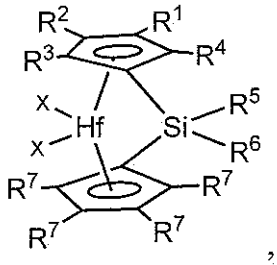
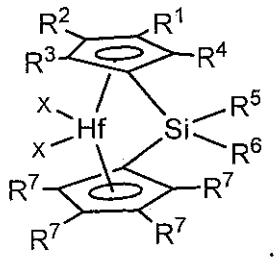
[0008a] In one aspect, there is provided a method of polymerizing olefins to produce a polyolefin polymer with control over long chain branching, comprising contacting ethylene and a comonomer with a catalyst system, wherein the catalyst system comprises a catalyst compound comprising:



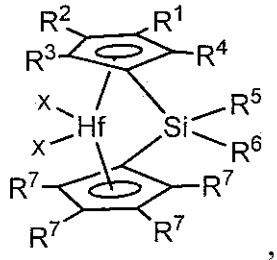
wherein R^1 is a saturated hydrocarbyl group of at least two carbons in length; R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure; R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^2 through a ring structure; R^4 is an H or a methyl group; R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6; R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5; each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; and Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group including Cl, F, or a divalent radical that links to an R^2, R^3, or R^7 group.

[0009] Another exemplary embodiment provides a catalyst composition comprising a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound includes:



In this formula, R^1 is a saturated hydrocarbyl group of at least two carbons in length. R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure. R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^2 through a ring structure. R^4 is an H or a methyl group. R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6. R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5. Each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to an adjacent R^7 group through a ring structure. Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to an R^2, R^3, or R^7 group.

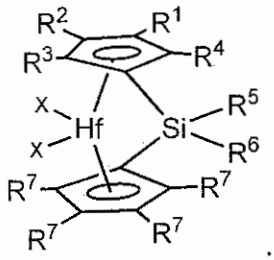
[0009a] In another aspect, there is provided a catalyst composition comprising a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound comprises:



,

wherein R^1 is a saturated hydrocarbyl group of at least two carbons in length; R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; R^4 is an H or a methyl group; R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6; R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5; each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; and Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to R^2, R^3, or R^7.

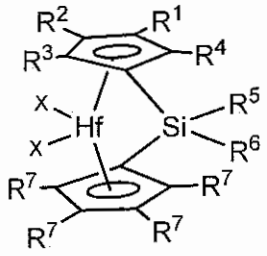
[0010] Another embodiment provides a polymer formed from a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound includes:



In this formula, R^1 is a saturated hydrocarbyl group of at least two carbons in length. R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure. R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^2 through a ring structure. R^4 is an H or a methyl group. R^5 is

an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6. R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5. Each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to an adjacent R^7 group through a ring structure. Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to an R^2, R^3, or R^7 group.

[0010a] In another aspect, there is provided a polymer formed from a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound comprises:



,

wherein R^1 is a saturated hydrocarbyl group of at least two carbons in length; R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure; R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^2 through a ring structure; R^4 is an H or a methyl group; R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6; R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5; each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; and Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to an R^2, R^3, or R^7 group.

DETAILED DESCRIPTION

[0011] Fig. 1 is a graph of shear viscosity for polymers produced by the test catalysts versus the control polymers.

[0012] Fig. 2 is a graph of elongation viscosity for polymers produced by the test catalysts versus the control polymers.

[0013] Fig. 3 is a graph of melt strength for polymers produced by the test catalysts versus the control polymers.

[0014] Fig. 4 is a comparative chart showing the values used to produce a 1 mil film of the two test polymers versus a control.

[0015] Fig. 5 is a comparative chart of physical properties for 1-mil (25.4 μm) films made from the test polymers and compared to an Enable resin using Exceed as a control.

[0016] Fig. 6 is a graph showing that the polymers made by the test catalysts have heat seal properties similar to those of the Exceed control.

[0017] Fig. 7 is a comparative chart of physical properties for 2-mil (50.8 μm) films made from the test polymers and compared to an Enable resin, using Exceed as a control.

[0018] Fig. 8 is a graph showing that the polymers made by the test catalysts have heat seal properties similar to those of the Exceed control.

DETAILED DESCRIPTION

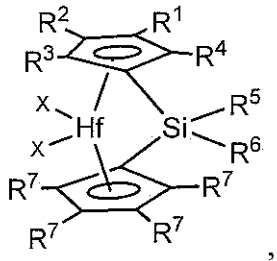
[0019] It has been discovered that bridged hafnocenes having a 3-propyl substituant are highly active on supports and appear to produce linear low density polyethylene with low or undetectable long chain branching. In addition, the comonomer (C6) incorporation is flat to slightly favoring a broad orthogonal composition distribution (BOCD). These properties provide attractive properties for films produced with this resin.

[0020] In lab testing an exemplary hafnocene (Me_2Si(3-n-propyl-η^5-Cp)(η^5-$CpMe_4$)$HfMe_2$) (catalyst A) was supported on SMAO and run in a gas phase batch reactor, producing linear low

CLAIMS

What is claimed is:

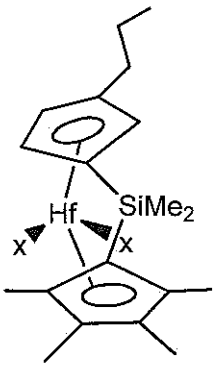
1. A catalyst composition comprising a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound comprises:



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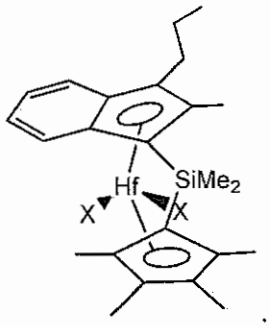
wherein R^1 is a saturated hydrocarbyl group of at least two carbons in length; R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; R^4 is an H or a methyl group; R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6; R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5; each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; and Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to R^2, R^3, or R^7.

2. The catalyst composition of claim 1, wherein the catalyst compound comprises:



; or

wherein the catalyst compound comprises:



3. The catalyst composition of claim 1, comprising an activator comprising an acid derived from a weakly coordinating anion; or

wherein the activator comprises an aluminoxane compound, an organoboron, an organoaluminum compound or combinations thereof; or

wherein the activator comprises methyl aluminoxane or modified methylaluminoxane.

4. The catalyst composition of claim 1, comprising a support comprising a mineral, a clay, a metal oxide, a metalloid oxide, a mixed metal oxide, a mixed metalloid oxide, a mixed metal-metalloid oxide, a polymer, or any combinations thereof.

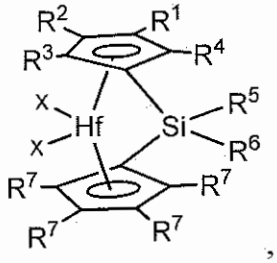
5. The catalyst composition of claim 4, wherein the support is a polyolefin or a polyolefin derivative; or

wherein the support has been thermally treated and/or chemically treated with an acid, an organoaluminum, or a fluoriding agent, or any combinations thereof; or

wherein the support has been thermally treated; or

wherein the support comprises silica, alumina, aluminosilicate, titanated silica, or titanated alumina, or any combinations thereof.

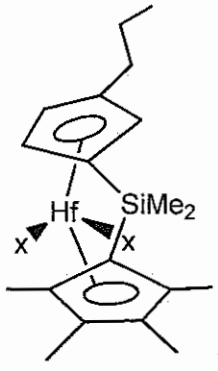
6. A polymer formed from a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound comprises:



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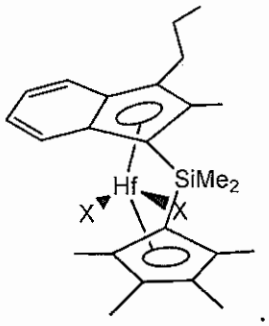
wherein R^1 is a saturated hydrocarbyl group of at least two carbons in length; R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure; R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^2 through a ring structure; R^4 is an H or a methyl group; R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6; R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5; each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; and Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group, or a divalent radical that links to an R^2, R^3, or R^7 group.

7. The polymer of claim 6, wherein the catalyst compound comprises:

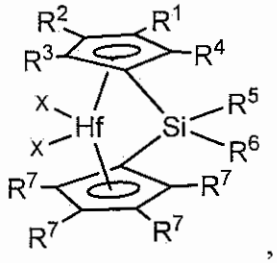


; or

wherein the catalyst compound comprises:

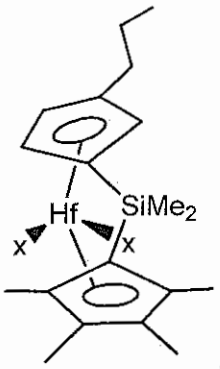


8. A method of polymerizing olefins to produce a polyolefin polymer with control over long chain branching, comprising contacting ethylene and a comonomer with a catalyst system, wherein the catalyst system comprises a catalyst compound comprising:



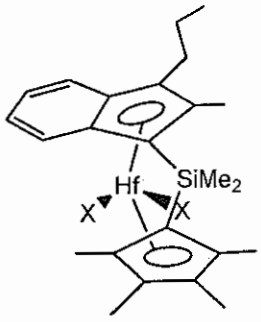
wherein R^1 is a saturated hydrocarbyl group of at least two carbons in length; R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure; R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^2 through a ring structure; R^4 is an H or a methyl group; R^5 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^6; R^6 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or forms a ring structure with R^5; each R^7 is independently an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group; and Each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, a heteroatom group including Cl, F, or a divalent radical that links to an R^2, R^3, or R^7 group.

9. The method of claim 8, wherein the catalyst compound comprises:



; or

wherein the catalyst compound comprises:



.

10. The method of claim 8, wherein measuring a sample of the polyolefin polymer comprises measuring comonomer incorporation as a function of a molecular weight; or

wherein measuring a sample comprises determining a physical property of a plastic sample; or

wherein measuring a sample comprises determining a flow index, a melt index, a ratio of two melt indices, a density, a molecular weight distribution, a comonomer content, or any combinations thereof; or

wherein changing a process parameter comprises adjusting a reactor temperature; or

wherein changing a process parameter comprises adjusting an ethylene partial pressure.

11. The method of claim 8, comprising adjusting a ratio of the comonomer to ethylene within a polymerization reactor to control a composition distribution, a molecular weight distribution, a melt index (I_2), or a ratio of two melt indices, or any combinations thereof, of the polyolefin polymer; or

comprising adjusting a ratio of hydrogen to ethylene within a polymerization reactor to control a composition distribution, a molecular weight distribution, a melt index (I_2), or a ratio of two melt indices, or any combinations thereof, of the polyolefin polymer.

12. The method of claim 8, comprising forming a product from the polyolefin polymer; or

comprising continuously combining the catalyst compound with another catalyst compound on a support to form a commonly supported catalyst system; or

comprising:

measuring a sample of the polyolefin polymer to obtain an initial product property; and

changing a process parameter to obtain a second product property, based, at least in part, on the initial product property.