei et al., *Fluidized Bed Polyethylene Reactor Modeling in Condensed Mode Operation*, Macromol. Symp., 2007, vol. 259, pp. 135-144.

SUMMARY

[0003] We discovered a method of independently changing a melt rheology property value of a bimodal polyethylene polymer being made using a bimodal catalyst system in a single gas phase polymerization reactor. The method comprises process conditions comprising alkane(s) in the reactor. The method comprises a bimodal catalyst system that consists essentially of a metallocene catalyst and a single-site non-metallocene catalyst and is characterized by an inverse response to alkane(s) concentration such that when the alkane(s) concentration increases, the melt rheology property value of new bimodal polyethylene polymer being made by the bimodal catalyst system decreases, and when the alkane(s) concentration decreases, the melt rheology property value of new bimodal polyethylene polymer being made by the bimodal catalyst system increases. The method comprises changing concentration of the alkane(s) in the reactor. The amount of change in alkane(s) concentration is sufficient to effect a measurable change in the melt rheology property value. Other than that, the method is not particularly limited.

[0003a] In one aspect, the present disclosure refers to a method of independently changing a melt rheology property value of a bimodal polyethylene polymer being made using a bimodal catalyst system in a single gas phase polymerization (GPP) reactor under process conditions comprising (C_5-C_{20})alkane(s) in the reactor, wherein the bimodal polyethylene polymer comprises a higher molecular weight (HMW) component and a lower molecular weight (LMW) component, wherein the bimodal catalyst system consists essentially of a metallocene catalyst and a single-site non-metallocene catalyst and the bimodal catalyst system is characterized by an inverse response to (C_5-C_{20})alkane(s) concentration such that when the (C_5-C_{20})alkane(s) concentration is increased, the melt rheology property

value of the resulting bimodal polyethylene polymer is decreased, and when the (C_5-C_{20})alkane(s) concentration is decreased, the melt rheology property value of the resulting bimodal polyethylene polymer is increased; the method comprising changing concentration of the (C_5-C_{20})alkane(s) in the reactor by an amount sufficient to effect a measurable change in the melt rheology property value; wherein any other process condition that could change the melt rheology property value is controlled in such a way so as to not negative the effect of the change in (C_5-C_{20})alkane(s) concentration on the melt rheology property value; wherein the any other process condition that could change the melt rheology property value is H_2/C_2 molar ratio and bed temperature.

DETAILED DESCRIPTION

[0004] The Summary and Abstract are incorporated here by reference. Some aspects are numbered for ease of reference.

[0005] Aspect 1. A method of independently changing a melt rheology property value of a bimodal polyethylene polymer being made using a bimodal catalyst system in a single gas phase polymerization (GPP) reactor under process conditions comprising (C_5-C_{20})alkane(s) in the reactor, wherein the bimodal polyethylene polymer comprises a higher molecular weight (HMW) component and a lower molecular weight (LMW) component, wherein the bimodal catalyst system consists essentially of a metallocene catalyst and a single-site non-

CLAIMS

1. A method of independently changing a melt rheology property value of a bimodal polyethylene polymer being made using a bimodal catalyst system in a single gas phase polymerization (GPP) reactor under process conditions comprising (C_5-C_{20})alkane(s) in the reactor, wherein the bimodal polyethylene polymer comprises a higher molecular weight (HMW) component and a lower molecular weight (LMW) component, wherein the bimodal catalyst system consists essentially of a metallocene catalyst and a single-site non-metallocene catalyst and the bimodal catalyst system is characterized by an inverse response to (C_5-C_{20})alkane(s) concentration such that when the (C_5-C_{20})alkane(s) concentration is increased, the melt rheology property value of the resulting bimodal polyethylene polymer is decreased, and when the (C_5-C_{20})alkane(s) concentration is decreased, the melt rheology property value of the resulting bimodal polyethylene polymer is increased; the method comprising changing concentration of the (C_5-C_{20})alkane(s) in the reactor by an amount sufficient to effect a measurable change in the melt rheology property value; wherein any other process condition that could change the melt rheology property value is controlled in such a way so as to not negative the effect of the change in (C_5-C_{20})alkane(s) concentration on the melt rheology property value; wherein the any other process condition that could change the melt rheology property value is H_2/C_2 molar ratio and bed temperature.

2. The method of claim 1 wherein the melt rheology property being changed is a melt flow ratio or a modulus ratio or both.

3. The method of claim 2 wherein the melt flow ratio is MFR5, wherein MFR5 equals I_{21}/I_5; measured according to Melt Flow Ratio MFR5 Test Method; and the modulus ratio is melt elasticity G'/G″ (0.1 radians per second), wherein G' is elastic (storage) modulus and G″ is viscous (loss) modulus), measured according to the Melt Elasticity Test Method.

4. The method of any one of claims 1 to 3 comprising feeding into the GPP reactor a controlled amounts of fresh quantity of ethylene, fresh quantity of the bimodal catalyst system, fresh quantity of the (C_5-C_{20})alkane(s), optionally fresh quantity of hydrogen gas (H_2), if any, characterized by a hydrogen-to-ethylene (H_2/C_2) molar ratio, and optionally fresh quantity of an alpha-olefin, if any, characterized by an alpha-olefin-to-ethylene (C_x/C_2) molar ratio; polymerizing in the GPP reactor some of the ethylene and, optionally, the alpha-olefin (if any) with the bimodal catalyst system; (d) discharging from the GPP reactor a gas/vapor mixture (“discharged gas/vapor mixture) comprising vented (C_5-C_{20})alkane(s),

vented unreacted ethylene, vented unreacted hydrogen gas, if any, and vented unreacted alpha-olefin, if any, wherein the discharged gas/vapor mixture is characterized by a total concentration of the vented (C_5-C_{20})alkane(s) therein of from 1.0 to 20.0 mole percent (mol%); and making in the GPP reactor a first bimodal polyethylene polymer having a melt rheology property characterized by a first value; wherein the changing comprises increasing or decreasing the controlled amount of the fresh (C_4-C_{12})alkane(s) being fed into the GPP reactor so as to effectively increase or decrease, respectively, the total concentration of the vented (C_5-C_{20})alkane(s) in the discharged gas/vapor mixture by at least 1.0 mol%; and after the changing step making a second bimodal polyethylene polymer having the melt rheology property characterized by a second steady-state value, which is lesser than or greater than, respectively, the first steady-state value by at least ± 1.0%

5. The method of any one of claims 1 to 4 wherein the metallocene catalyst of the bimodal catalyst system is an (alkyl-substituted cyclopentadienyl)(unsubstituted or alkyl-substituted cyclopentadienyl)MX_2 and the single-site non-metallocene catalyst of the bimodal catalyst system is an ((alkyl-substituted-phenylamido)ethyl)-amine MX_2, wherein each M independently is zirconium (Zr) or hafnium (Hf); and each X is independently selected from F, Cl, Br, I, benzyl, -$CH_2Si(CH_3)_3$, a (C_1-C_5)alkyl, and a (C_2-C_5)alkenyl.

6. The method of any one of claims 1 to 5 wherein the single gas phase polymerization reactor is a floating-bed gas phase polymerization (FB-GPP) reactor and wherein the process conditions comprise (a) to (e): (a) the FB-GPP reactor having a floating resin bed at a bed temperature from 80 to 110 degrees Celsius (° C.); (b) the FB-GPP reactor receiving feeds of respective controlled amounts of fresh ethylene, fresh bimodal catalyst system, fresh (C_5-C_{20})alkane(s), optionally fresh hydrogen gas (H_2) characterized by a hydrogen-to-ethylene (H_2/C_2) molar ratio, and optionally fresh alpha-olefin characterized by an alpha-olefin-to-ethylene (C_x/C_2) molar ratio; (c) polymerizing in the FB-GPP reactor some of the ethylene and, optionally, the alpha-olefin with the bimodal catalyst system; (d) discharging from the FB-GPP reactor a gas/vapor mixture comprising vented (C_5-C_{20})alkane(s), vented unreacted ethylene, vented unreacted hydrogen gas, if any, and vented unreacted alpha-olefin, if any, wherein the discharged gas/vapor mixture is characterized by a total concentration of the vented (C_5-C_{20})alkane(s) therein of from 1.0 to 20.0 mole percent (mol%); and (e) making in the FB-GPP reactor a first bimodal polyethylene polymer having a melt rheology property characterized by a first value; wherein the changing comprises increasing or decreasing the controlled amount of the fresh (C_5-C_{20})alkane(s) being fed into the FB-GPP reactor so as to effectively increase or decrease, respectively, the total

concentration of the vented (C_5-C_{20})alkane(s) in the discharged gas/vapor mixture by at least 1.0 mol%; and after the changing step making a second bimodal polyethylene polymer having the melt rheology property characterized by a second steady-state value, which is lesser than or greater than, respectively, the first steady-state value by at least ± 1.0%.

7. The method of claim 1 wherein the melt rheology property value is also independently changeable by changing a H_2/C_2 molar ratio and/or bed temperature in the GPP reactor, and wherein the H_2/C_2 molar ratio and bed temperature are kept constant during the method.

8. The method of any one of claims 1 to 6 wherein the melt rheology property value is also independently changeable by changing a H_2/C_2 molar ratio or bed temperature or both in the GPP reactor, and wherein the method further comprises changing the H_2/C_2 molar ratio and/or bed temperature in such a way so as to add to the change in the melt rheology property value made by the change in (C_5-C_{20})alkane(s) concentration.

9. The method of any one of claims 1 to 6 wherein the melt rheology property value is also independently changeable by changing a H_2/C_2 molar ratio or bed temperature or both in the GPP reactor, and wherein the method further comprises changing the H_2/C_2 molar ratio and/or bed temperature in such a way so as to partially subtract from the change in the melt rheology property value made by the change in (C_5-C_{20})alkane(s) concentration.