[0005] In view of the above deficits in the performance of many known LLDPE polymers, it is desirable to identify process and/or compositional means and methods which can be employed in producing new, differentiated LLDPE polymers. Furthermore, it is desirable that such new means and/or methods offer process and product advancements such as enhanced catalyst efficiencies, narrower polydispersities, and narrower SCBD for improved uniformity of such products.

SUMMARY OF THE INVENTION

[0005a] In an aspect, there is provided a process to prepare a multi-metallic procatalyst comprising (a) reacting a hydrocarbon-soluble organomagnesium compound or complex thereof and an active non-metallic or metallic halide to form a halogenated magnesium support; (b) contacting the magnesium halide support with a conditioning compound containing an element selected from the group consisting of boron, aluminum, gallium, indium and tellurium under conditions sufficient to form a conditioned magnesium halide support; (c) contacting the conditioned magnesium halide support and a compound containing, as a first metal, titanium, to form a supported titanium compound; (d) contacting the supported titanium compound and a second metal and a third metal independently selected from the group consisting of zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, and tungsten, provided that the second metal and the third metal are not the same; and further provided that the molar ratio of the magnesium to a combination of the titanium and the second and third metals ranges from 30:1 to 5:1; under conditions sufficient to form a multi-metallic procatalyst.

[0006] In ana ~~first~~ embodiment, the present disclosure~~invention~~ provides a process to prepare a tri-metallic procatalyst comprising (a) reacting a hydrocarbon-soluble organomagnesium compound or complex thereof and an active non-metallic or metallic halide to form a halogenated magnesium support; b) contacting the magnesium halide support with a conditioning compound containing an element selected from the group consisting of boron, aluminum, gallium, indium and tellurium under conditions sufficient to form a conditioned magnesium halide support; (c) contacting the conditioned magnesium halide support and a compound containing, as a first metal, titanium, to form a supported titanium compound; (d) contacting the supported titanium compound and a second metal and a third metal independently selected from the group consisting of zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, and tungsten, provided that the second metal and the third metal are not the same; and further provided that the molar ratio of the magnesium to a combination of the titanium and the second and third metals ranges from 30:1 to 5:1; under conditions sufficient to form a multi-metallic procatalyst.

[0007] In a second aspect~~embodiment~~, the present disclosure~~invention~~ provides a multi-metallic procatalyst obtained according to the above process ~~described in the above first embodiment~~.

[0008] In ana ~~third~~ embodiment, the present disclosure~~invention~~ provides a multi-metallic polymerization catalyst comprising the reaction product of the multi-metallic procatalyst as described above and an organometallic cocatalyst.

[0008a] In a third aspect, there is provided a polyethylene polymer prepared by a process wherein ethylene and optionally one or more olefin comonomers are polymerized in the presence of the multi-metallic polymerization catalyst as defined herein.

[0009] In an ~~fourth~~ embodiment, the present invention provides a polyethylene polymer prepared by a process wherein ethylene and optionally one or more olefin comonomers are polymerized in the presence of the tri-metallic polymerization catalyst, as described above.

[0010] In yet another embodiment~~aspect~~ the disclosure~~invention~~ provides an LLDPE polymer having a polydispersity of less than 3.50, optionally a high density fraction of less than 25 weight percent, and a molecular weight at comonomer content ratio (MWCCR) in the range of 0.75 to 1.1.

[0011] In still another embodiment~~aspect~~ the disclosure~~invention~~ provides an LLDPE polymer prepared by a process wherein the procatalyst composition described hereinabove is contacted with an organometallic cocatalyst such that a catalyst is formed; ethylene; and an olefin co-monomer; under conditions such that an LLDPE polymer having the above properties is formed.

[0012] In yet another embodimentaspect the disclosureinvention provides an article prepared from this LLDPE polymer.

[0012a] In a fourth aspect, there is provided a composition comprising the polyethylene polymer as defined herein, and one or more polymers or one or more additives.

[0012b] In a fifth aspect, there is provided an article comprising the polyethylene polymer as defined herein.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0013] The catalyst compositions of the invention may be defined herein as being at least trimetallic, but may also include more than three transition metals, and thus may in one embodiment be defined more comprehensively as multi-metallic. These three, or more, transition metals are specifically selected prior to production of the catalyst. While a wide variety of combinations is possible, all catalysts used in the invention include titanium as one element.

[0014] The catalyst compositions may be prepared beginning first with preparation of a conditioned magnesium halide based support. Preparation of a conditioned magnesium halide based support begins with selecting an organomagnesium compound or a complex including an organomagnesium compound. Such compound or complex is desirably soluble in an inert hydrocarbon diluent. The concentrations of components are preferably such that when the active halide, such as a metallic or non-metallic halide, and the magnesium complex are combined, the resultant slurry is from about 0.005 to about 0.2 molar (moles/liter) with respect to magnesium. Examples of suitable inert organic diluents include liquefied ethane, propane, isobutane, n-butane, n-hexane, the various isomeric hexanes, isooctane, paraffinic mixtures of alkanes having from 5 to 10 carbon atoms, cyclohexane, methylcyclopentane, dimethylcyclohexane, dodecane, industrial solvents composed of saturated or aromatic hydrocarbons such as kerosene, naphthas, and combinations thereof, especially when freed of any olefin compounds and other impurities, and especially those having boiling points in the range from about -50 °C to about 200 °C. Also included as suitable inert diluents are ethylbenzene, cumene, decalin and combinations thereof.

[0015] Suitable organomagnesium compounds and complexes may include, for example, magnesium C2-C8 alkyls and aryls, magnesium alkoxides and aryloxides, carboxylated magnesium alkoxides, and carboxylated magnesium aryloxides. Preferred sources of magnesium moieties may include the magnesium C2-C8 alkyls and C1-C4 alkoxides. Such organomagnesium compound or complex may be reacted with a metallic or non-metallic halide source, such as a chloride, bromide, iodide, or fluoride, in order to make a magnesium halide compound under suitable conditions. Such conditions may include a temperature ranging from -25 °C to 100 °C, preferably 0 °C to 50 °C; a time ranging from 1 to 12 hours, preferably from 4 to 6 hours; or both. The result is a magnesium halide based support.

[0016] The magnesium halide support is then reacted with a selected conditioning compound containing an element selected from the group consisting of boron, aluminum, gallium, indium and tellurium, under conditions suitable to form a conditioned magnesium