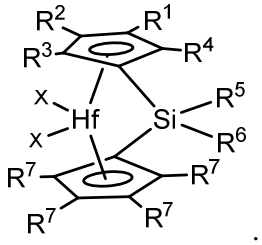
[0006] It is generally known in the art that a polyolefin's composition distribution is largely dictated by the type of catalyst used and is typically invariable for a given catalyst system. Ziegler-Natta catalysts and chromium based catalysts produce resins with broad composition distributions (BCD), whereas metallocene catalysts normally produce resins with narrow composition distributions (NCD).

[0007] In addition to short chain branching, as discussed above, polymer catalysts often generate polymers that have long chain branching. Long chain branching may be useful in some applications, for example, contributing to polymer alignment in processing, which can make the polymer tougher. However, the alignment can also create problems, such as anisotropy in polymer properties. Accordingly, control over long chain branching would be useful.

SUMMARY

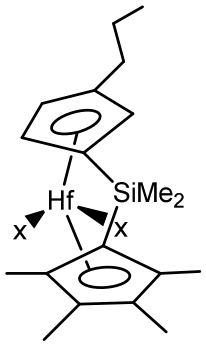
[0008] An example described herein provides a method of polymerizing olefins to produce a polyolefin polymer with control over long chain branching, including contacting ethylene and a comonomer with a catalyst system, wherein the catalyst system includes a catalyst compound comprising:



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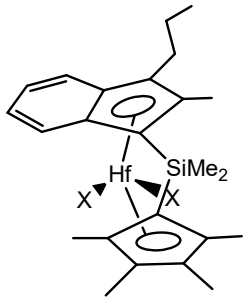
In this formula, R^1 is a saturated hydrocarbyl group of at least two carbons in length. R^2 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom group, or connects to R^3 through a ring structure. R^3 is an H, a hydrocarbyl group, a substituted hydrocarbyl group, a heteroatom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

[0008a] In one aspect, the present disclosure refers to 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:



, or

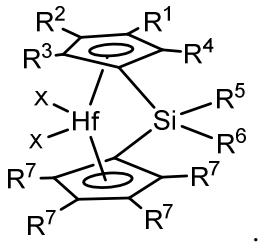
wherein the catalyst compound comprises:



,

wherein each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, or a heteroatom group.

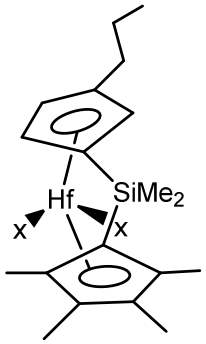
[0009] Another example provides a catalyst composition comprising a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound includes:



.

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.

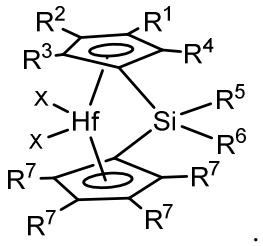
[0009a] In another aspect, the present disclosure refers to a catalyst composition comprising a catalyst compound supported to form a supported catalyst system, wherein the catalyst compound comprises:



,

wherein each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, or a heteroatom group.

[0010] Another example 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.

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.

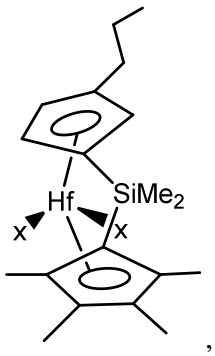
[0013] Fig. 3 is a graph of melt strength for polymers produced by the test catalysts versus the control polymers.

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

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:



,

wherein each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, or a heteroatom group .

2. 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.

3. 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.

4. The catalyst composition of claim 3, wherein the support is a polyolefin or a polyolefin derivative; or

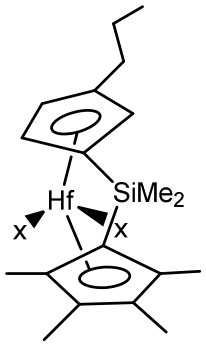
wherein the support has been thermally treated and/or chemically treated with an acid, an organoaluminum, or a fluoriding agent, or any combinations thereof; or

wherein the support has been thermally treated; or

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

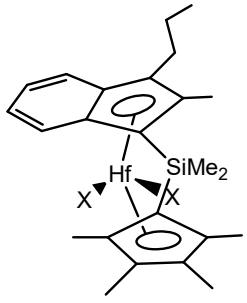
5. The catalyst composition of claim 1, comprising a silica support and a methyl aluminoxane activator.

6. 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:



, or

wherein the catalyst compound comprises:



,

wherein each X is independently a leaving group selected from a halogen, a labile hydrocarbyl, a substituted hydrocarbyl, or a heteroatom group.

7. The method of claim 6, 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.

8. The method of claim 6, 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.

9. The method of claim 6, 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.