METAL-LIGAND COMPLEXES

Field of Disclosure

[0001] Embodiments of the present disclosure are directed towards metal-ligand complexes, more specifically, metal-ligand complexes that may be utilized to make olefin polymerization catalysts.

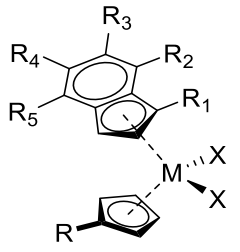
Background

[0002] Polymers may be utilized for a number of products including as films, fibers, nonwoven and/or woven fabrics, extruded articles, and/or molded articles, among others. Polymers can be formed by reacting one or more types of monomer in a polymerization reaction in the presence of a polymerization catalyst.

Summary

[0003] The present disclosure provides various ~~embodiments~~examples, including:

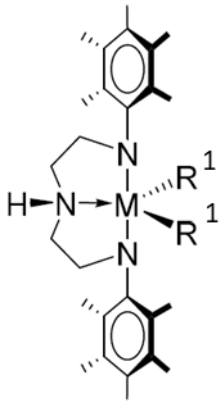
[0004] A metal-ligand complex of Formula I:



Formula I

[0005] wherein M is titanium, zirconium, or hafnium; R is hydrogen or a (C_1 to C_4) alkyl; R^1 is a (C_1 to C_4) alkyl ; any one or two of R^2, R^3, R^4, R^5 is independently a (C_1 to C_{20}) alkyl and the three or two of R^2, R^3, R^4, R^5 is H; and each X is independently a halide, a (C_1 to C_{20}) alkyl, a (C_7 to C_{20}) aralkyl, a (C_1 to C_6) alkyl-substituted (C_6 to C_{12}) aryl, a (C_1 to C_6) alkyl-substituted benzyl, or a silicon-containing alkyl.

[0006] A bimodal catalyst system comprising the metal-ligand complex of Formula I and a bis(2-(pentamethylphenylamido)ethyl)-amine zirconium complex of Formula III:



Formula III

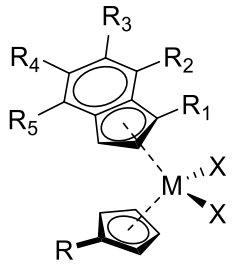
wherein M is Zr and each R^1 independently is Cl, Br, a (C_1 to C_{20}) alkyl, a (C_1 to C_6) alkyl-substituted (C_6-C_{12}) aryl, benzyl, or a (C_1 to C_6) alkyl-substituted benzyl.

[0007] A method of making a polymerization catalyst, the method comprising contacting, under activating conditions, the metal-ligand complex of Formula I or the bimodal catalyst system with an activator so as to activate the metal-ligand complex or the bimodal catalyst system, thereby making the polymerization catalyst.

[0008] A method of making a polyolefin polymer, the method comprising contacting, under polymerization conditions, an olefin with the polymerization catalyst so as to polymerize the olefin, thereby making a polyolefin polymer.

[0009] A polyolefin polymer made by the method of making same.

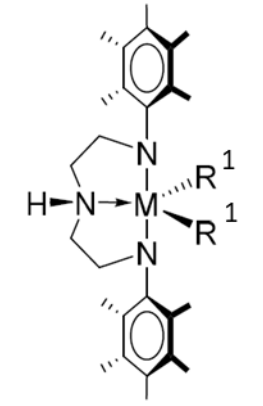
[0009a] In one aspect, the present disclosure refers to a metal-ligand complex of Formula I:



Formula I

wherein M is titanium, zirconium, or hafnium; R is hydrogen or a (C_1 to C_4) alkyl; R^1 is a (C_1 to C_4) alkyl; any one or two of R^2, R^3, R^4 is independently a (C_1 to C_{20}) alkyl and the three or two of R^2, R^3, R^4 is H; R^5 is H; and each X is independently a halide, a (C_1 to C_{20}) alkyl, a (C_7 to C_{20}) aralkyl, a (C_1 to C_6) alkyl-substituted (C_6 to C_{12}) aryl, a (C_1 to C_6) alkyl-substituted benzyl, or a silicon-containing alkyl.

[0009b] In another aspect, the present disclosure refers to a bimodal catalyst system comprising the metal-ligand complex as described herein and a bis(2-(pentamethylphenylamido)ethyl)-amine zirconium complex of Formula III:



Formula III

wherein M is Zr and each R^1 independently is Cl, Br, a (C_1 to C_{20}) alkyl, a (C_1 to C_6) alkyl-substituted (C_6-C_{12}) aryl, benzyl, or a (C_1 to C_6) alkyl-substituted benzyl.

[0009c] In another aspect, the present disclosure refers to a method of making a polymerization catalyst, the method comprising contacting, under activating conditions, the metal-ligand complex or the bimodal catalyst system as described herein with an activator so as to activate the metal-ligand complex or the bimodal catalyst system, thereby making the polymerization catalyst.

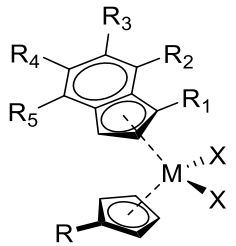
[0009d] In another aspect, the present disclosure refers to a method of making a polyolefin polymer, the method comprising:

contacting, under activating conditions, the metal-ligand complex or the bimodal catalyst system as described herein with an activator so as to activate the metal-ligand complex or the bimodal catalyst system, thereby making a polymerization catalyst; and

contacting, under polymerization conditions, an olefin with the polymerization catalyst so as to polymerize the olefin, thereby making a polyolefin polymer.

Detailed Description

[0010] The metal-ligand complexes disclosed herein can be represented by Formula I:

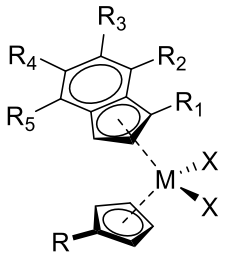


Formula I

[0011] wherein M is titanium, zirconium, or hafnium; R is hydrogen or a (C_1 to C_4) alkyl; R^1 is a (C_1 to C_4) alkyl ; any one or two of R^2, R^3, R^4, R^5 is independently a (C_1 to C_{20}) alkyl and the three or two of R^2, R^3, R^4, R^5 is H; and each X is independently a halide, a (C_1 to C_{20}) alkyl, a (C_7 to C_{20}) aralkyl, a (C_1 to C_6) alkyl-substituted (C_6 to C_{12}) aryl, a (C_1 to C_6) alkyl-substituted benzyl, or a silicon-containing alkyl.

What is claimed is:

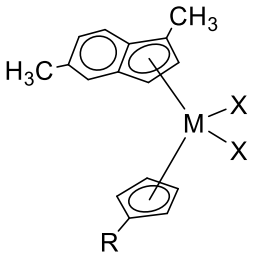
1. A metal-ligand complex of Formula I:



Formula I

wherein M is titanium, zirconium, or hafnium; R is hydrogen or a (C_1 to C_4) alkyl; R^1 is a (C_1 to C_4) alkyl; any one or two of R^2, R^3, R^4~~, R^5~~ is independently a (C_1 to C_{20}) alkyl and the three or two of R^2, R^3, R^4~~, R^5~~ is H; R^5 is H; and each X is independently a halide, a (C_1 to C_{20}) alkyl, a (C_7 to C_{20}) aralkyl, a (C_1 to C_6) alkyl-substituted (C_6 to C_{12}) aryl, a (C_1 to C_6) alkyl-substituted benzyl, or a silicon-containing alkyl.

2. The metal-ligand complex of ~~Formula I~~claim 1, wherein when R^1 is ~~a~~ C_1 alkyl, R^2 is hydrogen,~~-~~ R^3 is ~~a C_1 alkyl~~hydrogen, R^4 is~~ hydrogen~~ C_1 alkyl, ~~R^5 is hydrogen,~~ the metal-ligand complex is represented by Formula II:



Formula II

wherein R is hydrogen or a (C_1 to C_2) alkyl, M is titanium, zirconium, or hafnium, and where each X is independently a halide, a (C_1 to C_{20}) alkyl, a (C_7 to C_{20}) aralkyl, a (C_1 to C_6) alkyl-substituted (C_6 to C_{12}) aryl, a (C_1 to C_6) alkyl-substituted benzyl, or a silicon-containing alkyl.

3. The metal-ligand complex of claim 1 or claim 2, wherein R is hydrogen.

4. The metal-ligand complex of claim 1 or claim 2, wherein R is a (C_1 to C_2) alkyl.

5. The metal-ligand complex of claim 1 or claim 2, wherein R is methyl.

6. The metal-ligand complex of claim 1 or claim 2, wherein R is ethyl.

7. The metal-ligand complex of claim 1 or claim 2, wherein M is Zr.

8. The metal-ligand complex of claim 1 or claim 2, wherein each X is independently Cl, a (C_1 to C_3) alkyl, or benzyl.

9. The metal-ligand complex of claim 1 or claim 2 selected from:

metal-ligand complex of Formula I, wherein R is hydrogen, M is zirconium, and each X is Cl;

metal-ligand complex of Formula I, wherein R is methyl, M is zirconium, and each X is Cl;

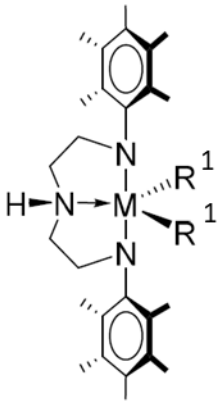
metal-ligand complex of Formula I, wherein R is ethyl, M is zirconium, and each X is Cl;

metal-ligand complex of Formula I, wherein R is hydrogen, M is zirconium, and each X is methyl;

metal-ligand complex of Formula I, wherein R is methyl, M is zirconium, and each X is methyl; and

metal-ligand complex of Formula I, wherein R is ethyl, M is zirconium, and each X is methyl.

10. A bimodal catalyst system comprising the metal-ligand complex of claim 1 or claim 2 and a bis(2-(pentamethylphenylamido)ethyl)-amine zirconium complex of Formula III:



Formula III

wherein M is Zr and each R^1 independently is Cl, Br, a (C_1 to C_{20}) alkyl, a (C_1 to C_6) alkyl-substituted (C_6-C_{12}) aryl, benzyl, or a (C_1 to C_6) alkyl-substituted benzyl.

11. A method of making a polymerization catalyst, the method comprising contacting, under activating conditions, the metal-ligand complex of claim 1 or claim 2 or the bimodal catalyst system of claim 10 with an activator so as to activate the metal-ligand complex or the bimodal catalyst system, thereby making the polymerization catalyst.

12. The method of claim 11 wherein the activator is methylaluminoxane.

~~13. A polymerization catalyst made by the method of claim 11.~~

~~14~~13. A method of making a polyolefin polymer, the method comprising:

contacting, under activating conditions, the metal-ligand complex of claim 1 or claim 2 or the bimodal catalyst system of claim 10 with an activator so as to activate the metal-ligand complex or the bimodal catalyst system, thereby making a polymerization catalyst; and

contacting, under polymerization conditions, an olefin with the polymerization catalyst ~~of claim 13~~ so as to polymerize the olefin, thereby making a polyolefin polymer.

~~15. A polyolefin polymer made by the method of claim 14.~~