

CLAIMS

What is claimed is:

1. A compound represented by Formula (AI):



wherein:

E is nitrogen or phosphorous;

d is 1, 2 or 3; k is 1, 2, or 3; n is 1, 2, 3, 4, 5, or 6; n - k = d (preferably d is 1, 2 or 3; k is 3; n is 4, 5, or 6, preferably when M is B, n is 4);

10 R^1 is a C_1 - C_{20} (preferably C_1 to C_{10}) linear alkyl group; wherein R^1 is optionally substituted,

each of R^2 and R^3 is independently an optionally substituted C_1 - C_{40} linear alkyl group or a meta- and/or para-substituted phenyl group, where the meta and para substituents are, independently, an optionally substituted C_1 to C_{40} hydrocarbyl group, an optionally substituted
15 alkoxy group, an optionally substituted silyl group, a halogen, or a halogen containing group, wherein R^1 , R^2 , and R^3 together comprise 15 or more carbon atoms;

M is an element selected from group 13 of the Periodic Table of the Elements; and

20 each Q is independently a hydride, bridged or unbridged dialkylamido, halide, alkoxide, aryloxy, hydrocarbyl, substituted hydrocarbyl, halocarbyl, substituted halocarbyl, or halosubstituted-hydrocarbyl radical, provided that when Q is a fluorophenyl group, then R^2 is not a C_1 - C_{40} linear alkyl group.

2. The compound of claim 1 wherein R^1 is C_1 to C_{10} linear alkyl group, preferably methyl.

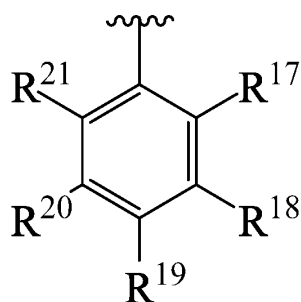
25 3. The compound of claim 1 or 2 wherein R^2 is a meta- and/or para-substituted phenyl group, where the meta and para substituents are, independently, an optionally substituted C_1 to C_{40} hydrocarbyl group, an optionally substituted alkoxy group, an optionally substituted silyl group, a halogen or a halogen containing group.

30 4. The compound of claim 1, 2, or 3 wherein R^3 is an optionally substituted C_1 - C_{40} linear alkyl group.

5. The compound of claim 1 wherein R^1 is methyl; R^2 is a meta- and/or para-substituted phenyl group, where the meta and para substituents are, independently, an optionally

substituted C₁ to C₄₀ hydrocarbyl group, an optionally substituted alkoxy group, an optionally substituted silyl group, a halogen or a halogen containing group; and R³ is an optionally substituted C₁-C₄₀ linear alkyl group.

- 5 6. The compound of claim 1 wherein R¹ is methyl; R² is a meta- and/or para-substituted phenyl group, where the meta and para substituents are, independently, an optionally substituted C₁ to C₄₀ hydrocarbyl group; and R³ is an optionally substituted C₁-C₄₀ linear alkyl group.
- 10 7. The compound of any of the above claims, wherein R² is a para substituted phenyl selected from the group consisting of methylphenyl, ethylphenyl, n-propylphenyl, n-butylphenyl, n-pentylphenyl, n-hexylphenyl, n-heptylphenyl, n-octylphenyl, n-nonylphenyl, n-decylphenyl, n-undecylphenyl, n-dodecylphenyl, n-tridecylphenyl, n-tetradecylphenyl, n-pentadecylphenyl, n-hexadecylphenyl, n-heptadecylphenyl, n-octadecylphenyl, n-nonadecylphenyl, n-icosylphenyl, n-henicosylphenyl, n-docosylphenyl, n-tricosylphenyl, n-tetracosylphenyl, n-pentacosylphenyl, n-hexacosylphenyl, n-heptacosylphenyl, n-octacosylphenyl, n-nonacosylphenyl, and n-tricontylphenyl.
- 15 8. The compound of any of claims 1 to 7, wherein R² is a meta substituted phenyl having one or two meta substituents, which may be the same or different, where the substituents are independently selected from the group consisting of: methylphenyl, ethylphenyl, n-propylphenyl, n-butylphenyl, n-pentylphenyl, n-hexylphenyl, n-heptylphenyl, n-octylphenyl, n-nonylphenyl, n-decylphenyl, n-undecylphenyl, n-dodecylphenyl, n-tridecylphenyl, n-tetradecylphenyl, n-pentadecylphenyl, n-hexadecylphenyl, n-heptadecylphenyl, n-octadecylphenyl, n-nonadecylphenyl, n-icosylphenyl, n-henicosylphenyl, n-docosylphenyl, n-tricosylphenyl, n-tetracosylphenyl, n-pentacosylphenyl, n-hexacosylphenyl, n-heptacosylphenyl, n-octacosylphenyl, n-nonacosylphenyl, n-tricontylphenyl.
- 20 9. The compound of any of claims 1 to 5, wherein the meta- and/or para-substituted phenyl group is represented by the formula:
- 25 30

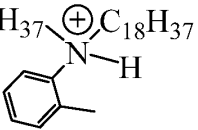
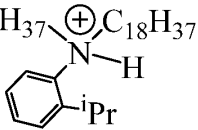
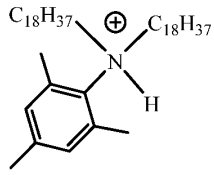
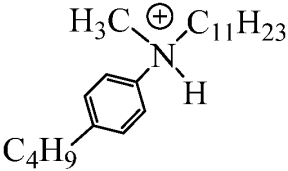
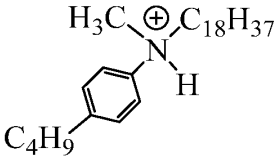
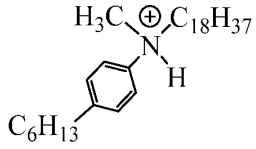
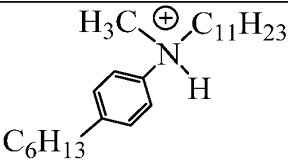
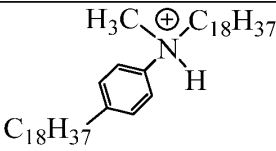
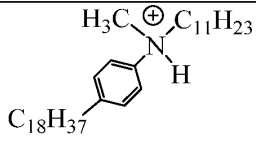
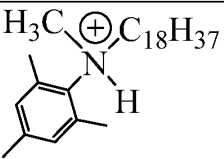
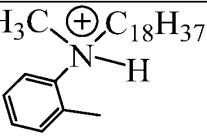
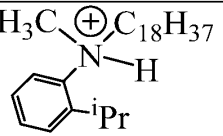
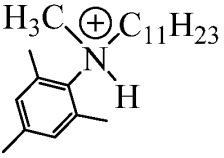
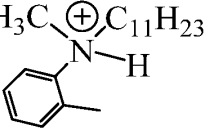
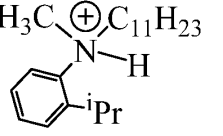
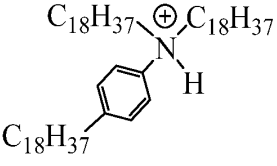
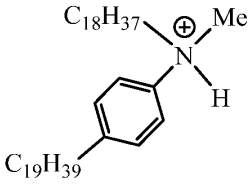
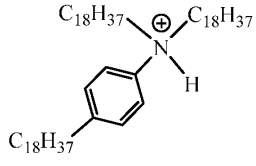
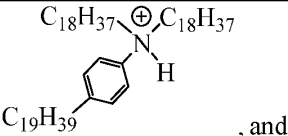
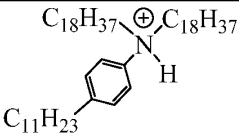
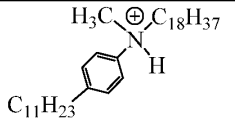


, where R¹⁷ and R²¹ are hydrogen, and each of R¹⁸, R¹⁹, and R²⁰ is independently selected from hydrogen, C₁-C₄₀ hydrocarbyl or C₁-C₄₀ substituted hydrocarbyl, halogen, or a halogen-containing group.

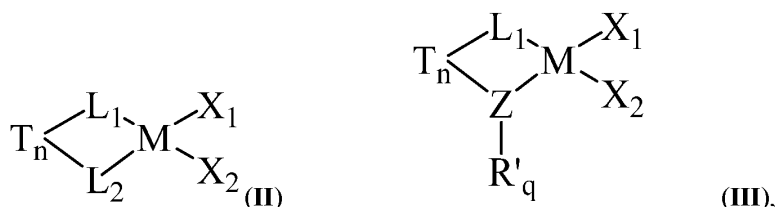
- 5 10. The compound of claim 9 wherein R¹⁷ and R²¹ are hydrogen, and one, two, or three of R¹⁸, R¹⁹, and R²⁰ are selected from the group consisting of n-hexyl, n-heptyl, n-octyl, n-nonyl, n-decyl, n-undecyl, n-dodecyl, n-tridecyl, n-tetradecyl, n-pentadecyl, n-hexadecyl, n-heptadecyl, n-octadecyl, n-nonadecyl, n-icosyl, n-henicosyl, n-docosyl, n-tricosyl, n-tetracosyl, n-pentacosyl, n-hexacosyl, n-heptacosyl, n-octacosyl, n-nonacosyl, n-tricontyl,
 - 10 trimethylsilyl, triethylsilyl, tripropylsilyl, tributylsilyl, trihexylsilyl, triheptylsilyl, trioctylsilyl, trinonylsilyl, tridecylsilyl, triundecylsilyl, tridodecylsilyl, tri-tridecylsilyl, tri-tetradecylsilyl, tri-pentadecylsilyl, tri-hexadecylsilyl, tri-heptadecylsilyl, tri-octadecylsilyl, tri-nonadecylsilyl, tri-icosylsilyl, Br, Cl, F, methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy, nonoxy, decoxy, undecoxy, dodecoxy, tridecoxy, tetradeoxy, pentadeoxy, hexadeoxy,
 - 15 heptadeoxy, octadeoxy, nonadeoxy, icosoxy, and phenoxy.
11. The compound of claim 9 wherein R¹ is methyl and R² is a C₆ to C₄₀ linear alkyl group.
12. The compound of claim 1 wherein, R¹ is methyl, R² is n-hexyl, n-heptyl, n-octyl, n-nonyl, n-decyl, n-undecyl, n-dodecyl, n-tridecyl, n-tetradecyl, n-pentadecyl, n-hexadecyl, n-heptadecyl, n-octadecyl, n-nonadecyl, or n-icosyl, and R³ is methylphenyl, ethylphenyl, n-propylphenyl, n-butylphenyl, n-pentylphenyl, n-hexylphenyl, n-heptylphenyl, n-octylphenyl, n-nonylphenyl, n-decylphenyl, n-undecylphenyl, n-dodecylphenyl, n-tridecylphenyl, n-tetradecylphenyl, n-pentadecylphenyl, n-hexadecylphenyl, n-heptadecylphenyl, n-octadecylphenyl, n-nonadecylphenyl, or n-icosylphenyl.
 - 20
 - 25
13. The compound of any of the above claims wherein E is nitrogen.
14. The compound of any of the above claims wherein M is boron.

15. The compound of any of the above claims wherein Q is an optionally substituted aryl group, preferably a halogen substituted aryl group.
- 5 16. The compound of any of the above claims wherein Q is a perfluoroaryl group.
17. The compound of any of the above claims wherein when Q is a fluorophenyl group, then R² is not an optionally substituted C₁-C₄₀ linear alkyl group.
- 10 18. The compound of any of the above claims wherein when Q is a substituted phenyl group, then R² is not a C₁-C₄₀ linear alkyl group.
19. The compound of any of the above claims wherein each Q is perfluoronaphthyl.
- 15 20. The compound of claim 1, 14, 15, 16, 17, 18, or 19, wherein the cation represented by the formula [R¹R²R³EH]_d⁺ is selected from the group consisting of:

1		2		3	
4		5		6	
7		8		9	
10		11		12	

13		14		15	
16		17 A		18	
19		20 A		21	
22		23		24	
25		26		27	
28		29		30	
31		32		33	

21. The compound of any of claims 1 to 20, wherein the compound has a solubility of more than 10 mM at 25°C (stirred 2 hours) in methylcyclohexane and /or a solubility of more than 1 mM at 25°C (stirred 2 hours) in isohexane.
- 5 22. A catalyst system comprising a catalyst and the activator compound of any of claims 1 to 21.
23. The catalyst system of claim 22, further comprising a support material, preferably selected from Al₂O₃, ZrO₂, SiO₂, SiO₂/Al₂O₃, SiO₂/TiO₂, silica clay, silicon oxide/clay, or
- 10 mixtures thereof.
24. The catalyst system of claim 22 or 23, wherein the catalyst is represented by formula (II) or formula (III):



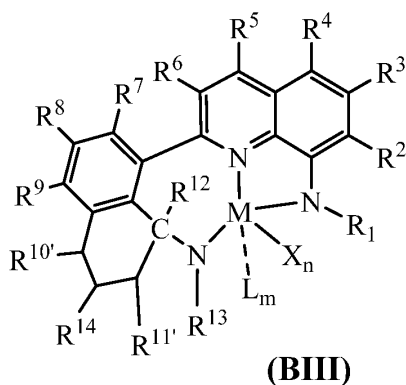
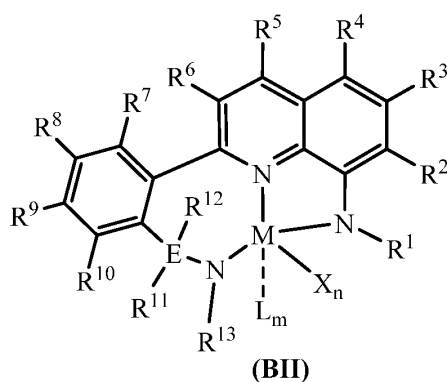
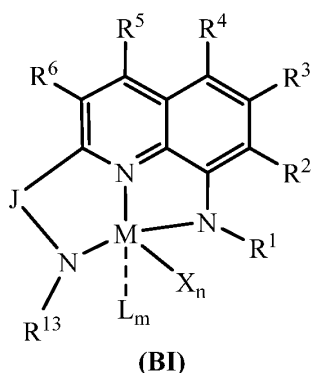
- 15 wherein in formula (II) and formula (III): M is the metal center, and is a Group 4 metal; n is 0 or 1; T is an optional bridging group selected from dialkylsilyl, diarylsilyl, dialkylmethyl, ethylenyl or hydrocarbylethylenyl wherein one, two, three or four of the hydrogen atoms in ethylenyl are substituted by hydrocarbyl; Z is nitrogen, oxygen, sulfur, or phosphorus; R' is a cyclic, linear or branched C₁ to C₄₀ alkyl or substituted alkyl group, preferably R' is a linear C₁-
- 20 C₄₀ alkyl or substituted alkyl group, preferably a linear C₁-C₄₀ alkyl or substituted alkyl group; q is 1 or 2; and X₁ and X₂ are, independently, hydrogen, halogen, hydride radicals, hydrocarbyl radicals, substituted hydrocarbyl radicals, halocarbyl radicals, substituted halocarbyl radicals, silylcarbyl radicals, substituted silylcarbyl radicals, germylcarbyl radicals, or substituted germylcarbyl radicals; or both X₁ and X₂ are joined and bound to the metal atom to form a
- 25 metallacycle ring containing from about 3 to about 20 carbon atoms; or both together can be an olefin, diolefin or aryne ligand.
25. The catalyst system of claim 24, wherein the catalyst is C₂ symmetrical.
- 30 26. The catalyst system of claim 22 or 23, wherein the catalyst is rac-dimethylsilyl-bis(indenyl)hafnium dimethyl.

27. The catalyst system of claim 22 or 23, wherein the catalyst is one or more of:
- dimethylsilylbis(tetrahydroindenyl)MX_n,
 dimethylsilyl bis(2-methylindenyl)MX_n,
 5 dimethylsilyl bis(2-methylfluorenyl)MX_n,
 dimethylsilyl bis(2-methyl-5,7-propylindenyl)MX_n,
 dimethylsilyl bis(2-methyl-4-phenylindenyl)MX_n,
 dimethylsilyl bis(2-ethyl-5-phenylindenyl)MX_n,
 dimethylsilyl bis(2-methyl-4-biphenylindenyl)MX_n,
 10 dimethylsilylene bis(2-methyl-4-carbazolylindenyl)MX_n,
rac-dimethylsilyl-bis-(5,6,7,8-tetrahydro-5,5,8,8-tetramethyl-2-methyl-1H-benz(f)indene)MX_n,
 diphenylmethylene (cyclopentadienyl)(fluorenyl)MX_n,
 bis(methylcyclopentadienyl)MX_n,
 15 *rac*-dimethylsilylbis(2-methyl,3-propyl indenyl)MX_n,
 dimethylsilylbis(indenyl)MX_n,
Rac-meso-diphenylsilyl-bis(n-propylcyclopentadienyl)MX_n,
 1, 1'-bis(4-triethylsilylphenyl)methylene-(cyclopentadienyl)(3,8-di-tertiary-butyl-1-fluorenyl)MX_n (bridge is considered the 1 position),
 20 bis-trimethylsilylphenyl-methylene(cyclopentadienyl)(di-t-butylfluorenyl)MX_n,
 bis-trimethylsilylphenyl-methylene(cyclopentadienyl)(fluorenyl)MX_n,
 bisphenylmethylene(cyclopentadienyl)(dimethylfluorenyl)MX_n,
 bis(n-propylcyclopentadienyl)MX_n,
 bis(n-butylcyclopentadienyl)MX_n,
 25 bis(n-pentylcyclopentadienyl)MX_n,
 (n-propyl cyclopentadienyl)(n-butylcyclopentadienyl)MX_n,
 bis[(2-trimethylsilyl)ethyl]cyclopentadienyl]MX_n,
 bis(trimethylsilyl cyclopentadienyl)MX_n,
 dimethylsilylbis(n-propylcyclopentadienyl)MX_n,
 30 dimethylsilylbis(n-butylcyclopentadienyl)MX_n,
 bis(1-n-propyl-2-methylcyclopentadienyl)MX_n,
 (n-propylcyclopentadienyl)(1-n-propyl-3-n-butylcyclopentadienyl)MX_n,
 bis(1-methyl, 3-n-butyl cyclopentadienyl)MX_n,
 bis(indenyl)MX_n,

- dimethylsilyl (tetramethylcyclopentadienyl)(cyclododecylamido)MX_n,
 dimethylsilyl (tetramethylcyclopentadienyl)(t-butylamido)MX_n,
 μ -(CH₃)₂Si(cyclopentadienyl)(1-adamantylamido)MX_n,
 μ -(CH₃)₂Si(3-tertbutylcyclopentadienyl)(1-adamantylamido)MX_n,
 5 μ -(CH₃)₂(tetramethylcyclopentadienyl)(1-adamantylamido)MX_n,
 μ -(CH₃)₂Si(tetramethylcyclopentadienyl)(1-adamantylamido)MX_n,
 μ -(CH₃)₂C(tetramethylcyclopentadienyl)(1-adamantylamido)MX_n,
 μ -(CH₃)₂Si(tetramethylcyclopentadienyl)(1-tertbutylamido)MX_n,
 μ -(CH₃)₂Si(fluorenyl)(1-tertbutylamido)MX_n,
 10 μ -(CH₃)₂Si(tetramethylcyclopentadienyl)(1-cyclododecylamido)MX_n,
 μ -(C₆H₅)₂C(tetramethylcyclopentadienyl)(1-cyclododecylamido)MX_n,
 μ -(CH₃)₂Si(η^5 -2,6,6-trimethyl-1,5,6,7-tetrahydro-s-indacen-1-yl)(tertbutylamido)MX_n,
 where M is selected from Ti, Zr, and Hf; X is selected from the group consisting of halogens,
 hydrides, C₁₋₁₂ alkyls, C₂₋₁₂ alkenyls, C₆₋₁₂ aryls, C₇₋₂₀ alkylaryls, C₁₋₁₂ alkoxys, C₆₋₁₆ aryloxys,
 15 C₇₋₁₈ alkylaryloxys, C₁₋₁₂ fluoroalkyls, C₆₋₁₂ fluoroaryls, and C₁₋₁₂ heteroatom-containing
 hydrocarbons, substituted derivatives thereof, and combinations thereof, and where n is zero
 or an integer from 1 to 4, preferably X is selected from halogens (such as bromide, fluoride,
 chloride), or C₁ to C₂₀ alkyls (such as methyl, ethyl, propyl, butyl, and pentyl) and n is 1 or 2,
 preferably 2.
 20
 28. The catalyst system of claim 22 or 23, wherein the catalyst is one or more of:
 bis(1-methyl, 3-n-butyl cyclopentadienyl) M(R)₂;
 dimethylsilyl bis(indenyl)M(R)₂;
 bis(indenyl)M(R)₂;
 25 dimethylsilyl bis(tetrahydroindenyl)M(R)₂;
 bis(n-propylcyclopentadienyl)M(R)₂;
 dimethylsilyl (tetramethylcyclopentadienyl)(cyclododecylamido)M(R)₂;
 dimethylsilyl (tetramethylcyclopentadienyl)(cyclododecylamido)M(R)₂;
 dimethylsilyl (tetramethylcyclopentadienyl)(t-butylamido)M(R)₂;
 30 dimethylsilyl (tetramethylcyclopentadienyl)(t-butylamido)M(R)₂;
 μ -(CH₃)₂Si(cyclopentadienyl)(1-adamantylamido)M(R)₂;
 μ -(CH₃)₂Si(3-tertbutylcyclopentadienyl)(1-adamantylamido)M(R)₂;
 μ -(CH₃)₂(tetramethylcyclopentadienyl)(1-adamantylamido)M(R)₂;
 μ -(CH₃)₂Si(tetramethylcyclopentadienyl)(1-adamantylamido)M(R)₂;

- μ -(CH₃)₂C(tetramethylcyclopentadienyl)(1-adamantylamido)M(R)₂;
 μ -(CH₃)₂Si(tetramethylcyclopentadienyl)(1-tertbutylamido)M(R)₂;
 μ -(CH₃)₂Si(fluorenyl)(1-tertbutylamido)M(R)₂;
 μ -(CH₃)₂Si(tetramethylcyclopentadienyl)(1-cyclododecylamido)M(R)₂;
 5 μ -(C₆H₅)₂C(tetramethylcyclopentadienyl)(1-cyclododecylamido)M(R)₂;
 μ -(CH₃)₂Si(η^5 -2,6,6-trimethyl-1,5,6,7-tetrahydro-s-indacen-1-yl)(tertbutylamido)M(R)₂;
 where M is selected from Ti, Zr, and Hf; and R is selected from halogen or C₁ to C₅ alkyl.

29. The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula
 10 **(BI)**, Formula **(BII)**, or Formula **(BIII)**:



wherein:

- 15 M is a group 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 metal;
 J is group including a three-atom-length bridge between the quinoline and the amido nitrogen;

E is carbon, silicon, or germanium;

X is an anionic leaving group;

L is a neutral Lewis base;

R^1 and R^{13} are independently selected from the group including of hydrocarbyls,
5 substituted hydrocarbyls, and silyl groups;

R^2 , R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , R^{10} , $R^{10'}$, R^{11} , $R^{11'}$, R^{12} , and R^{14} are independently hydrogen, hydrocarbyl, alkoxy, silyl, amino, aryloxy, substituted hydrocarbyl, halogen, or phosphino;

n is 1 or 2;

10 m is 0, 1, or 2, where n+m is not greater than 4; and

any two R groups are optionally joined to form a substituted hydrocarbyl, unsubstituted hydrocarbyl, substituted heterocyclic, or unsubstituted heterocyclic, saturated or unsaturated ring, where the ring has 5, 6, 7, or 8 ring atoms and where substitutions on the ring can join to form additional rings;

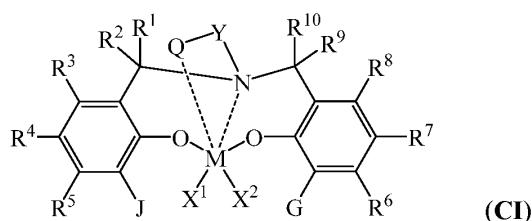
15 any two X groups are optionally joined together to form a dianionic group;

any two L groups are optionally joined together to form a bidentate Lewis base; and

any X group is optionally joined to an L group to form a monoanionic bidentate group.

30 The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula

20 (CI):



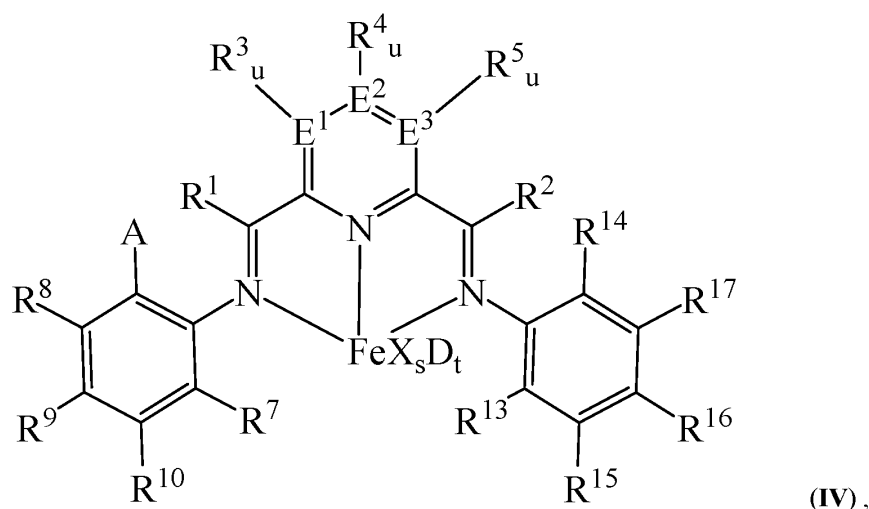
wherein M is a Group 4 metal; X^1 and X^2 are independently a univalent C_1 - C_{20} hydrocarbyl, C_1 - C_{20} substituted hydrocarbyl, a heteroatom or a heteroatom-containing group, or X^1 and X^2 join together to form a C_4 - C_{62} cyclic or polycyclic ring structure; each R^1 , R^2 , R^3 , R^4 , R^5 , R^6 ,

25 R^7 , R^8 , R^9 , and R^{10} is independently hydrogen, C_1 - C_{40} hydrocarbyl, C_1 - C_{40} substituted hydrocarbyl, a heteroatom or a heteroatom-containing group, or two or more of R^1 , R^2 , R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , or R^{10} are optionally joined together to form a C_4 - C_{62} cyclic or polycyclic ring structure, or a combination thereof; Q is a neutral donor group; J is heterocycle, a substituted or unsubstituted C_7 - C_{60} fused polycyclic group, where at least one ring is aromatic and where at least one ring, which may or may not be aromatic, has at least five ring atoms; G

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is as defined for J or may be hydrogen, C₂-C₆₀ hydrocarbyl, C₁-C₆₀ substituted hydrocarbyl, or optionally independently form a C₄-C₆₀ cyclic or polycyclic ring structure with R⁶, R⁷, or R⁸ or a combination thereof; Y is divalent C₁-C₂₀ hydrocarbyl or divalent C₁-C₂₀ substituted hydrocarbyl or (-Q-Y-) together form a heterocycle; and heterocycle may be aromatic and/or may have multiple fused rings.

31. The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula (IV):



10 wherein:

A is chlorine, bromine, iodine, -CF₃ or -OR¹¹;

each of R¹ and R² is independently hydrogen, C₁-C₂₂-alkyl, C₂-C₂₂-alkenyl, C₆-C₂₂-aryl, arylalkyl where alkyl has from 1 to 10 carbon atoms and aryl has from 6 to 20 carbon atoms, or five-, six- or seven-membered heterocyclyl comprising at least one atom selected from the group consisting of N, P, O and S;

15 wherein each of R¹ and R² is optionally substituted by halogen, -NR¹¹₂, -OR¹¹ or -SiR¹²₃;

wherein R¹ optionally bonds with R³, and R² optionally bonds with R⁵, in each case to independently form a five-, six- or seven-membered ring;

20 R⁷ is a C₁-C₂₀ alkyl;

each of R³, R⁴, R⁵, R⁸, R⁹, R¹⁰, R¹⁵, R¹⁶, and R¹⁷ is independently hydrogen, C₁-C₂₂-alkyl, C₂-C₂₂-alkenyl, C₆-C₂₂-aryl, arylalkyl where alkyl has from 1 to 10 carbon atoms and aryl has from 6 to 20 carbon atoms, -NR¹¹₂, -OR¹¹, halogen, -SiR¹²₃ or five-, six- or seven-

membered heterocyclyl comprising at least one atom selected from the group consisting of N, P, O, and S;

wherein R^3 , R^4 , R^5 , R^7 , R^8 , R^9 , R^{10} , R^{15} , R^{16} , and R^{17} are optionally substituted by halogen, $-NR^{11}_2$, $-OR^{11}$ or $-SiR^{12}_3$;

5 wherein R^3 optionally bonds with R^4 , R^4 optionally bonds with R^5 , R^7 optionally bonds with R^{10} , R^{10} optionally bonds with R^9 , R^9 optionally bonds with R^8 , R^{17} optionally bonds with R^{16} , and R^{16} optionally bonds with R^{15} , in each case to independently form a five-, six- or seven-membered carbocyclic or heterocyclic ring, the heterocyclic ring comprising at least one atom from the group consisting of N, P, O and S;

10 R^{13} is C_1 - C_{20} -alkyl bonded with the aryl ring via a primary or secondary carbon atom;
 R^{14} is chlorine, bromine, iodine, $-CF_3$ or $-OR^{11}$, or C_1 - C_{20} -alkyl bonded with the aryl ring;

each R^{11} is independently hydrogen, C_1 - C_{22} -alkyl, C_2 - C_{22} -alkenyl, C_6 - C_{22} -aryl, arylalkyl where alkyl has from 1 to 10 carbon atoms and aryl has from 6 to 20 carbon atoms,
 15 or $-SiR^{12}_3$, wherein R^{11} is optionally substituted by halogen, or two R^{11} radicals optionally bond to form a five- or six-membered ring;

each R^{12} is independently hydrogen, C_1 - C_{22} -alkyl, C_2 - C_{22} -alkenyl, C_6 - C_{22} -aryl, arylalkyl where alkyl has from 1 to 10 carbon atoms and aryl has from 6 to 20 carbon atoms, or two R^{12} radicals optionally bond to form a five- or six-membered ring;

20 each of E^1 , E^2 , and E^3 is independently carbon, nitrogen or phosphorus;
 each u is independently 0 if E^1 , E^2 , and E^3 is nitrogen or phosphorus and is 1 if E^1 , E^2 , and E^3 is carbon;

each X is independently fluorine, chlorine, bromine, iodine, hydrogen, C_1 - C_{20} -alkyl, C_2 - C_{10} -alkenyl, C_6 - C_{20} -aryl, arylalkyl where alkyl has from 1 to 10 carbon atoms and
 25 aryl has from 6 to 20 carbon atoms, $-NR^{18}_2$, $-OR^{18}$, $-SR^{18}$, $-SO_3R^{18}$, $-OC(O)R^{18}$, $-CN$, $-SCN$, β -diketonate, $-CO$, $-BF_4^-$, $-PF_6^-$ or bulky non-coordinating anions, and the radicals X can be bonded with one another;

each R^{18} is independently hydrogen, C_1 - C_{20} -alkyl, C_2 - C_{20} -alkenyl, C_6 - C_{20} -aryl, arylalkyl where alkyl has from 1 to 10 carbon atoms and aryl has from 6 to 20 carbon atoms,
 30 or $-SiR^{19}_3$, wherein R^{18} can be substituted by halogen or nitrogen- or oxygen-containing groups and two R^{18} radicals optionally bond to form a five- or six-membered ring;

each R^{19} is independently hydrogen, C_1 - C_{20} -alkyl, C_2 - C_{20} -alkenyl, C_6 - C_{20} -aryl or arylalkyl where alkyl has from 1 to 10 carbon atoms and aryl has from 6 to 20 carbon atoms,

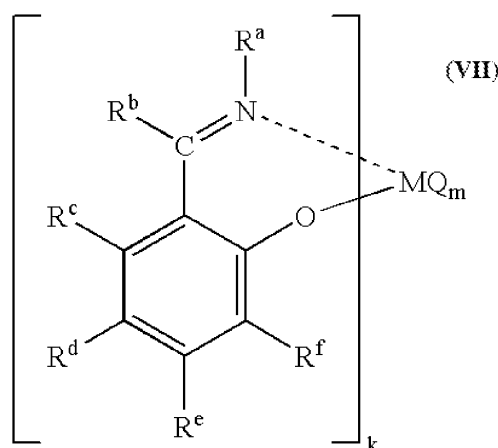
wherein R^{19} can be substituted by halogen or nitrogen- or oxygen-containing groups or two R^{19} radicals optionally bond to form a five- or six-membered ring;

s is 1, 2, or 3;

D is a neutral donor; and

5 t is 0 to 2.

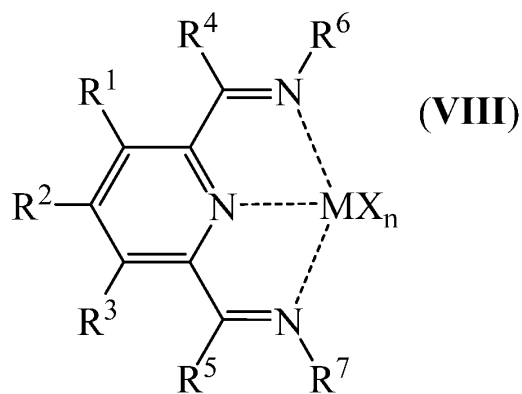
32. The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula (VII):



- 10 wherein M represents a transition metal atom selected from the groups 3 to 11 metals in the periodic table; k is an integer of 1 to 6; m is an integer of 1 to 6; R^a to R^f may be the same or different from one another and each represent a hydrogen atom, a halogen atom, a hydrocarbon group, a heterocyclic compound residue, an oxygen-containing group, a nitrogen-containing group, a boron-containing group, a sulfur-containing group, a phosphorus-containing group, a silicon-containing group, a germanium-containing group or a tin-containing group, among which 2 or more groups are optionally bound to each other to form a ring; when k is 2 or more, R^a groups, R^b groups, R^c groups, R^d groups, R^e groups, or R^f groups may be the same or different from one another, one group of R^a to R^f contained in one ligand and one group of R^a to R^f contained in another ligand may form a linking group or a single bond, and a heteroatom
- 15 contained in R^a to R^f may coordinate with or bind to M; m is a number satisfying the valence of M; Q represents a hydrogen atom, a halogen atom, an oxygen atom, a hydrocarbon group, an oxygen-containing group, a sulfur-containing group, a nitrogen-containing group, a boron-containing group, an aluminum-containing group, a phosphorus-containing group, a halogen-containing group, a heterocyclic compound residue, a silicon-containing group, a germanium-
- 20

containing group or a tin-containing group; when m is 2 or more, a plurality of groups represented by Q may be the same or different from one another, and a plurality of groups represented by Q may be mutually bound to form a ring.

- 5 33. The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula (VIII):

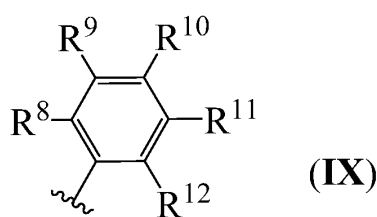


wherein:

- M is Co or Fe; each X is an anion; n is 1, 2 or 3, so that the total number of negative charges on said anion or anions is equal to the oxidation state of a Fe or Co atom present in (VIII);

R¹, R² and R³ are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl, or an inert functional group;

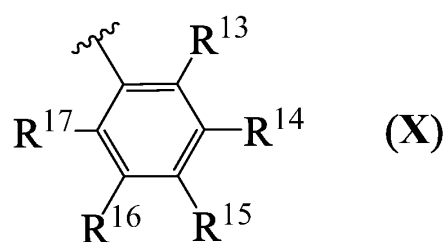
- R⁴ and R⁵ are each independently hydrogen, hydrocarbyl, an inert functional group or substituted hydrocarbyl;



R⁶ is represented by the formula (IX):

R⁷ is represented by the formula (X):

, and



wherein R^8 and R^{13} are each independently hydrocarbyl, substituted hydrocarbyl or an inert functional group;

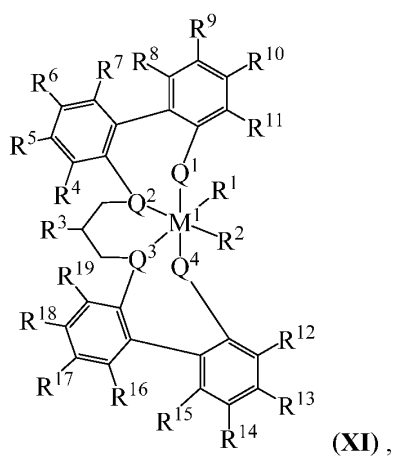
R^9 , R^{10} , R^{11} , R^{14} , R^{15} and R^{16} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or an inert functional group;

R^{12} and R^{17} are each independently hydrogen, hydrocarbyl, substituted hydrocarbyl or an inert functional group;

and provided that any two of R^8 , R^9 , R^{10} , R^{11} , R^{12} , R^{13} , R^{14} , R^{15} , R^{16} and R^{17} that are adjacent to one another, together optionally form a ring.

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34. The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula (XI):



M^1 is selected from the group consisting of titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum and tungsten; each of Q^1 , Q^2 , Q^3 , and Q^4 is independently oxygen or sulfur; R^1 and R^2 are independently hydrogen, halogen, hydroxyl, hydrocarbyl, or substituted hydrocarbyl, optionally R^1 and R^2 may also be joined together to form an alkanediyl group or a conjugated C_4 - C_{40} diene ligand which is coordinated to M^1 ;

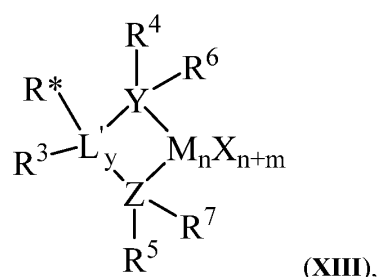
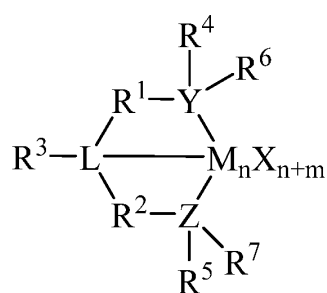
each of R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , R^{10} , R^{11} , R^{12} , R^{13} , R^{14} , R^{15} , R^{16} , R^{17} , R^{18} , and R^{19} is independently hydrogen, halogen, C_1 - C_{40} hydrocarbyl or C_1 - C_{40} substituted

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- hydrocarbyl, -NR'₂, -SR', -OR, -OSiR'₃, -PR'₂, where each R' is hydrogen, halogen, C₁-C₁₀ alkyl, or C₆-C₁₀ aryl, or one or more of R⁴ and R⁵, R⁵ and R⁶, R⁶ and R⁷, R⁸ and R⁹, R⁹ and R¹⁰, R¹⁰ and R¹¹, R¹² and R¹³, R¹³ and R¹⁴, R¹⁴ and R¹⁵, R¹⁶ and R¹⁷, R¹⁷ and R¹⁸, and R¹⁸ and R¹⁹ are optionally joined to form a saturated ring, unsaturated ring, substituted saturated ring, or substituted unsaturated ring;

R³ is a C₁-C₄₀ unsaturated alkyl or substituted C₁-C₄₀ unsaturated alkyl.

35. The catalyst system of claim 22 or 23, wherein the catalyst is represented by Formula (XII) or (XIII):



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- wherein M is a Group 3 to 12 transition metal or a Group 13 or 14 main group metal; each X is independently a leaving group; y is 0 or 1 (when y is 0 group L' is absent); 'n' is the oxidation state of M and is +3, +4, or +5; 'm' represents the formal charge of the YZL or the YZL' ligand, and is 0, -1, -2 or -3; L is a Group 15 or 16 element; L' is a Group 15 or 16 element or Group 14 containing group; Y is a Group 15 element; Z is a Group 15 element; R¹ and R² are, independently, a C₁ to C₂₀ hydrocarbon group, a heteroatom containing group having up to twenty carbon atoms, silicon, germanium, tin, lead, or phosphorus; R³ is optionally absent or may be a hydrocarbon group, a hydrogen, a halogen, a heteroatom containing group; R⁴ and R⁵ are independently an alkyl group, an aryl group, substituted aryl group, a cyclic alkyl group, a substituted cyclic alkyl group, a cyclic aralkyl group, a substituted cyclic aralkyl group, or multiple ring system; R⁶ and R⁷ are independently absent, hydrogen, an alkyl group, halogen, heteroatom, or a hydrocarbyl group; R* may be absent, or may be a hydrogen, a Group 14 atom containing group, a halogen, or a heteroatom containing group.

36. A method of polymerizing olefins to produce at least one polyolefin, the method comprising contacting at least one olefin with the catalyst system of any of claims 22 to 35, and obtaining a polyolefin.

37. The method of claim 36, wherein the at least one olefin is propylene and the polyolefin is isotactic polypropylene.
38. A method of polymerizing olefins to produce at least one polyolefin, the method
5 comprising contacting two or more different olefins with the catalyst system of any of claims 22 to 35; and obtaining a polyolefin.
39. The method of claim 38, wherein the two or more olefins are ethylene and propylene.
- 10 40. The method of claim 38 or 39, wherein the two or more olefins further comprise a diene.
41. The method of any of claims 36-40, wherein the polyolefin has an Mw of from about 50,000 to about 300,000 g/mol and a melt temperature of from about 120°C to about 140°C.
- 15 42. The method of claim 41, wherein the polyolefin has an Mw of from about 100,000 to about 300,000 and a melt temperature of from about 125°C to about 135°C.
43. The method of any of claims 36 to 42, wherein the method is performed in gas phase or slurry phase.
- 20 44. The method of any of claims 36 to 42, wherein the method is performed in solution phase.
45. A composition comprising the compound of any of claims 1-21 or the catalyst system
25 of any of claims 22-35 and an aliphatic solvent, where aromatic solvents are absent.
46. The method of claims 36-44, where the method is performed in the absence of aromatic solvents.