ETHYLENE/OCTENE MULTI-BLOCK COPOLYMER AND PROCESS FOR PRODUCING SAME

BACKGROUND

[0001] Ethylene/octene multi-block copolymer provides the benefits of both the durability and high temperature resistance of high density polyethylene while maintaining key properties of elastomeric, low density polyolefin such as elastic behavior, flexibility, and processability. Ethylene/octene multi-block copolymer typically contains high density "hard" segments and low density "soft" segments. The soft segment contains higher content of comonomer which may be soft and prone to sticking. For commercial production of ethylene/octene multi-block copolymers where bulk shipment is valuable, the low density soft block is a limiting constraint for large scale production and storage of pellets. Many applications could benefit from a lower density soft block (more octene incorporation), however the existing ethylene/octene multi-block copolymer system is limited due to poor solids handling.

[0002] The art recognizes the need for an ethylene/octene multi-block copolymer with increased soft segment octene incorporation and improved solids handling performance, specifically improved (lower) unconfined yield strength.

SUMMARY

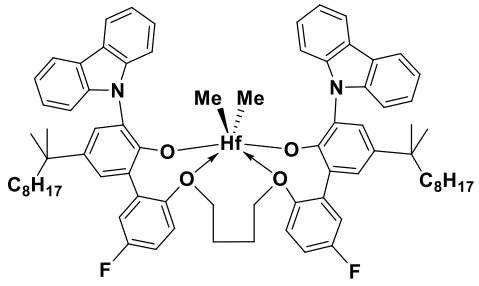
[0003] The present disclosure provides a process. In an example, the process includes contacting ethylene and octene under polymerization conditions at a temperature greater than 125°C with a catalyst system comprising (i) a first polymerization catalyst having the structure of Formula (III), a second polymerization catalyst having the structure of Formula (I), and (iii) a chain shuttling agent. The process includes forming an ethylene/octene multi-block copolymer having a normalized OOO triad content greater than 0.25.

[0003a] In one aspect, the present disclosure provides a process comprising:

contacting ethylene and octene under polymerization conditions at a temperature greater than 125°C with a catalyst system comprising

(i) a first polymerization catalyst having the structure of catalyst 1

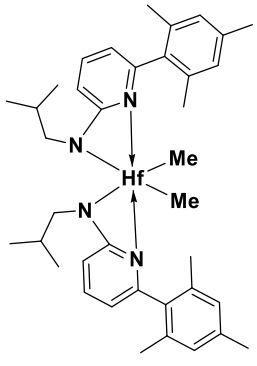
catalyst 1



;

(ii) a second polymerization catalyst having the structure of catalyst 2

catalyst 2



;

(iii) a first co-catalyst that is a mixture of methyldi(C_{14-18}alkyl)ammonium salts of tetrakis-(pentafluorophenyl)borate;

(iv) a second co-catalyst that is an iso-butyl, methyl, branched, cyclic and linear modified methyl aluminosiloxane (MMAO);

(v) a chain shuttling agent;

maintaining, during the contacting, an aluminum to hafnium molar ratio from 7.1 to 15.6; and forming an ethylene/octene multi-block copolymer having a normalized OOO triad content greater than 0.25, wherein the ethylene/octene multi-block copolymer has hard segments and soft segments, the soft segments having a soft segment melting temperature (SS-Tm)

from -30°C to 30°C, the ethylene/octene multi-block copolymer having a first TGIC peak temperature (T_{p1}) and a second TGIC peak temperature (T_{p2})

wherein T_{p2} fulfills Equation (A)

$T_{p2} \leq 0.0068 \times (SS\text{-}Tm)^2 + 0.07 \times (SS\text{-}Tm) + 73.2$.

[0004] The present disclosure provides the resultant composition produced by the process. In an example, the composition includes an ethylene/octene multi-block copolymer having a normalized OOO triad content greater than 0.25.

[0004a] In another aspect, the present disclosure provides a composition comprising: an ethylene/octene multi-block copolymer comprising hafnium and aluminum at an aluminum to hafnium molar ratio from 7.1 to 15.6; and the ethylene/octene multi-block copolymer has a normalized OOO triad content greater than 0.25.

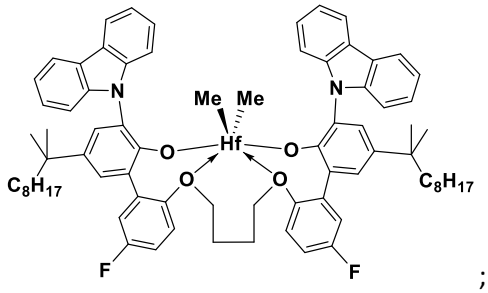
Claims

[Claim 1] A process comprising:

contacting ethylene and octene under polymerization conditions at a temperature greater than 125°C with a catalyst system comprising

(i) a first polymerization catalyst having the structure of catalyst 1

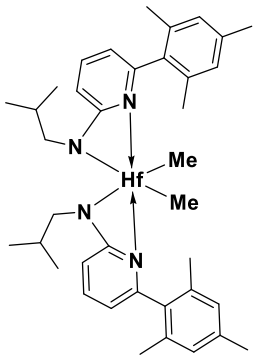
catalyst 1



;

(ii) a second polymerization catalyst having the structure of catalyst 2

catalyst 2



;

(iii) a first co-catalyst that is a mixture of methyldi(C_{14-18}alkyl)ammonium salts of tetrakis-(pentafluorophenyl)borate;

(iv) a second co-catalyst that is an iso-butyl, methyl, branched, cyclic and linear modified methyl aluminosiloxane (MMAO);

(v) a chain shuttling agent;

maintaining, during the contacting, an aluminum to hafnium molar ratio from 7.1 to 15.6; and

forming an ethylene/octene multi-block copolymer having a normalized OOO triad content greater than 0.25, wherein the ethylene/octene multi-block copolymer has hard segments and soft segments, the soft segments having a soft segment melting temperature (SS-Tm) from -30°C to 30°C, the ethylene/octene multi-block copolymer having a first TGIC peak temperature (T_{p1}) and a second TGIC peak temperature (T_{p2})

wherein T_{p2} fulfills Equation (A)

$T_{p2} \leq 0.0068 \times (SS\text{-}Tm)^2 + 0.07 \times (SS\text{-}Tm) + 73.2$.

[Claim 2] The process of claim 1 comprising contacting the ethylene and octene under polymerization conditions at a temperature from 130°C to 170°C.

[Claim 3] A composition comprising:

an ethylene/octene multi-block copolymer comprising hafnium and aluminum at an aluminum to hafnium molar ratio from 7.1 to 15.6; and

the ethylene/octene multi-block copolymer has a normalized OOO triad content greater than 0.25.

[Claim 4] The composition of claim 3 wherein the ethylene/octene multi-block copolymer comprises from 10 mol % to 30 mol % of octene.

[Claim 5] The composition of claim 4 wherein

the ethylene/octene multi-block copolymer comprises hard segments and soft segments, the soft segments having a soft segment melting temperature (SS-Tm) from -30°C to 30°C, the ethylene/octene multi-block copolymer having a first TGIC peak temperature (T_{p1}) and a second TGIC peak temperature (T_{p2})

wherein T_{p2} fulfills Equation (A)

$T_{p2} \leq 0.0068 \times (SS\text{-}Tm)^2 + 0.07 \times (SS\text{-}Tm) + 73.2$.

[Claim 6] The composition of claim 5 wherein the ethylene/octene multi-block copolymer has T_{p1} from 125°C to 150°C and a T_{p2} from 68°C to 90°C.

[Claim 7] The composition of claim 6 wherein the ethylene/octene multi-block copolymer has a glass transition temperature (Tg) from -70°C to -55°C.

[Claim 8] The composition of claim 7 wherein the ethylene/octene multi-block copolymer has a density from 0.855 to 0.890 grams per cubic centimeter (g/cc).

[Claim 9] The composition of claim 8 wherein the ethylene/octene multi-block copolymer has an unconfined yield strength (UYS) from 0 lb/ft^2 to less than 200 lb/ft^2 at 21°C after two months.

[Claim 10] The composition of any of claims 8-9 wherein the ethylene/octene multi-block copolymer has a funnel flow from greater than 150 g/s to 200 g/s after 6 weeks.

[Claim 11] The composition of any of claims 8-10 wherein the ethylene/octene multi-block copolymer has an unconfined yield strength (UYS) from 0 lb/ft^2 to less than 73 lb/ft^2 at 0°C after two months.