PROCESS FOR PRODUCING FOAM BEADS USING A MODIFIED ETHYLENE-BASED POLYMER

BACKGROUND

[0001] The present disclosure relates to ethylene-based polymer foams, also known as polyethylene foams.

[0002] Polyethylene foams are utilized in footwear components, such as midsole applications. Crosslinked ethylene-based polymers including ethylene vinyl acetate (EVA) copolymer and polyolefin elastomers have traditionally dominated the polyethylene foam market in footwear as they can easily be foamed with a chemical blowing agent. However, chemical blowing agents are known to produce unpleasant odors and contaminate molds.

[0003] Furthermore, crosslinked ethylene-based polymer foams are not recyclable because they are thermoset (rather than thermoplastic). Additionally, crosslinked ethylene-based polymer foam beads cannot be fused together to form a uniform article, such as a foam midsole. Consequently, crosslinked ethylene-based polymer foams are not traditionally prepared using a foam bead process, which utilizes a physical blowing agent.

[0004] The art recognizes the need for a process of forming ethylene-based foam beads that exhibit suitable density for foam sole and foam midsole applications. The art also recognizes the need for a process of forming ethylene-based foam beads that are not crosslinked.

[0005] The art recognizes the need for an ethylene-based foam bead formed from a composition with a suitable melt strength for foam applications, wherein the foam bead exhibits suitable density for foam applications, and is not crosslinked.

SUMMARY

[0006] The present disclosure provides a process. The process includes (i) forming a composition containing a peroxide-modified ethylene-based polymer selected from the group consisting of a peroxide-modified ethylene/α-olefin multi-block copolymer, a peroxide-modified low density polyethylene, and combinations thereof; (ii) contacting the composition with a blowing agent to form a foam composition; and (iii) forming foam beads comprising the foam composition.

[0006a] In one aspect, the present disclosure refers to a process comprising: (i) forming a composition comprising a peroxide-modified ethylene-based polymer selected from the group consisting of a peroxide-modified ethylene/α-olefin multi-block copolymer, a peroxide-

modified low density polyethylene, and combinations thereof, wherein the peroxide-modified ethylene-based polymer has been melt blended with a peroxide at a temperature , such that the peroxide acts as a rheology modifying agent in such a way (i) that the degree of long chain branching (LCB) in the peroxide-modified ethylene-based polymer is greater than the degree of LCB in the base ethylene-based polymer prior to peroxide modification, but (ii) the addition of peroxide does not induce crosslinking, as evidenced by the peroxide-modified ethylene-based polymer having a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765; (ii) contacting the composition with a blowing agent to form a foam composition; and (iii) forming foam beads comprising the foam composition; wherein the foam bead has a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765.

[0007] The present disclosure also provides a foam bead. The foam bead contains a composition containing a peroxide-modified ethylene-based polymer selected from the group consisting of a peroxide-modified ethylene/α-olefin multi-block copolymer, a peroxide-

modified low density polyethylene, and combinations thereof. The composition has (a) a melt strength from 9 cN to 30 cN and (b) a gel content of 0%. The foam bead has a foam density of less than 0.300 g/cc.

[0007a] In another aspect, the present disclosure refers to a foam bead comprising: a composition comprising a peroxide-modified ethylene-based polymer selected from the group consisting of a peroxide-modified ethylene/α-olefin multi-block copolymer, a peroxide-modified low density polyethylene, and combinations thereof; wherein the peroxide-modified ethylene-based polymer has been melt blended with a peroxide at a temperature, such that the peroxide acts as a rheology modifying agent in such a way (i) that the degree of long chain branching (LCB) in the peroxide-modified ethylene-based polymer is greater than the degree of LCB in the base ethylene-based polymer prior to peroxide modification, but (ii) the addition of peroxide does not induce crosslinking, as evidenced by the peroxide-modified ethylene-based polymer having a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765; the composition having (a) a melt strength from 9 cN to 30 cN; (b) a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765; and the foam bead having (i) a foam density of less than 0.300 g/cc as measured in accordance with ASTM D792-00 involving weighing polymer foam in water using a sinker and (ii) a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765.

DEFINITIONS

[0008] Any reference to the Periodic Table of Elements is that as published by CRC Press, Inc., 1990–1991. Reference to a group of elements in this table is by the new notation for numbering groups.

[0009] For purposes of United States patent practice, the contents of any referenced patent, patent application or publication are incorporated by reference in their entirety (or its equivalent US version is so incorporated by reference) especially with respect to the disclosure of definitions (to the extent not inconsistent with any definitions specifically provided in this disclosure) and general knowledge in the art.

[0010] The numerical ranges disclosed herein include all values from, and including, the lower

and upper value. For ranges containing explicit values (e.g., a range from 1 or 2, or 3 to 5, or 6, or 7), any subrange between any two explicit values is included (e.g., 1 to 2; 2 to 6; 5 to 7; 3 to 7; 5 to 6; etc.).

[0011] Unless stated to the contrary, implicit from the context, or customary in the art, all parts and percents are based on weight and all test methods are current as of the filing date of this disclosure.

[0012] The terms "blend" or "polymer blend," as used herein, is a blend of two or more polymers. Such a blend may or may not be miscible (not phase separated at molecular level). Such a blend may or may not be phase separated. Such a blend may or may not contain one or more domain configurations, as determined from transmission electron spectroscopy, light scattering, x-ray scattering, and other methods known in the art.

[0013] The term "block copolymer" or "segmented copolymer" refers to a polymer comprising two or more chemically distinct regions or segments (referred to as "blocks") joined in a linear manner, that is, a polymer comprising chemically differentiated units which are joined (covalently bonded) end-to-end with respect to polymerized functionality, rather than in pendent or grafted fashion. In an embodiment, the blocks differ in the amount or type of comonomer incorporated therein, the density, the amount of crystallinity, the type of crystallinity (e.g. polyethylene versus

CLAIMS

We Claim:

1. A process comprising:

(i) forming a composition comprising a peroxide-modified ethylene-based polymer selected from the group consisting of a peroxide-modified ethylene/α-olefin multi-block copolymer, a peroxide-modified low density polyethylene, and combinations thereof,

wherein the peroxide-modified ethylene-based polymer has been melt blended with a peroxide at a temperature, such that the peroxide acts as a rheology modifying agent in such a way (i) that the degree of long chain branching (LCB) in the peroxide-modified ethylene-based polymer is greater than the degree of LCB in the base ethylene-based polymer prior to peroxide modification, but (ii) the addition of peroxide does not induce crosslinking, as evidenced by the peroxide-modified ethylene-based polymer having a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765;

(ii) contacting the composition with a blowing agent to form a foam composition; and

(iii) forming foam beads comprising the foam composition;

wherein the foam bead has a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765.

2. The process of claim 1 comprising contacting the composition with the blowing agent at a temperature of from 100°C to 130°C.

3. The process of claim 1 or 2 wherein the blowing agent is a physical blowing agent.

4. The process of any of claims 1–3 comprising forming the composition solely from the peroxide-modified ethylene/α-olefin multi-block copolymer.

5. The process of any of claims 1–3 wherein the forming step comprises:
melt blending the peroxide-modified ethylene/α-olefin multi-block copolymer with an ethylene/α-olefin multi-block copolymer.

6. The process of any of claims 1–3 wherein the forming step comprises:
melt blending the peroxide-modified low density polyethylene with an ethylene/α-olefin multi-block copolymer.

7. The process of any of claims 1–6 wherein the composition has a melt strength from 9 cN to 30 cN.

8. The process of any of claims 1–7 wherein the foam beads have a foam density of less than 0.300 g/cc as measured in accordance with ASTM D792-00 involving weighing polymer foam in water using a sinker.

9. A foam bead comprising:

a composition comprising a peroxide-modified ethylene-based polymer selected from the group consisting of a peroxide-modified ethylene/α-olefin multi-block copolymer, a peroxide-modified low density polyethylene, and combinations thereof;

wherein the peroxide-modified ethylene-based polymer has been melt blended with a peroxide at a temperature, such that the peroxide acts as a rheology modifying agent in such a way (i) that the degree of long chain branching (LCB) in the peroxide-modified ethylene-based polymer is greater than the degree of LCB in the base ethylene-based polymer prior to peroxide modification, but (ii) the addition of peroxide does not induce crosslinking, as evidenced by the peroxide-modified ethylene-based polymer having a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765;

the composition having

(a) a melt strength from 9 cN to 30 cN;

(b) a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765; and

the foam bead having (i) a foam density of less than 0.300 g/cc as measured in accordance with ASTM D792-00 involving weighing polymer foam in water using a sinker and (ii) a gel content of 0% as measured by extraction in boiling decalin at 180 °C for 5 hours according to ASTM 2765.