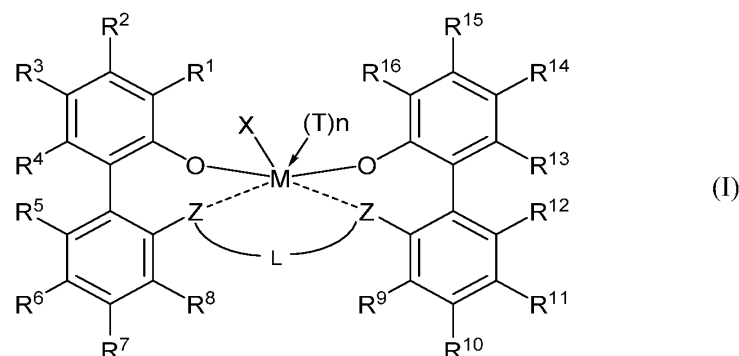


CLAIMS

1. A polymerization process comprising contacting ethylene and optionally one or more α -olefins in solution in the presence of one or more catalyst systems and a chain transfer agent, wherein the catalyst system comprises a metal–ligand complex according to formula (I):



where:

M is scandium, yttrium, or a lanthanide metal having an oxidation state of +3;

X is a ligand chosen from (C₁–C₄₀)hydrocarbyl,

(C₁–C₄₀)heterohydrocarbyl, –CH₂Si(R^C)_{3-Q}(OR^C)_Q,

–Si(R^C)_{3-Q}(OR^C)_Q, –OSi(R^C)_{3-Q}(OR^C)_Q, –CH₂Ge(R^C)_{3-Q}(OR^C)_Q,

–Ge(R^C)_{3-Q}(OR^C)_Q, –P(R^C)_{2-W}(OR^C)_W, –P(O)(R^C)_{2-W}(OR^C)_W, –N(R^C)₂, –NH(R^C),

–N(Si(R^C)₃)₂, –NR^CSi(R^C)₃, –NHSi(R^C)₃, –OR^C, –SR^C, –NO₂, –CN, –CF₃,

–OCF₃, –S(O)R^C, –S(O)₂R^C, –OS(O)₂R^C, –N=C(R^C)₂, –N=CH(R^C), –N=CH₂,

–N=P(R^C)₃, –OC(O)R^C, –C(O)OR^C, –N(R^C)C(O)R^C, –N(R^C)C(O)H,

–NHC(O)R^C, –C(O)N(R^C)₂, –C(O)NHR^C, –C(O)NH₂, a halogen, or a hydrogen,

wherein each R^C is independently a substituted or unsubstituted

(C₁–C₃₀)hydrocarbyl, or a substituted or unsubstituted

(C₁–C₃₀)heterohydrocarbyl, and each Q is 0, 1, 2 or 3 and each W is 0, 1, or 2;

B(R^Y)₄, Al(R^Y)₄, or Ga(R^Y)₄, wherein each R^Y is –H, (C₁–C₃₀)hydrocarbyl, or halogen atom;

each T is a Lewis Base;

n is 0, 1, or 2, when n is 1, X and T are optionally linked, when n is 2, X and one of T are optionally linked;

the metal–ligand complex is overall charge-neutral;

each Z is independently chosen from $-O-$, $-S-$, $-N(R^N)-$, or $-P(R^P)-$, wherein the dotted line optionally defines a dative bond;

R^1 and R^{16} are independently selected from the group consisting of (C_1-C_{40}) hydrocarbyl, (C_1-C_{40}) heterohydrocarbyl, $-Si(R^C)_3$, $-Ge(R^C)_3$, $-P(R^P)_2$, $-N(R^N)_2$, $-OR^C$, $-SR^C$, $-NO_2$, $-CN$, $-CF_3$, $R^CS(O)-$, $R^CS(O)_2-$, $-N=C(R^C)_2$, $R^CC(O)O-$, $R^COC(O)-$, $R^CC(O)N(R)-$, $(R^C)_2NC(O)-$, or halogen;

R^2 , R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , R^{10} , R^{11} , R^{12} , R^{13} , R^{14} , and R^{15} are independently selected from $-H$, (C_1-C_{40}) hydrocarbyl, (C_1-C_{40}) heterohydrocarbyl, $-Si(R^C)_3$, $-Ge(R^C)_3$, $-P(R^P)_2$, $-N(R^N)_2-OR^C$, $-SR^C$, $-NO_2$, $-CN$, $-CF_3$, $R^CS(O)-$, $R^CS(O)_2-$, $(R^C)_2C=N-$, $(R^C)_2P=N-$, $R^CC(O)O-$, $R^COC(O)-$, $R^CC(O)N(R)-$, $(R^C)_2NC(O)-$, and halogen;

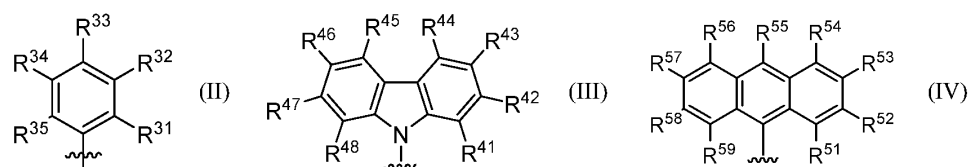
provided that when M is yttrium or a lanthanide metal, R^1 is not $-H$, phenyl or *tert*-butyl; and R^{16} is not $-H$, phenyl or *tert*-butyl;

L is (C_1-C_{40}) hydrocarbylene or (C_1-C_{40}) heterohydrocarbylene; and

each R^C , R^P , and R^N in formula (I) is independently a (C_1-C_{30}) hydrocarbyl, (C_1-C_{30}) heterohydrocarbyl, or $-H$.

2. The polymerization process of claim 1, wherein the chain transfer agent is chosen from (C_1-C_{40}) hydrocarbyl $_2$ Zn, $((C_1-C_{40})$ hydrocarbyl $_3$ Al, alkylaluminum halide, or modified alkyl aluminosilane.
3. The polymerization process of claim 1 or 2, wherein the catalyst system further comprises a co-catalyst.
4. The polymerization process of any one of the preceding claims, wherein a co-catalyst is absent from the catalyst system.
5. The polymerization process of any one of the preceding claims, wherein the polymerization process is a solution polymerization process.
6. The polymerization process of any one of the preceding claims, wherein the chain transfer agent is modified methylaluminum oxide.
7. The polymerization process of any one of claims 1 to 5, wherein the chain transfer agent is alkylaluminum.

8. The polymerization process of any one of claims 1 to 5, wherein the chain transfer agent is dialkyl zinc.
9. The polymerization process of any one of claims 1 to 5, wherein the chain transfer agent is a mixture of alkyl aluminium and alkyl zinc compound.
10. The polymerization process according to any one of the preceding claims, wherein:
 R^2 , R^4 , R^5 , R^{12} , R^{13} , and R^{15} are hydrogen; and
 each Z is oxygen.
11. The polymerization process according to any one of the preceding claims, where R^1 and R^{16} are chosen from radicals having formula (II), radicals having formula (III), and radicals having formula (IV):



where each of R^{31-35} , R^{41-48} , and R^{51-59} is independently chosen from $-H$, (C_1-C_{40}) hydrocarbyl, (C_1-C_{40}) heterohydrocarbyl, $-\text{Si}(\text{R}^C)_3$, $-\text{Ge}(\text{R}^C)_3$, $-\text{P}(\text{R}^P)_2$, $-\text{N}(\text{R}^N)_2$, $-\text{OR}^C$, $-\text{SR}^C$, $-\text{NO}_2$, $-\text{CN}$, $-\text{CF}_3$, $\text{R}^C\text{S}(\text{O})-$, $\text{R}^C\text{S}(\text{O})_2-$, $(\text{R}^C)_2\text{C}=\text{N}-$, $\text{R}^C\text{C}(\text{O})\text{O}-$, $\text{R}^C\text{OC}(\text{O})-$, $\text{R}^C\text{C}(\text{O})\text{N}(\text{R}^N)-$, $(\text{R}^C)_2\text{NC}(\text{O})-$, or halogen.

12. The polymerization process according to any one of the preceding claims, wherein R^1 and R^{16} are identical.
13. The polymerization process according to any one of the preceding claims, wherein at least one of R^1 and R^{16} is a radical having formula (III).
14. The polymerization process according to claim 13, wherein R^{42} and R^{47} are (C_1-C_{20}) hydrocarbyl, $-\text{Si}[(C_1-C_{20})\text{hydrocarbyl}]_3$, or $-\text{Ge}[(C_1-C_{20})\text{hydrocarbyl}]_3$.
15. The polymerization process according to claim 13, wherein R^{43} and R^{46} are (C_1-C_{20}) hydrocarbyl, $-\text{Si}[(C_1-C_{20})\text{hydrocarbyl}]_3$, or $-\text{Ge}[(C_1-C_{20})\text{hydrocarbyl}]_3$.

16. The metal–ligand complex according to claims 13 to 15, wherein optionally R^{42} and R^{43} are linked to form a cyclic structure, and optionally R^{46} and R^{47} are linked to form a cyclic structure.
17. The polymerization process according to any one of the preceding claims, wherein at least one of R^1 and R^{16} is a radical having formula (II).
18. The polymerization process according to claim 17 wherein R^{32} and R^{34} are (C_1-C_{20}) hydrocarbyl, $-Si[(C_1-C_{20})\text{hydrocarbyl}]_3$, or $-Ge[(C_1-C_{20})\text{hydrocarbyl}]_3$.
19. The polymerization process according to claims 1 to 11, wherein at least one of R^1 and R^{16} is a radical having formula (IV).
20. The polymerization process according to claim 19, wherein at least two of R^{52} , R^{53} , R^{55} , R^{57} , and R^{58} are (C_1-C_{20}) hydrocarbyl, $-Si[(C_1-C_{20})\text{hydrocarbyl}]_3$, or $-Ge[(C_1-C_{20})\text{hydrocarbyl}]_3$.
21. The metal–ligand complex according to claims 19 or 20, wherein optionally R^{52} and R^{53} are linked to form a cyclic structure, and optionally R^{57} and R^{58} are linked to form a cyclic structure.
22. The polymerization process according to any one of the preceding claims, wherein:
at least one of R^6 , R^7 , and R^8 is halogen; and
at least one of R^9 , R^{10} , and R^{11} is halogen.
23. The polymerization process according to any one of the preceding claims, wherein R^3 and R^{14} are (C_1-C_{10}) alkyl.
24. The polymerization process according to any one of the preceding claims, wherein R^3 and R^{14} are methyl, R^6 and R^{11} are halogen.
25. The polymerization process according to any one of claims 1 to 22, wherein R^3 and R^{14} are $-OR^C$, wherein R^C is (C_1-C_{30}) hydrocarbyl.
26. The polymerization process according to any one of claims 1 to 22, wherein R^6 and R^{11} are *tert*-butyl.
27. The polymerization process according to any one of claims 1 to 22, wherein R^3 and R^{14} are *tert*-octyl, *n*-octyl, or *n*-octylalkoxy.

28. The polymerization process according to any one of the preceding claims, where L is chosen from $-\text{CH}_2-$, $-\text{CH}_2(\text{CH}_2)_m\text{CH}_2-$ where m is from 0 to 3, $-\text{CH}_2\text{Si}(\text{R}^C)_2\text{CH}_2-$, $-\text{CH}_2\text{Ge}(\text{R}^C)_2\text{CH}_2-$, $-\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}^*(\text{CH}_3)$, and $-\text{CH}_2(\text{phen-1,2-di-yl})\text{CH}_2-$, where each R^C in L is $(\text{C}_1-\text{C}_{20})$ hydrocarbyl, and “C*” is a carbon atom from which a hydrogen atom is removed to form a secondary or tertiary alkyl radical.
29. The polymerization process according to any one of the preceding claims, wherein X is $-\text{CH}_2\text{Si}[(\text{C}_1-\text{C}_{20})\text{alkyl}]_3$.
30. The polymerization process according to any one of the preceding claims, wherein n is 1 or 2; and at least one T is $(\text{C}_1-\text{C}_{20})$ heterohydrocarbon, wherein the hetero atom of the heterohydrocarbon is oxygen.
31. The polymerization process according to any one of the preceding claims, wherein n is 1 or 2; and at least one T is tetrahydrofuran, diethyl ether, or methyl *tert*-butyl ether (MTBE).
32. The polymerization process according to any one of the preceding claims, wherein when M is yttrium or a lanthanide metal, at least one of R^{5-8} is not $-\text{H}$ and at least one of R^{9-12} is not $-\text{H}$.
33. The polymerization process according to any one of the preceding claims, wherein at least one of R^8 and R^9 is not $-\text{H}$.
34. The polymerization process according to any one of the preceding claims, wherein the catalyst system further comprises an additive.
35. The polymerization process of claim 34, wherein the additive is modified methylaluminumoxane.
36. The polymerization process of claim 34, wherein the additive is alkylaluminum.
37. The polymerization process of claim 34, wherein the additive is a borate based additive.