performance in one aspect are often detrimental in others. To be formed into films, desirable flow properties are also beneficial. Polymer compositions that provide a good balance of properties, e.g., impact strength and flow properties, will find application where more costly or cumbersome polymers are currently used.

SUMMARY

[05] Examples of the disclosure address one or more of the shortcomings of polyethylene compositions, particularly, polyethylene compositions for film applications and films made therefrom. Examples of the disclosure are based in part on the discovery that particular chromium-based catalysts, in combination with certain operating and processing conditions, can produce polyethylene copolymers with an improved balance of density, impact strength, tear strength and flow properties.

[06] In one aspect, the present disclosure refers to a film comprising: a polyethylene copolymer formed using a reduced chromium oxide catalyst, ethylene monomers and a co-monomer selected from 1-butene or 1-hexene, the polyethylene copolymer formed with the co-monomer to ethylene monomer gas mole ratio in a range of 0.012 to 0.04 to form the polyethylene copolymer having a density measured according to ASTM D1505 in the range of from 0.9350 to 0.950 g/cm^3 and an I_{21}/I_5 in a range of 18.0 to 30.0, where I_{21} is measured according to ASTM D1238 at 190 °C with a 21.6 kg weight and I_5 is measured according to ASTM D1238 at 190 °C with a 5.0 kg weight, wherein the polyethylene copolymer formed using the reduced chromium oxide catalyst provides an improvement in a dart drop impact (g/μm, measured according to ASTM D-1709, method A, at a drop height of 0.66 meter) of the film of 17 percent to 56 percent as compared to a film of the polyethylene copolymer formed using a silyl chromate catalyst in place of the reduced chromium oxide catalyst. Thus, examples of the disclosure relate to films comprising a polyethylene copolymer formed using a reduced chromium oxide catalyst, ethylene monomers and a co-monomer selected from 1-butene or 1-hexene, the polyethylene copolymer formed with the co-monomer to ethylene monomer mole ratio in a range of about 0.012 to about 0.04 to form the polyethylene copolymer having a density in the range of from about 0.9350 to about 0.950 g/cm^3 and an I_{21}/I_5 in a range of about 18.0 to about 30.0, wherein the polyethylene copolymer formed using the reduced chromium oxide catalyst provides an improvement in a dart drop impact (g/μm) of the film of 17 percent to 56 percent as compared to a film of the polyethylene copolymer formed

using a silyl chromate catalyst in place of the reduced chromium oxide catalyst. The reduced chromium oxide catalyst can be reduced with diethylaluminum ethoxide (DEAlE).

[07] The polyethylene copolymer can have the following properties. The polyethylene copolymer can have a melt index (I_5) of about 0.4 to about 1.0 g/10 min. The polyethylene copolymer can also have flow index (I_{21}) of about 5.0 to about 25.0 g/10 min. The polyethylene copolymer can have an I_{21}/I_5 of about 18.0 to about 28.0. The polyethylene copolymer can have a Mw $\geq$ about 100,000 g/mol. The polyethylene copolymer can have a Mw/Mn of about 6.0 to about 50.0.

[08] The film formed from the polyethylene copolymer can have the following properties. The film formed from the polyethylene copolymer can have a dart drop impact of about 10.0 to about 20.0 g/μm. The film can also have a TD Elmendorf Tear of about 2.4 g/μm to about 15.0 g/μm. The film can have an MD Elmendorf Tear of about 0.6 g/μm to about 5.0 g/μm. The film can have a 2% secant modulus from about 600 MPa to about 1400 MPa. The film can have a thickness of about 5.0 to about 75.0 μm.

[09] In another aspect, the present disclosure refers to a method of making a film having improved dart impact, comprising providing a polyethylene copolymer formed using a reduced chromium oxide catalyst, ethylene monomers and a co-monomer selected from 1-butene or 1-hexene, where the co-monomer to ethylene monomer gas mole ratio is in a range of 0.012 to 0.04 to form the polyethylene copolymer having a density measured according to ASTM D1505 in the range of from 0.935 to 0.950 g/cm^3 and an I_{21}/I_5 in a range of 18 to 30, where I_{21} is measured according to ASTM D1238 at 190 °C with a 21.6 kg weight and I_5 is measured according to ASTM D1238 at 190 °C with a 5.0 kg weight; and forming the polyethylene into a film; wherein the polyethylene copolymer formed using the reduced chromium oxide catalyst provides an improvement in a dart drop impact (g/μm, measured according to ASTM D-1709, method A, at a drop height of 0.66 meter) of the film of 17 percent to 56 percent as compared to a film of the polyethylene copolymer formed using a silyl chromate catalyst in place of the reduced chromium oxide catalyst. The present disclosure also relate to the methods of making a film having improved dart impact as provided herein. The method can include providing the polyethylene copolymer formed using the reduced chromium oxide catalyst, ethylene monomers and the co-monomer selected from 1-butene or 1-hexene, where the co-monomer to ethylene monomer mole ratio is in a range of about 0.012 to about 0.04 to form the polyethylene copolymer having a density in the range of from about 0.935 to about 0.950 g/cm^3 and an I_{21}/I_5 in a range of about 18 to about 30, and forming the polyethylene into a film; wherein the polyethylene copolymer formed using the reduced chromium oxide catalyst provides an improvement in a dart drop impact (g/μm) of the film of 17 percent to 56 percent as compared to a film of the polyethylene copolymer formed using a silyl chromate catalyst in place of the reduced chromium oxide catalyst.

[010] Another example relates to a process for polymerizing olefins to produce the polymer of having a density in the range of from about 0.935 to about 0.950 g/cm^3 and an I_{21}/I_5 in a range of about 18 to about 30 comprising contacting the olefins, under polymerization conditions, with a catalyst system comprising a chromium-oxide containing catalyst compound and one or more organoaluminum activators, wherein the olefins include ethylene and one or more C_3 to C_{20} α-olefins (e.g., 1-butene, 1-hexene, etc.).

BRIEF DESCRIPTION OF THE DRAWINGS

[011] FIG. 1 is a simplified process flow diagram of the polymerization system in accordance with embodiments of the present techniques.

DETAILED DESCRIPTION

[012] Before the present compounds, components, compositions, and/or methods are disclosed and described, it is to be understood that unless otherwise indicated this invention is not limited to specific compounds, components, compositions, reactants, reaction conditions, ligands, catalyst structures, or the like, as such may vary, unless otherwise specified. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting.

Definitions

[013] For purposes herein a "polymer" has two or more of the same or different polymer units derived from one or more different monomers, e.g., homopolymers, copolymers, terpolymers, etc. A "homopolymer" is a polymer having polymer units that are the same. A

"copolymer" is a polymer having two or more polymer units that are different from each other. A "terpolymer" is a polymer having three polymer units that are different from each other. "Different" in reference to polymer units indicates that the polymer units differ from each other by at least one atom or are different isomerically. Accordingly, the definition of copolymer, as used herein, includes terpolymers and the like. An oligomer is typically a polymer having a low molecular weight, such as a Mn of less than 20,000 g/mol or an Mn of less than 2,500 g/mol, or a low number of polymer units, such as 100 polymer units or less, 75 polymer units or less, or 50 polymer units or less.

[014] As used herein the term "polyethylene" refers to compositions wherein ≥ 50 wt% of the monomers in the polymer units is derived from ethylene-monomer. The remaining polymer units are typically derived from one or more optional co-monomers, e.g., olefins.

[015] For purposes herein an "olefin," alternatively referred to as "alkene," is a linear, branched, or cyclic compound comprising carbon and hydrogen having at least one double bond. For purposes of this specification and the claims appended thereto, when a polymer or copolymer is referred to as comprising an olefin, the olefin present in such polymer or copolymer is the polymerized form of the olefin. For example, when a copolymer is said to have an "ethylene" content of 75 wt% to 85 wt%, it is understood that the polymer unit in the copolymer is derived from ethylene in the polymerization reaction and said derived units are present at 75 wt% to 85 wt%, based upon the weight of the polymer. A higher α-olefin is defined to be an α-olefin having 4 or more carbon atoms. For the purposes of this disclosure ethylene is considered an alpha-olefin. Suitable co-monomers for use in the polyethylenes described herein include C_3 to C_{20} olefins, e.g., C_3 to C_{10} olefins, C_4 to C_8 olefins, ethylene, propylene, butenes (e.g., 1-butene), pentenes, hexenes (e.g., 1-hexene), heptenes, octenes, and mixtures thereof.

[016] As used herein, Mn is number average molecular weight, Mw is weight average molecular weight, and Mz is z average molecular weight, wt% is weight percent, and mol% is mole percent. Molecular weight distribution (MWD), also referred to as polydispersity, is defined to be Mw divided by Mn. Unless otherwise noted, all molecular weight units (e.g., Mw, Mn, Mz) are g/mol. Mn and Mw are measured as discussed herein.

[017] Unless otherwise stated, any reference herein to the Periodic Table of the Elements and groups thereof refers to the NEW NOTATION published in HAWLEY'S CONDENSED CHEMICAL DICTIONARY, Thirteenth Edition, John Wiley & Sons, Inc., (1997).

What is claimed is:

1. A film comprising: a polyethylene copolymer formed using a reduced chromium oxide catalyst, ethylene monomers and a co-monomer selected from 1-butene or 1-hexene, the polyethylene copolymer formed with the co-monomer to ethylene monomer gas mole ratio in a range of 0.012 to 0.04 to form the polyethylene copolymer having a density measured according to ASTM D1505 in the range of from 0.9350 to 0.950 g/cm^3 and an I_{21}/I_5 in a range of 18.0 to 30.0, where I_{21} is measured according to ASTM D1238 at 190 °C with a 21.6 kg weight and I_5 is measured according to ASTM D1238 at 190 °C with a 5.0 kg weight, wherein the polyethylene copolymer formed using the reduced chromium oxide catalyst provides an improvement in a dart drop impact (g/μm, measured according to ASTM D-1709, method A, at a drop height of 0.66 meter) of the film of 17 percent to 56 percent as compared to a film of the polyethylene copolymer formed using a silyl chromate catalyst in place of the reduced chromium oxide catalyst.

2. The film of claim 1, wherein the polyethylene copolymer has a melt index (I_5) of 0.4 to 1.0 g/10 min.

3. The film of claim 1, wherein the polyethylene copolymer has a flow index (I_{21}) of 5.0 to 25.0 g/10 min.

4. The film of claim 1, where the reduced chromium oxide catalyst is reduced with diethylaluminum ethoxide (DEAlE); or wherein the polyethylene copolymer has an I_{21}/I_5 of 18.0 to 28.0; or wherein the polyethylene copolymer has a Mw/Mn of 6.0 to 50.0; or wherein the polyethylene copolymer has a Mw $\geq$ 100,000 g/mol.

5. The film of claim 1, wherein the film has a dart drop impact of 10.0 to 20.0 g/μm; or wherein the film has a TD Elmendorf Tear of 2.4 g/μm to 15.0 g/μm; or wherein the film has an MD Elmendorf Tear of 0.6 g/μm to 5.0 g/μm; or wherein the film has a 2% secant modulus from 600 MPa to 1400 MPa.

6. The film of claim 1 having a thickness of 5.0 to 75.0 μm.

7. A method of making a film having improved dart impact, comprising

providing a polyethylene copolymer formed using a reduced chromium oxide catalyst, ethylene monomers and a co-monomer selected from 1-butene or 1-hexene, where the co-monomer to ethylene monomer gas mole ratio is in a range of 0.012 to 0.04 to form the polyethylene copolymer having a density measured according to ASTM D1505 in the range of from 0.935 to 0.950 g/cm^3 and an I_{21}/I_5 in a range of 18 to 30, where I_{21} is measured according to ASTM D1238 at 190 °C with a 21.6 kg weight and I_5 is measured according to ASTM D1238 at 190 °C with a 5.0 kg weight; and

forming the polyethylene into a film; wherein the polyethylene copolymer formed using the reduced chromium oxide catalyst provides an improvement in a dart drop impact (g/μm, measured according to ASTM D-1709, method A, at a drop height of 0.66 meter) of the film of 17 percent to 56 percent as compared to a film of the polyethylene copolymer formed using a silyl chromate catalyst in place of the reduced chromium oxide catalyst.

8. The method of claim 7, wherein the polyethylene copolymer has a melt index (I_5) of 0.4 to 1.0 g/10 min.

9. The method of claim 7, wherein the polyethylene copolymer has a flow index (I_{21}) of 5.0 to 25.0 g/10 min.

10. The method of claim 8, wherein the polyethylene copolymer has an I_{21}/I_5 of 18.0 to 28.0; or wherein the polyethylene copolymer has a Mw $\geq$ 100,000 g/mol; or wherein the polyethylene copolymer has a Mw/Mn of 6.0 to 50.0; or wherein the film has a dart drop impact of 10.0 to 20.0 g/μm; or wherein the film has a TD Elmendorf Tear of 2.4 g/μm to 15.0 g/μm; or wherein the film has an MD Elmendorf Tear of 0.6 g/μm to 5.0 g/μm; or wherein the film has a 2% secant modulus from 600 MPa to 1400 MPa.