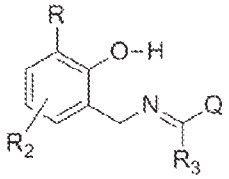
CLAIMS

1. A catalyst composition comprising:

(i) a metal salt complex of an imine bis(phenol) compound characterized by Structure I:



Structure I

wherein:

O and N represent oxygen and nitrogen respectively;

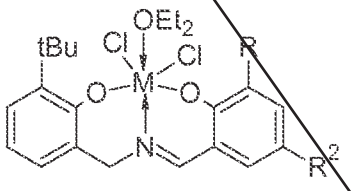
R comprises a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group;

R^2 and R^3 can each independently be hydrogen, a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group; and

Q is a donor group; and

(ii) a metallocene complex.

2. The composition of claim 1 wherein the metal salt complex of an imine (bis) phenolate compound comprises a compound having Structure XIV:

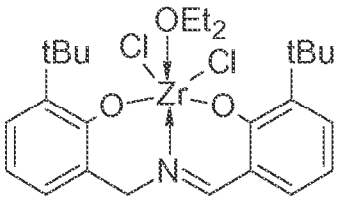


Structure XIV

where M is a Group 3 to Group 12 transition metal or lanthanide, Et_2O is optional; and

R and R^2 can each independently be hydrogen, a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group.

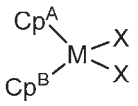
3. The composition of claim 1 wherein the metal salt complex of an imine bis(phenol) compound comprises a compound having structure X:



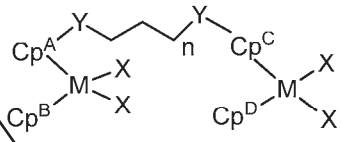
Structure X

where Et_2O is optional.

4. The composition of claim 1 wherein the metallocene compound is represented by a compound having general Formula 1 or Formula 2:



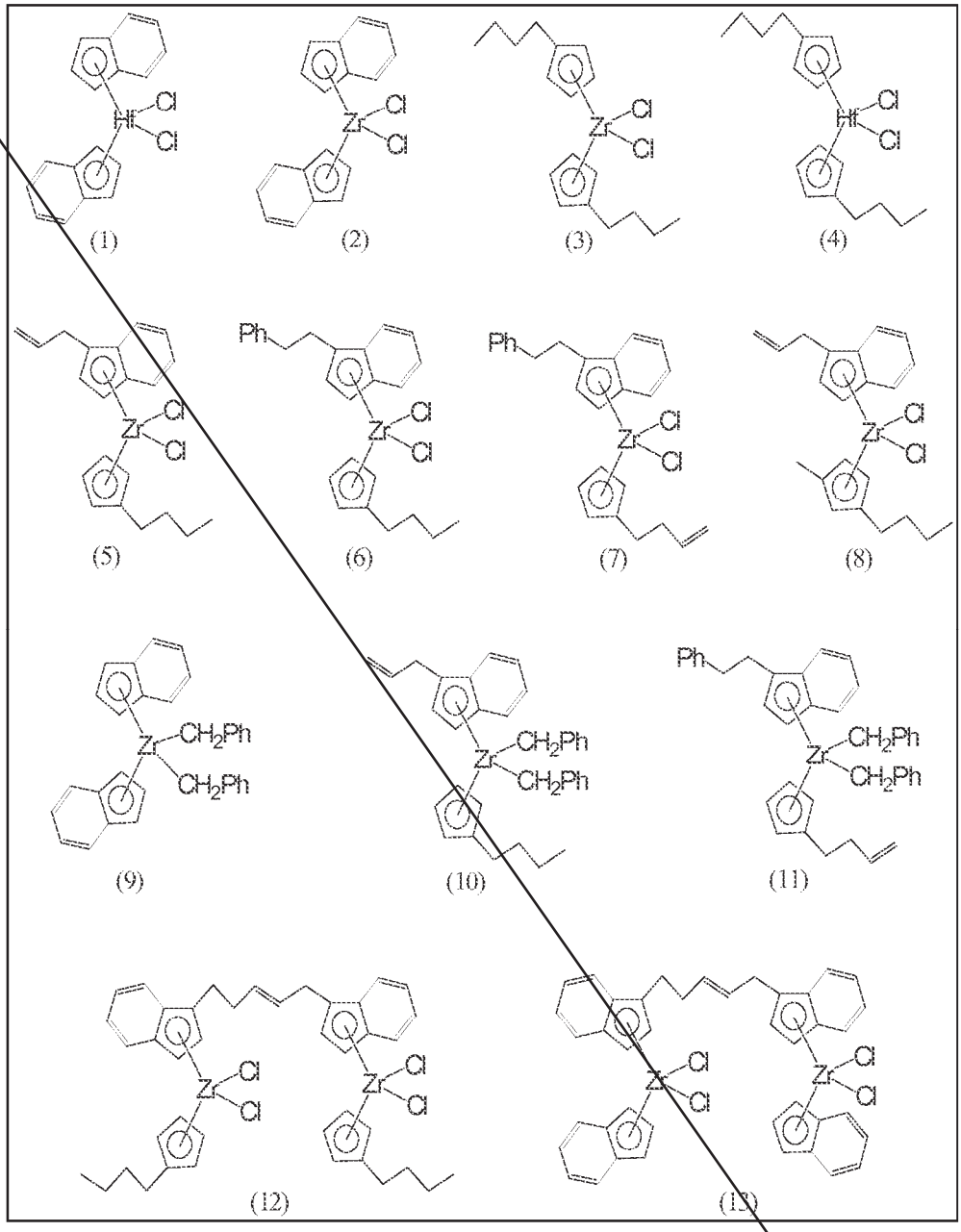
Formula 1



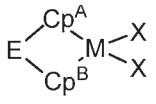
Formula 2

where each X is independently F, Cl, Br, I, methyl, benzyl, phenyl, H, BH_4, a hydrocarbyloxide group having up to 20 carbon atoms, a hydrocarbylamino group having up to 20 carbon atoms, a trihydrocarbylsilyl group having up to 20 carbon atoms, OBR'_2 wherein R' may be an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms, and SO_3R'', wherein R'' may be an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms; Y is a CR_2 or SiR_2 group where R is hydrogen or a hydrocarbyl group; Cp^A, Cp^B, Cp^C, and Cp^D are each independently a substituted or unsubstituted cyclopentadienyl group, indenyl group, or flourenyl group and where any substituent on Cp^A, Cp^B, Cp^C, and Cp^D can be H, a hydrocarbyl group having up to 18 carbon atoms or a hydrocarbylsilyl group having up to 18 carbon atoms.

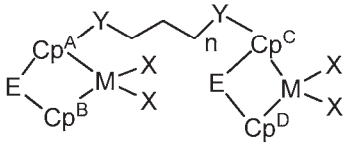
5. The composition of claim 1 wherein the metallocene compound comprises at least one of the compounds of Structures 1-13:



6. The composition of claim 1 wherein the metallocene compound is represented by a compound having general Formula 3 or Formula 4:



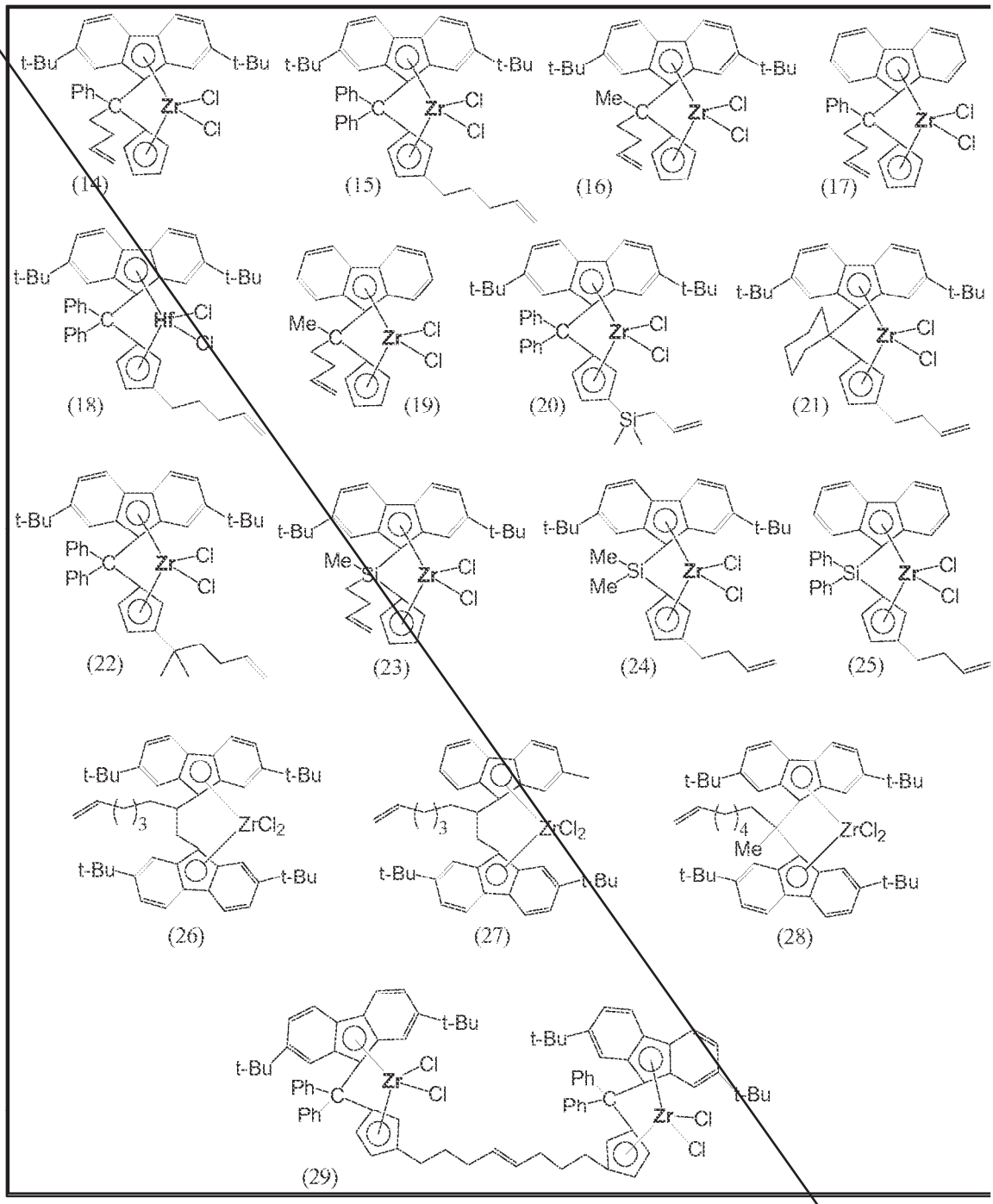
Formula 3



Formula 4

where M is Ti, Zr or Hf; each X is independently F, Cl, Br, I, methyl, phenyl, benzyl, H, BH_4, a hydrocarbyloxide group having up to 20 carbon atoms, a hydrocarbylamino group having up to 20 carbon atoms, a trihydrocarbylsilyl group having up to 20 carbon atoms, OBR'_2 wherein R' may be an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms, or SO_3R'' wherein R'' may be an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms; Y is a CR_2, SiR_2, or R_2CCR_2 group which may be linear or cyclic and where R is hydrogen or a hydrocarbyl group; Cp^A, Cp^B, Cp^C, and Cp^D are each independently a substituted or unsubstituted cyclopentadienyl group, indenyl group, or flourenyl group and where any substituent on Cp^A, Cp^B, Cp^C, and Cp^D can be H, a hydrocarbyl group having up to 18 carbon atoms or a hydrocarbylsilyl group having up to 18 carbon atoms. E represents a bridging group which may comprise (i) a cyclic or heterocyclic moiety having up to 18 carbon atoms, (ii) a group represented by the general formula $E^AR^{3A}R^{4A}$, wherein E^A is C or Si, and R^{3A} and R^{4A} are independently H or a hydrocarbyl group having up to 18 carbon atoms, (iii) a group represented by the general formula —$CR^{3B}R^{4B}$—$CR^{3C}R^{4C}$—, wherein R^{3B}, R^{4B}, R^{3C}, and R^{4C} are independently H or a hydrocarbyl group having up to 10 carbon atoms, or (iv) a group represented by the general formula —$SiR^{3D}R^{4D}$—$SiR^{3E}R^{4E}$—, wherein R^{3D}, R^{4D}, R^{3E}, and R^{4E} are independently H or a hydrocarbyl group having up to 10 carbon atoms, and wherein at least one of R^{3A}, R^{3B}, R^{4A}, R^{4B}, R^{3C}, R^{4C}, R^{3D}, R^{4D}, R^{3E}, R^{4E}, or the substituent on Cp, Cp_1, or Cp_2, is (1) a terminal alkenyl group having up to 12 carbon atoms or (2) a dinuclear compound wherein each metal moiety has the same structural characteristic.

7. The composition of claim 1 wherein the metallocene compound comprises at least one of the compounds of Structures 14-29:



8. The composition of claim 1 wherein the metal salt complex of an imine phenol compound and the metallocene complex are present in an amount of from about 100:1 to about 1:100 based on the total weight of the catalyst composition.

9. The composition of claim 1 further comprising a metal alkyl compound.

10. The composition of claim 9, wherein the metal alkyl compound comprises an organoaluminum compound, an aluminoxane compound, and organoboron or organoborate compound, an ionizing ionic compound, or combinations thereof.

11. The composition of claim 1, further comprising an activator-support comprising a solid oxide treated with an electron-withdrawing anion.

12. The composition of claim 11 wherein the solid oxide comprises silica, alumina, silica-alumina, silica-coated alumina, aluminum phosphate, aluminophosphate, heteropolytungstate, titania, zirconia, magnesia, boria, zinc oxide, a mixed oxide thereof, or combinations thereof; and

the electron-withdrawing anion comprises sulfate, bisulfate, fluoride, chloride, bromide, iodide, fluorosulfate, fluoroborate, phosphate, fluorophosphate, trifluoroacetate, triflate, fluorozirconate, fluorotitanate, phospho-tungstate, or combinations thereof.

13. The composition of claim 9 wherein the metal alkyl comprises trialkylaluminum, an alkylaluminum halide, an alkylaluminum alkoxide, an aluminoxane, or combinations thereof.

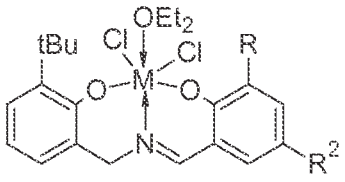
14. The composition of claim 9 wherein the metal alkyl comprises methyl lithium, n-butyl lithium, sec-butyl lithium, tert-butyl lithium, diethyl magnesium, di-n-butylmagnesium, ethylmagnesium chloride, n-butylmagnesium chloride, diethyl zinc, trimethylaluminum, triethylaluminum, tripropylaluminum, tributylaluminum, trihexylaluminum, trioctylaluminum, diethylaluminum chloride, diethylaluminum bromide, ethylaluminum dichloride, ethylaluminum sesquichloride, methylaluminoxane (MAO), ethylaluminoxane, modified methylaluminoxane (MMAO), n-propylaluminoxane, iso-propylaluminoxane, n-butylaluminoxane, sec-butylaluminoxane, iso-butylaluminoxane, t-butyl aluminoxane, 1-pentylaluminoxane, 2-pentylaluminoxane, 3-pentylaluminoxane, iso-pentylaluminoxane, neopentylaluminoxane, borates, or combinations thereof.

15. A polymerization process comprising:

contacting the catalyst composition of claim 9 with an olefin monomer and optionally an olefin comonomer under conditions suitable for the formation of a polymer; and

recovering the polymer.

16. A polymerization process comprising contacting a catalyst composition with a monomer under conditions suitable for the formation of a polymer and recovering the polymer, wherein the catalyst composition comprises a metal salt complex of an imine (bis) phenolate compound, a metallocene complex, a solid oxide, and an optional metal alkyl and wherein the metal salt complex of an imine (bis) phenolate compound comprises a compound having Structure XIV



Structure XIV

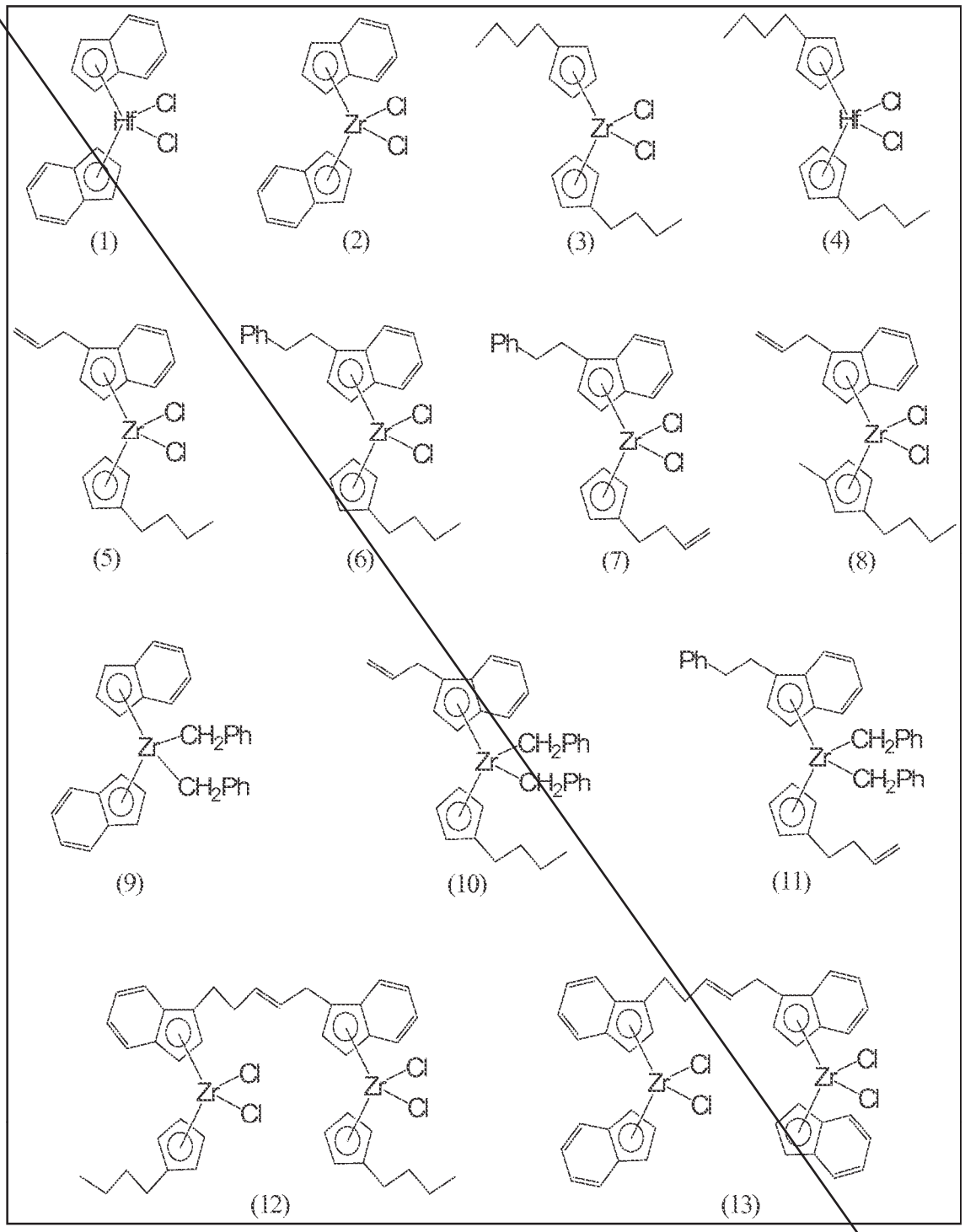
where M is titanium, zirconium, or hafnium;

Et_2O is optional;

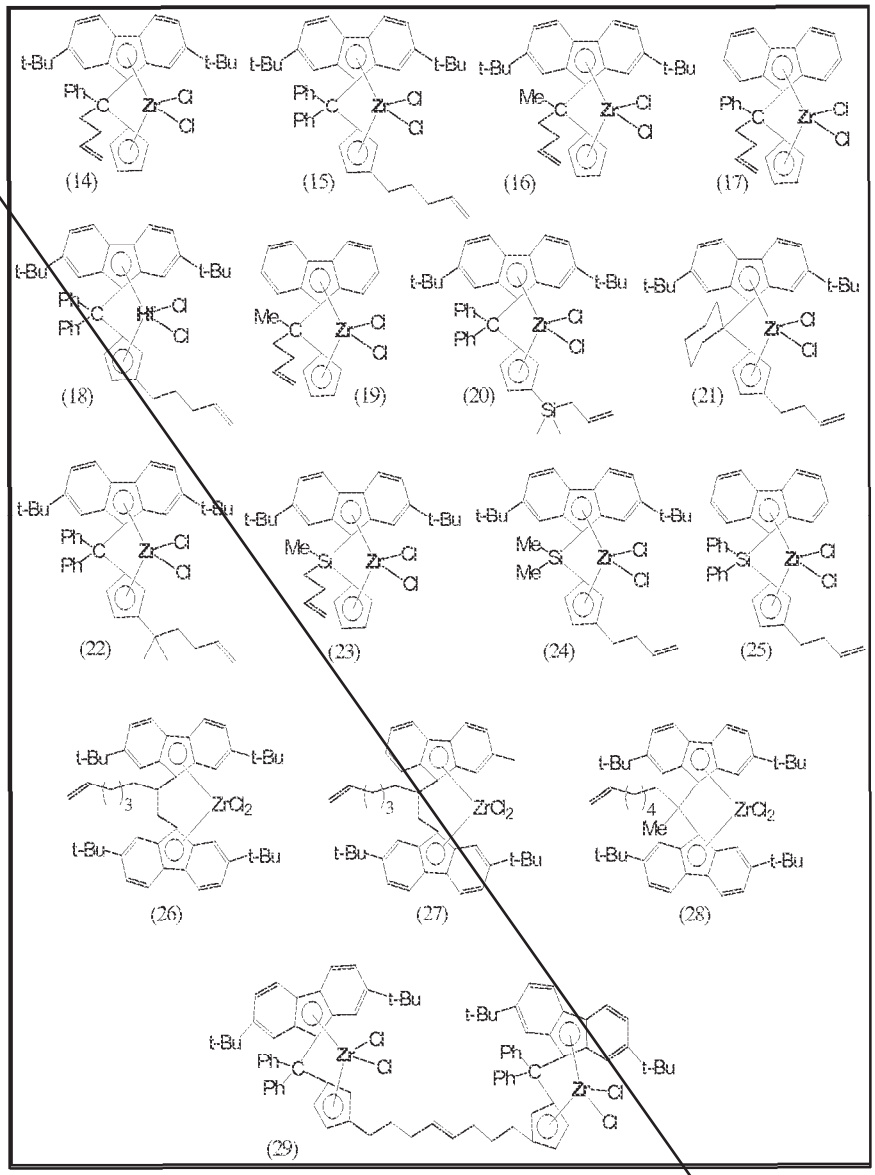
R comprises a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group; and

R^2 comprises hydrogen, a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group.

17. The process of claim 16 wherein the metallocene compound comprises at least one of the compounds of Structures 1-13:


Hf
Cl
Cl
(1)
Zr
Cl
Cl
(2)
Zr
Cl
Cl
(3)
Hf
Cl
Cl
(4)
Zr
Cl
Cl
(5)
Ph
Zr
Cl
Cl
(6)
Ph
Zr
Cl
Cl
(7)
Zr
Cl
Cl
(8)
Zr
CH2Ph
CH2Ph
(9)
Zr
CH2Ph
CH2Ph
(10)
Ph
Zr
CH2Ph
CH2Ph
(11)
Zr
Cl
Cl
Zr
Cl
Cl
(12)
Zr
Cl
Cl
Zr
Cl
Cl
(13)

18. The process of claim 16 wherein the metallocene compound comprises at least one of the compounds of Structures 14-29:



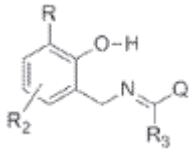
19. The process of claim 16 wherein the ratio of the metal salt complex of an imine (bis) phenolate compound to metallocene complex is from about 100:1 to about 1:100.

20. The process of claim 16 wherein the monomer comprises ethylene and the polymer comprises polyethylene.

CLAIMS

1. A catalyst composition comprising:

(i) a metal salt complex prepared from an imine phenol compound characterized by Structure I:



Structure I

wherein:

O and N represent oxygen and nitrogen respectively;

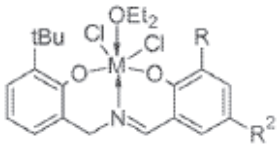
R is a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group;

R^2 and R^3 are each independently hydrogen, a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group; and

Q is a donor group; and

(ii) a metallocene complex.

2. The composition of claim 1 wherein the metal salt complex prepared from an imine phenol compound has Structure XIV:

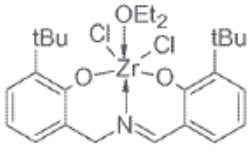


Structure XIV

where M is a Group 3 to Group 12 transition metal or lanthanide, Et_2O is optional; and

R and R^2 are each independently hydrogen, a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group.

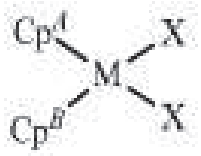
3. The composition of claim 1 wherein the metal salt complex prepared from an imine phenol compound has structure X:



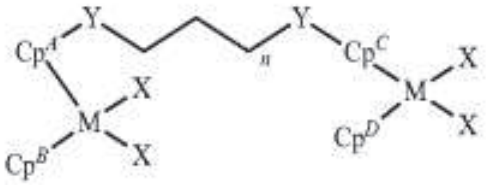
Structure X

where Et_2O is optional.

4. The composition of claim 1 wherein the metallocene compound is represented by a compound having general Formula 1 or Formula 2:



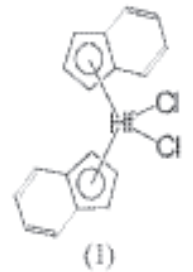
Formula 1



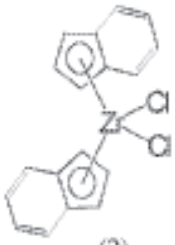
Formula 2

where each X is independently F, CI, Br, I, methyl, benzyl, phenyl, H, BH_4, a hydrocarbyloxide group having up to 20 carbon atoms, a hydrocarbylamino group having up to 20 carbon atoms, a trihydrocarbylsilyl group having up to 20 carbon atoms, OBR'_2 wherein R' may be an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms, and $SO_3R"$, wherein R" is an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms; Y is a CR_2 or SiR_2 group where R is hydrogen or a hydrocarbyl group; Cp^A, Cp^B, Cp^C, and Cp^D are each independently a substituted or unsubstituted cyclopentadienyl group, indenyl group, or flourenyl group and where any substituent on Cp^A, Cp^B, Cp^C, and Cp^D is H, a hydrocarbyl group having up to 18 carbon atoms or a hydrocarbylsilyl group having up to 18 carbon atoms.

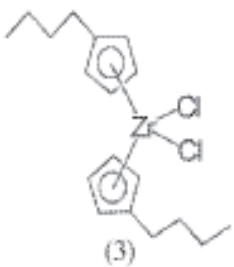
5. The composition of claim 1 wherein the metallocene compound comprises at least one of the compounds of Structures 1-13:



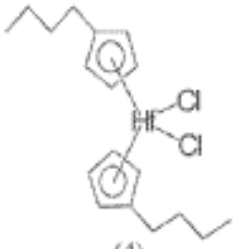
(1)



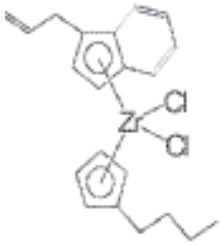
(2)



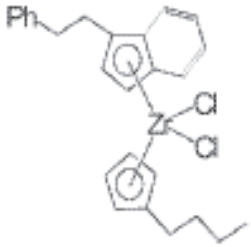
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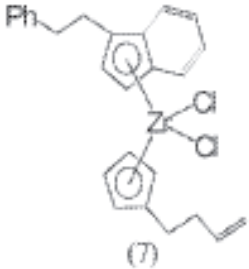
(4)



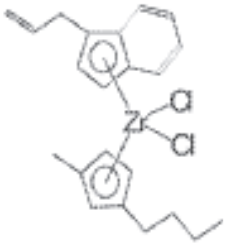
(5)



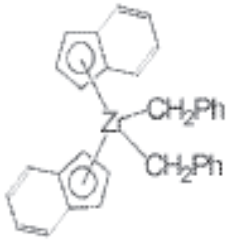
(6)



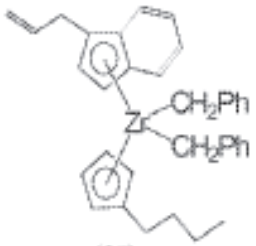
(7)



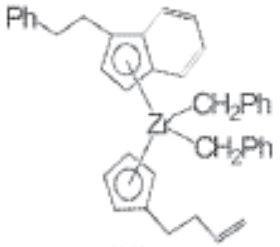
(8)



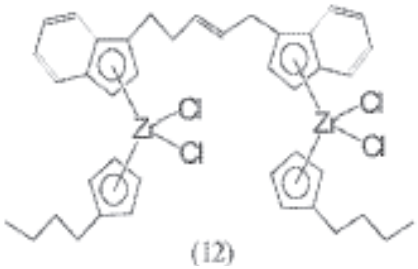
(9)



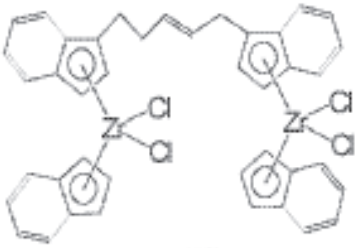
(10)



(11)



(12)

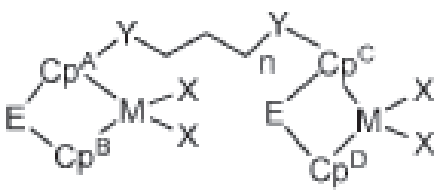


(13)

6. The composition of claim 1 wherein the metallocene compound is represented by a compound having general Formula 3 or Formula 4:



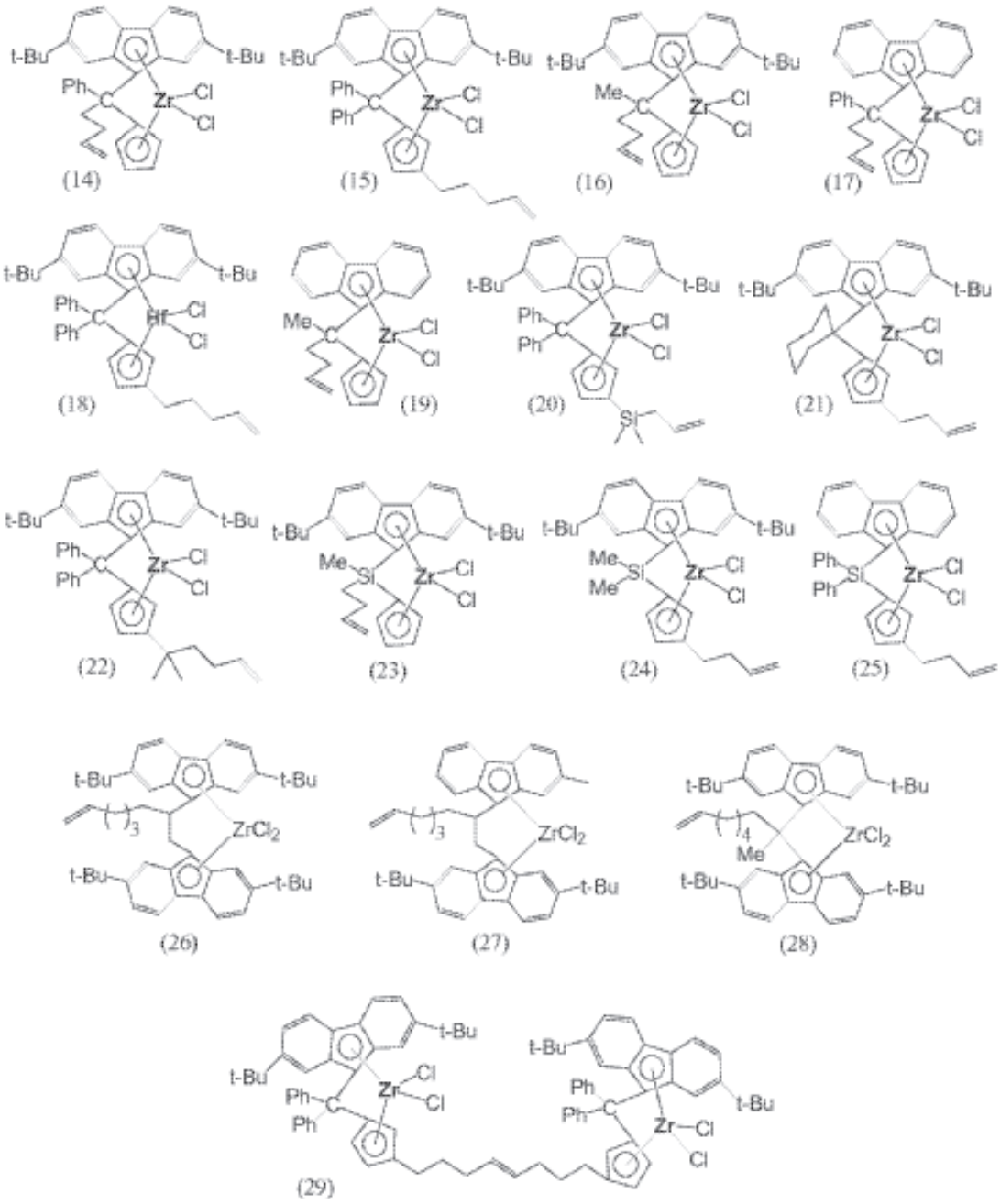
Formula 3



Formula 4

where M is Ti, Zr or Hf; each X is independently F, CL Br, I, methyl, phenyl, benzyl, H, BH_4, a hydrocarbyloxide group having up to 20 carbon atoms, a hydrocarbylamino group having up to 20 carbon atoms, a trihydrocarbylsilyl group having up to 20 carbon atoms, OBR'_2 wherein R' is an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms, or $SO_3R"$ wherein R" is an alkyl group having up to 12 carbon atoms or an aryl group having up to 12 carbon atoms; Y is a CR_2, SiR_2, or R_2CCR_2 group which may be linear or cyclic and where R is hydrogen or a hydrocarbyl group; Cp^A, Cp^B, Cp^C, and Cp^D are each independently a substituted or unsubstituted cyclopentadienyl group, indenyl group, or flourenyl group and where any substituent Cp^A, Cp^B, Cp^C, and Cp^D is a H, a hydrocarbyl group having up to 18 carbon atoms or a hydrocarbylsilyl group having up to 18 carbon atoms. E represents a bridging group comprising (i) a cyclic or heterocyclic moiety having up to 18 carbon atoms, (ii) a group represented by the general formula $E^AR^{3A}R^{4A}$, wherein E^A is C or Si, and R^{3A} and R^{4A} are independently H or a hydrocarbyl group having up to 18 carbon atoms, (iii) a group represented by the general formula —$CR^{3B}R^{4B}$—$CR^{3C}R^{4C}$— , wherein R^{3B}, R^{4B}, R^{3C}, and R^{4C} are independently H or a hydrocarbyl group having up to 10 carbon atoms, or (iv) a group represented by the general formula —$SiR^{3D}R^{4D}$— $SiR^{3E}R^{4E}$—, wherein R^{3D}, R^{4D}, R^{3E}, and R^{4E} are independently H or a hydrocarbyl group having up to 10 carbon atoms, and wherein at least one of R^{3A}, R^{3B}, R^{4A}, R^{4B}, R^{3C}, R^{4C}, R^{3D}, R^{4D}, R^{3E}, R^{4E}, or the substituent on Cp, Cp_1, or Cp_2, is (1) a terminal alkenyl group having up to 12 carbon atoms or (2) a dinuclear compound wherein each metal moiety has the same structural characteristic.

7. The composition of claim 1 wherein the metallocene compound comprises at least one of the compounds of Structures 14-29:



8. The composition of claim 1 wherein the metal salt complex prepared from an imine phenol compound and the metallocene complex are present in an amount of from about 100:1 to about 1:100 based on the total weight of the catalyst composition.

9. The composition of claim 1 further comprising a metal alkyl compound.

10. The composition of claim 9, wherein the metal alkyl compound comprises an organoaluminum compound, an aluminoxane compound, and organoboron or organoborate compound, an ionizing ionic compound, or combinations thereof.

11. The composition of claim 1, further comprising an activator-support comprising a solid oxide treated with an electron-withdrawing anion.

12. The composition of claim 11 wherein the solid oxide comprises silica, alumina, silica-alumina, silica-coated alumina, aluminum phosphate, aluminophosphate, heteropolytungstate, titania, zirconia, magnesia, boria, zinc oxide, a mixed oxide thereof, or combinations thereof; and the electron-withdrawing anion comprises sulfate, bisulfate, fluoride, chloride, bromide, iodide, fluorosulfate, fluoroborate, phosphate, fluorophosphate, trifluoroacetate, triflate, fluorozirconate, fluorotitanate, phospho-tungstate, or combinations thereof.

13. The composition of claim 9 wherein the metal alkyl comprises trialkylaluminum, an alkylaluminum halide, an alkylaluminum alkoxide, an aluminoxane, or combinations thereof.

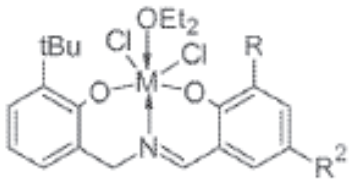
14. The composition of claim 9 wherein the metal alkyl comprises methyl lithium, n-butyl lithium, sec-butyl lithium, tert-butyl lithium, diethyl magnesium, di-n-butylmagnesium, ethylmagnesium chloride, n-butylmagnesium chloride, diethyl zinc, trimethylaluminum, triethylaluminum, tripropylaluminum, tributylaluminum, trihexylaluminum, trioctylaluminum, diethylaluminum chloride, diethylaluminum bromide, ethylaluminum dichloride, ethylaluminum sesquichloride, methylaluminoxane (MAO), ethylaluminoxane, modified methylaluminoxane (MMAO), n-propylaluminoxane, iso-propylaluminoxane, n-butylaluminoxane, sec-butylaluminoxane, iso-butylaluminoxane, t-butyl aluminoxane, l-pentylaluminoxane, 2-pentylaluminoxane, 3-pentylaluminoxane, iso-pentylaluminoxane, neopentylaluminoxane, borates, or combinations thereof.

15. A polymerization process comprising:

contacting the catalyst composition of claim 9 with an olefin monomer and optionally an olefin comonomer under conditions suitable for the formation of a polymer; and

recovering the polymer.

16. A polymerization process comprising contacting a catalyst composition with a monomer under conditions suitable for the formation of a polymer and recovering the polymer, wherein the catalyst composition comprises a metal salt complex prepared from an imine bis(phenol) compound, a metallocene complex, a solid oxide, and an optional metal alkyl and wherein the metal salt complex prepared from an imine (bis)phenol compound has Structure XIV:



Structure XIV

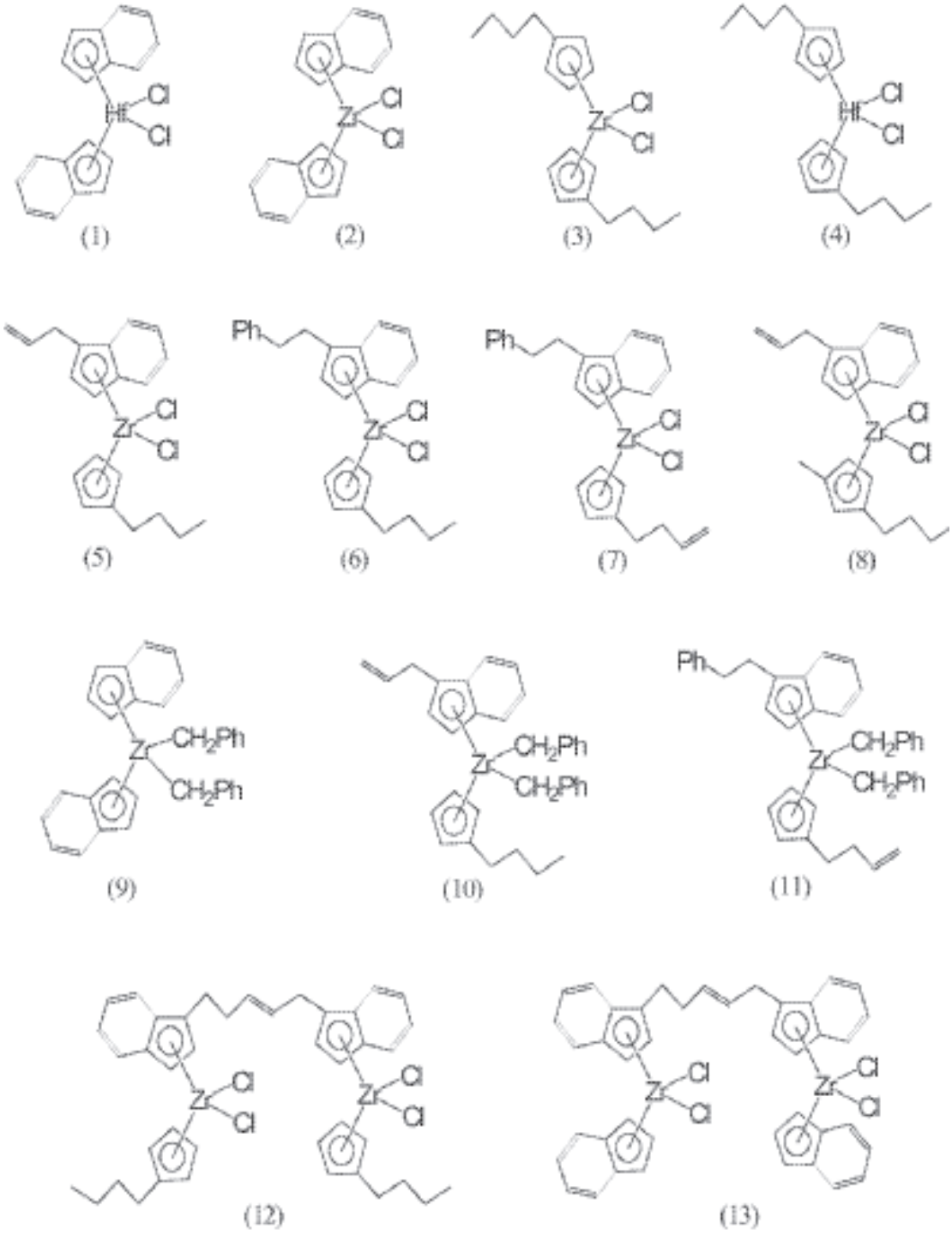
where M is titanium, zirconium, or hafnium;

Et_2O is optional;

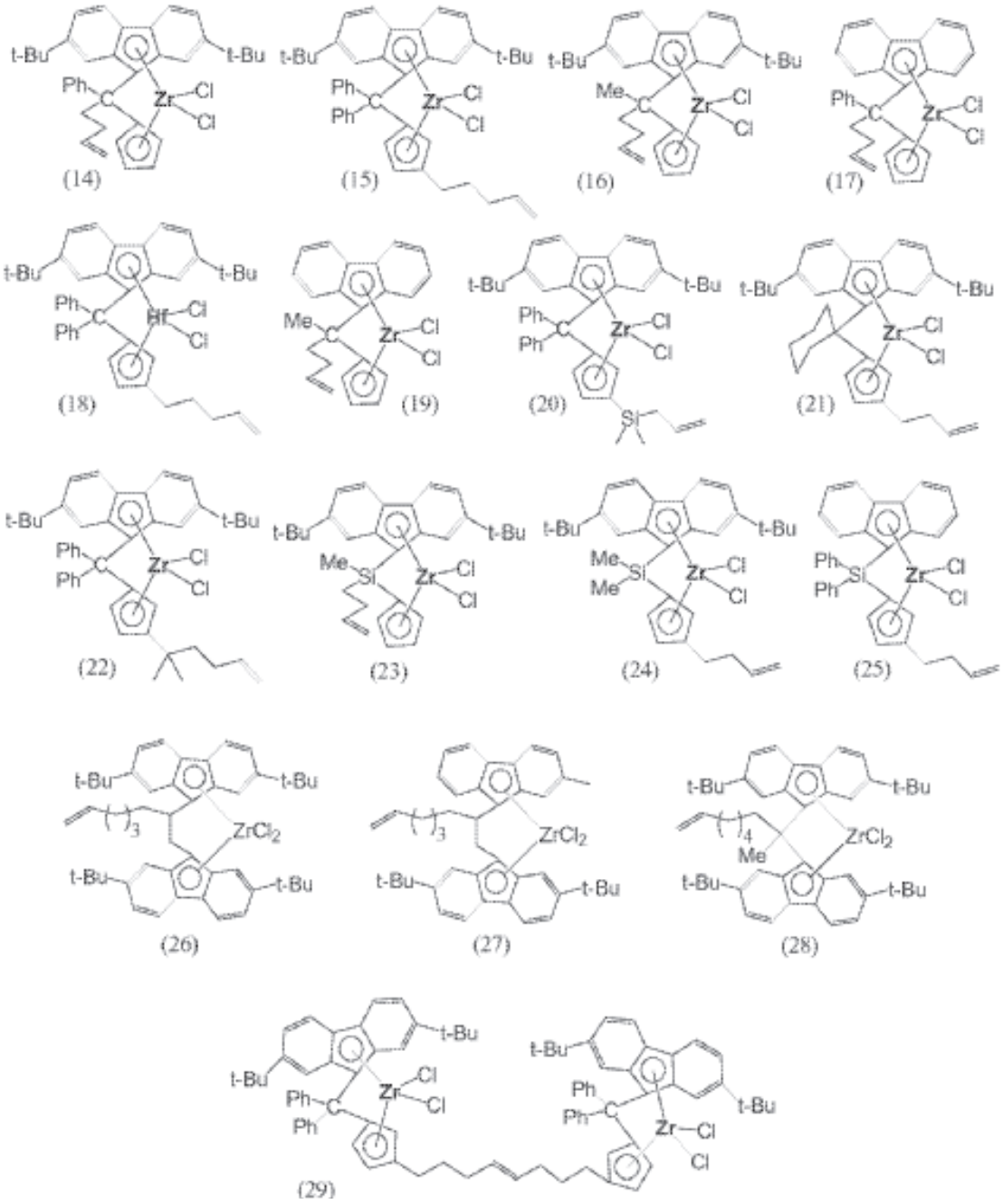
R comprises a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group; and

R^2 comprises hydrogen, a halogen, a hydrocarbyl group, or a substituted hydrocarbyl group.

17. The process of claim 16 wherein the metallocene compound comprises at least one of the compounds of Structures 1-13:



18. The process of claim 16 wherein the metallocene compound comprises at least one of the compounds of Structures 14-29:



19. The process of claim 16 wherein the ratio of the metal salt complex prepared from an imine (bis)phenol compound to metallocene complex is from about 100:1 to about 1:100.

20. The process of claim 16 wherein the monomer comprises ethylene and the polymer comprises polyethylene.