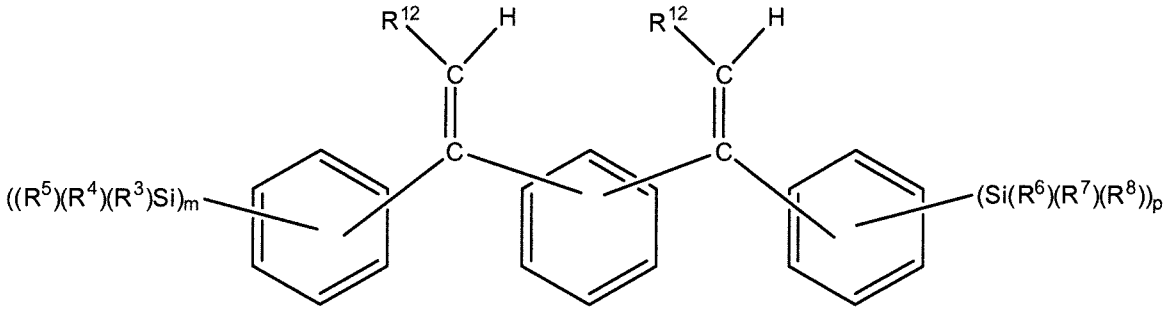
embodiments thereof as defined herein in the description of the polymerization initiator.

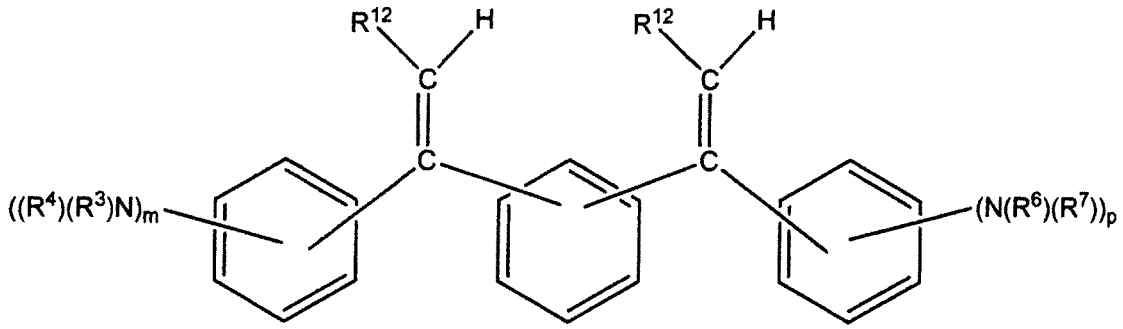
In one embodiment, the polymerization initiator of Formula 17 as defined above is obtained by reacting a compound of the following Formula 22



Formula 22

wherein R^3, R^4, R^5, R^6, R^7, R^8, R^{12}, m and p are as defined for Formula 17,
with at least one compound of Formula 3, wherein M^1 and R^1 are as defined for Formula 17, and optionally a Lewis base.

In one embodiment, the polymerization initiator of Formula 18 as defined above is obtained by reacting a compound of the following Formula 23



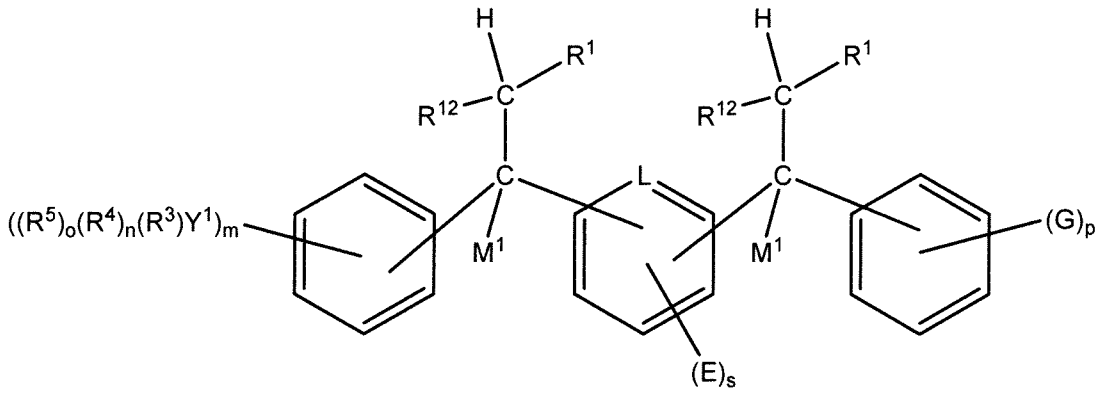
Formula 23

wherein R^3, R^4, R^6, R^7, R^{12}, m and p are as defined for Formula 18,
with at least one compound of Formula 3, wherein M^1 and R^1 are as defined for Formula 18, and optionally a Lewis base.

In one embodiment, the polymerization initiator of Formula 19 as defined above is obtained by reacting a compound of the following Formula 24

CLAIMS

1. A polymerization initiator represented by the following Formula 1:



Formula 1,

or a Lewis base adduct thereof,

wherein

each M^1 is independently selected from lithium, sodium and potassium;

each R^1 is independently selected from (C_1-C_{100}) alkyl and (C_2-C_{100}) alkenyl, optionally substituted with one or more (C_6-C_{12}) aryl groups and optionally linked to the carbon atom C by up to 25 monomer units selected from conjugated diene monomers and aromatic vinyl compounds, especially butadiene, isoprene and styrene;

each R^{12} is independently selected from hydrogen, (C_1-C_{10}) alkyl, (C_6-C_{12}) aryl and (C_7-C_{18}) alkylaryl;

each Y^1 is independently selected from a nitrogen atom, a sulfur atom and a silicon atom;

R^3, R^4 and R^5 are each independently selected from (C_1-C_{18}) alkyl, di(C_1-C_6) alkyl amine (only when Y^1 is a silicon atom), (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$, wherein R^{14}, R^{15} and R^{16} are each independently selected from (C_1-C_{18}) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl; n and o are each an integer selected from 0 and 1; and n+o=1 when Y^1=N, n=o=0 when Y^1=S, and n+o=2 when Y^1=Si;

m is an integer selected from 1, 2 and 3;

each E is independently selected from (C_1-C_{18}) alkyl, (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and -$Y^3(R^9)(R^{10})_t(R^{11})_u$, wherein

Y^3 is selected from a nitrogen atom, a sulfur atom and a silicon atom; R^9, R^{10} and R^{11} are each independently selected from (C_1-C_{18}) alkyl, di(C_1-C_6) alkyl amine (only when Y^3 is a silicon atom), (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl, and, when Y^3 is not a silicon atom, -$SiR^{20}R^{21}R^{22}$, wherein R^{20}, R^{21} and R^{22} are each independently selected from (C_1-C_{18}) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl; t and u are each an integer selected

from 0 and 1; and t+u=1 when Y^3=N, t=u=0 when Y^3=S, and t+u=2 when Y^3=Si;

s is an integer selected from 0, 1 and 2;

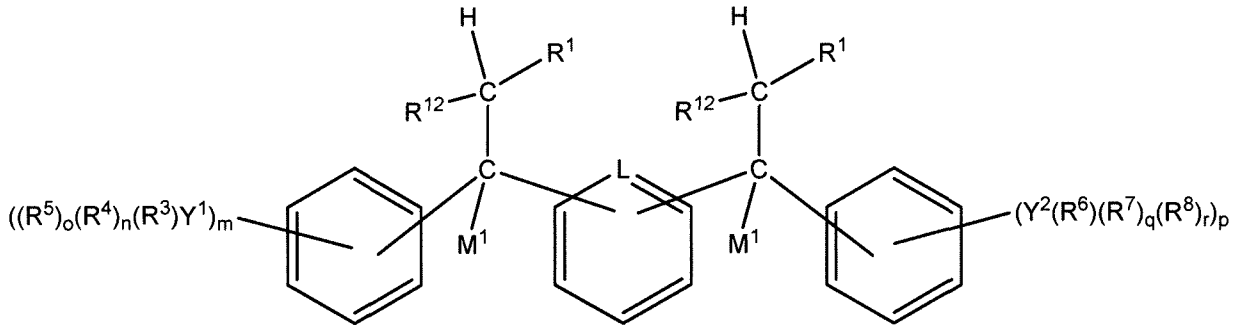
each G is independently selected from (C_1-C_{18}) alkyl, (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and -$Y^2(R^6)(R^7)_q(R^8)_r$, wherein

Y^2 is selected from a nitrogen atom, a sulfur atom and a silicon atom; R^6, $R^7$and R^8 are each independently selected from (C_1-C_{18}) alkyl, di(C_1-C_6) alkyl amine (only when Y^2 is a silicon atom), (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{18}) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl; q and r are each an integer selected from 0 and 1; and q+r=1 when Y^2=N, q=r=0 when Y^2=S, and q+r=2 when Y^2=Si;

p is an integer selected from 0, 1, 2 and 3;

L is selected from nitrogen, >C-H and >C-$Y^3(R^9)(R^{10})_t(R^{11})_u$, wherein Y^3, R^9, R^{10}, R^{11}, t and u are independently as defined above.

2. The polymerization initiator according to claim 1 which is represented by the following Formula 5:



Formula 5,

or a Lewis base adduct thereof,

wherein

M^1 is lithium;

each R^1 is independently selected from (C_1-C_{18}) alkyl;

p is an integer selected from 1, 2 and 3;

L is selected from nitrogen and >C-H; and

all other substituents or groups are as defined for Formula 1 in claim 1,

in particular wherein

(i) each R^1 is independently selected from (C_1-C_7) alkyl;

R^{12} is hydrogen;

R^3, R^4 and R^5 are each independently selected from (C_1-C_{10}) alkyl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$, wherein R^{14}, R^{15} and R^{16} are each independently selected from (C_1-C_{16}) alkyl; and

R^6, R^7 and R^8 are each independently selected from (C_1-C_{10}) alkyl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{16}) alkyl, or

(ii) each R^1 is independently selected from (C_1-C_{10}) alkyl;

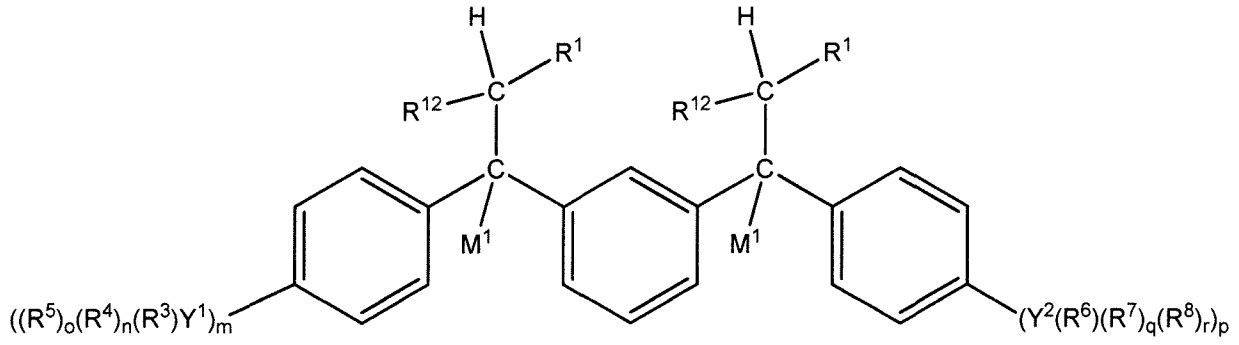
R^{12} is hydrogen;

R^3, R^4 and R^5 are each independently selected from (C_1-C_{18}) alkyl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$, wherein R^{14}, R^{15} and R^{16} are each independently selected from (C_1-C_{10}) alkyl;

R^6, R^7 and R^8 are each independently selected from (C_1-C_{18}) alkyl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{10}) alkyl;

m and p are each independently selected from an integer of 1 and 2.

3. The polymerization initiator according to claim 1 which is represented by the following Formula 6:



Formula 6,

or a Lewis base adduct thereof,

wherein

M^1 is lithium;

each R^1 is independently selected from (C_1-C_{10}) alkyl;

R^{12} is hydrogen;

R^3, R^4 and R^5 are each independently selected from (C_1-C_{18}) alkyl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$, wherein R^{14}, R^{15} and R^{16} are each independently selected from (C_1-C_{10}) alkyl;

m and p are each independently an integer selected from 1 and 2;

R^6, R^7 and R^8 are each independently selected from (C_1-C_{18}) alkyl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{10}) alkyl; and

all other substituents or groups are as defined for Formula 1 in claim 1.

4. The polymerization initiator or a Lewis base adduct thereof according to claim 3, wherein

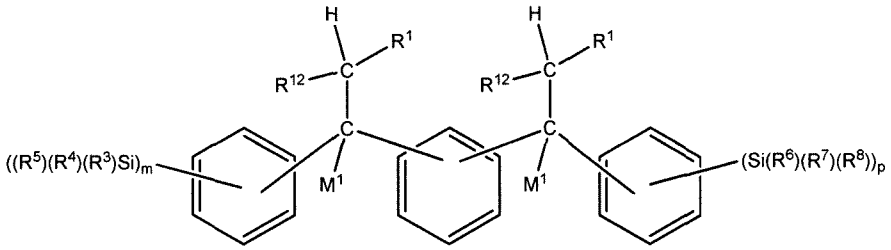
each R^1 is independently selected from (C_1-C_7) alkyl;

R^{12} is hydrogen;

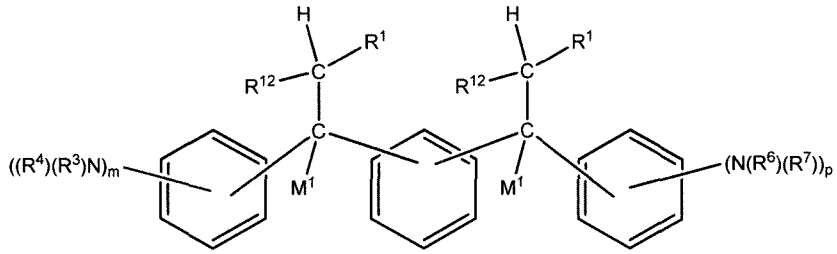
R^3, R^4 and R^5 are each independently selected from (C_1-C_{10}) alkyl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$, wherein R^{14}, R^{15} and R^{16} are selected from (C_1-C_{10}) alkyl; and

R^6, R^7 and R^8 are each independently selected from (C_1-C_{10}) alkyl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{10}) alkyl.

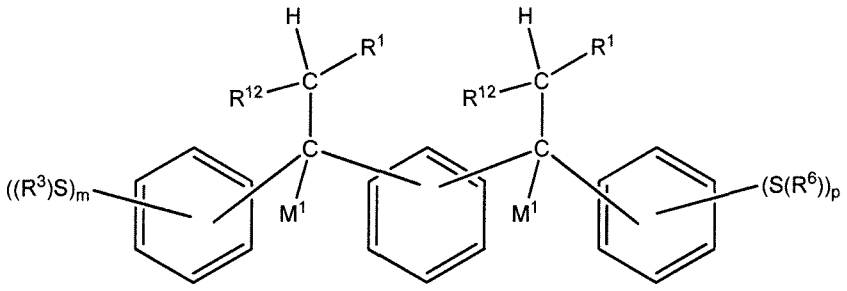
5. The polymerization initiator according to claim 1 which is represented by the following Formula 17, 18 or 19:



Formula 17



Formula 18



Formula 19

or a Lewis base adduct thereof,

wherein

M^1 is lithium;

each R^1 is independently selected from (C_1-C_{18}) alkyl; and

all other substituents or groups are as defined for Formula 1 in claim 1,

in particular wherein

(i) each R^1 is independently selected from (C_1-C_{10}) alkyl;

R^{12} is hydrogen;

R^3, R^4 and R^5 are each independently selected from (C_1-C_{18}) alkyl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$; wherein R^{14}, R^{15} and R^{16} are selected from (C_1-C_{10}) alkyl; and

R^6, R^7 and R^8 are each independently selected from (C_1-C_{18}) alkyl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{10}) alkyl, or

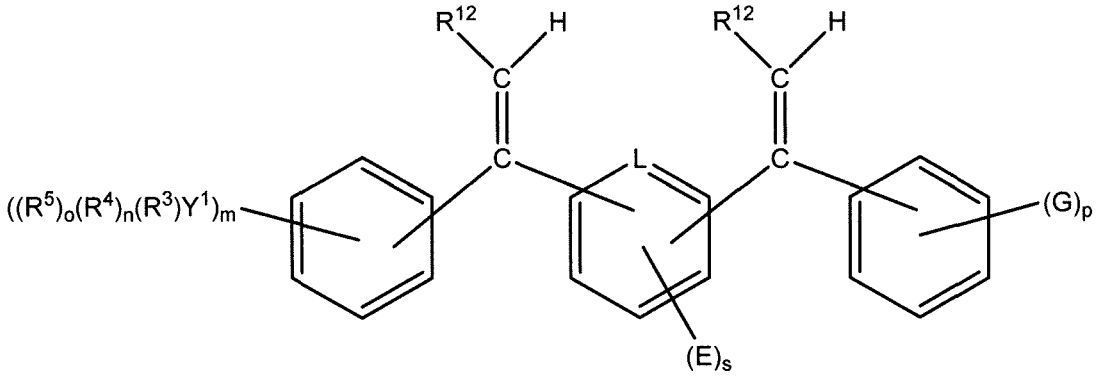
(ii) each R^1 is each independently selected from (C_1-C_7) alkyl;

R^{12} is hydrogen;

R^3, R^4 and R^5 are each independently selected from (C_1-C_{10}) alkyl and, when Y^1 is not a silicon atom, -$SiR^{14}R^{15}R^{16}$; wherein R^{14}, R^{15} and R^{16} are selected from (C_1-C_{10}) alkyl; and

R^6, R^7 and R^8 are each independently selected from (C_1-C_{18}) alkyl and, when Y^2 is not a silicon atom, -$SiR^{17}R^{18}R^{19}$, wherein R^{17}, R^{18} and R^{19} are each independently selected from (C_1-C_{10}) alkyl.

6. A method of making the polymerization initiator or a Lewis base adduct thereof as defined in any one of claims 1 to 5, comprising the step of reacting (i) a compound of Formula 2



Formula 2

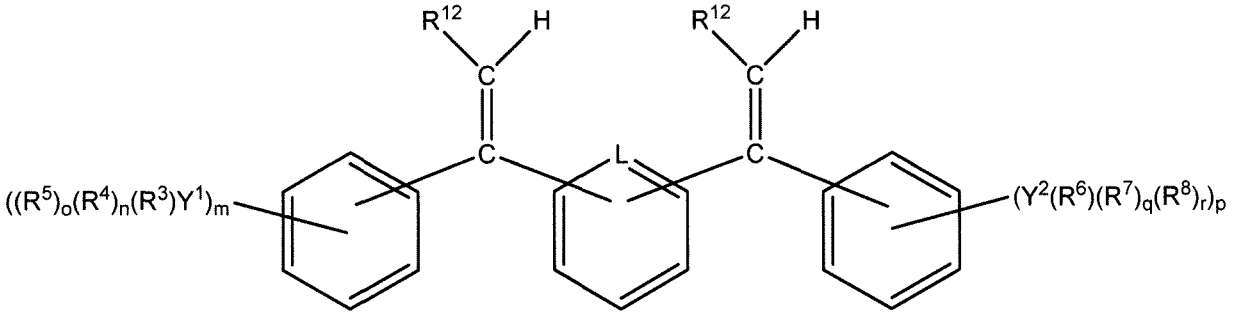
with (ii) at least one compound of Formula 3

$$R^1M^1$$

Formula 3

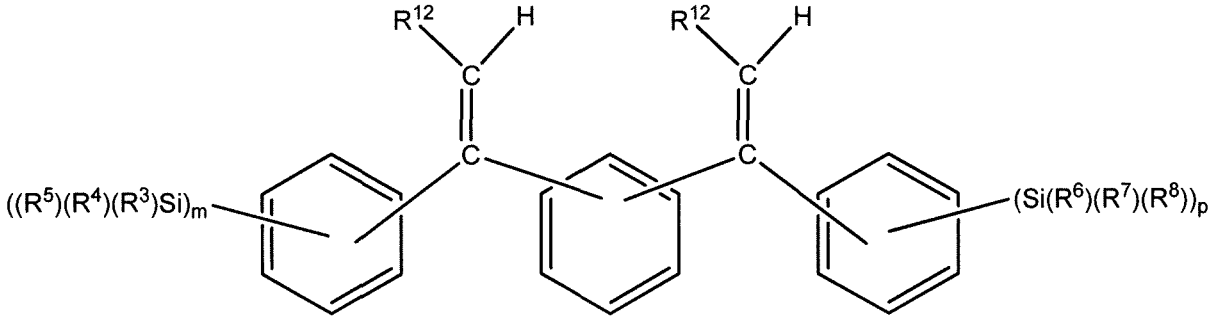
wherein L, E, G, Y^1, R^3, R^4, R^5, R^{12}, m, n, o, p and s and M^1 and R^1 are each as defined in claims 1-5.

7. The method according to claim 6, wherein the compound of Formula 2 is represented by the following Formula 7, 22, 23 or 24:

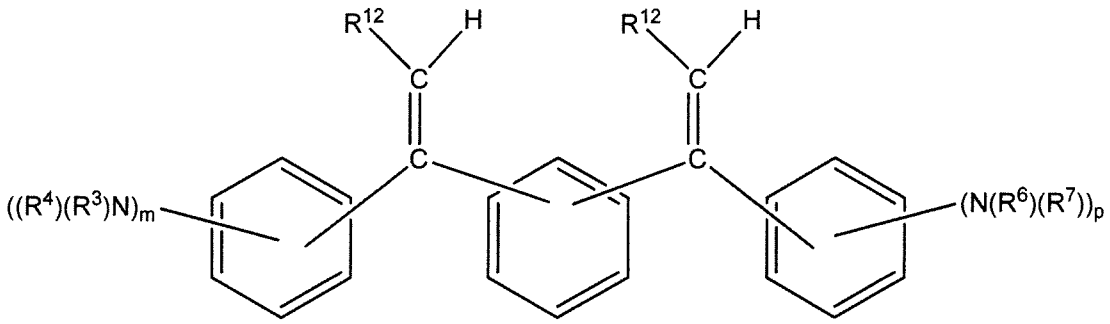


Formula 7

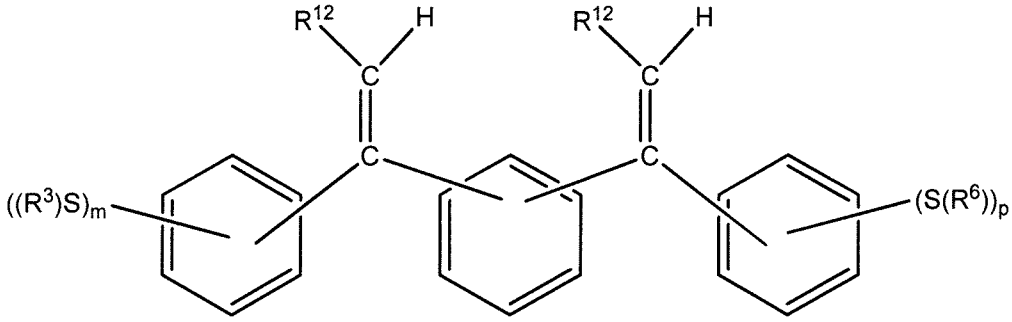
wherein L, Y^1, Y^2, R^3, R^4, R^5, R^6, R^7, R^8, R^{12}, m, n, o, p, q and r are as defined in claim 2;



Formula 22



Formula 23



Formula 24

wherein R^3, R^4, R^5, R^6, R^7, R^8, R^{12}, m and p are as defined in claim 5 for Formulas 17, 18 and 19, respectively.

8. A method of making a polymer, comprising the step of reacting

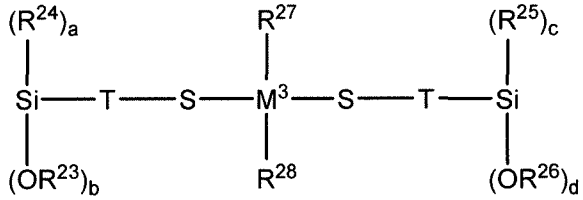
i) a polymerization initiator as defined in any one of claims 1 to 5, or a Lewis base adduct thereof, and

ii) at least one type of polymerizable monomers selected from conjugated olefins and aromatic vinyl compounds, and

optionally reacting the polymer with one or more chain end modifying agents so as to provide a chain end-modified polymer,

wherein the at least one type of polymerizable monomers may optionally be selected from 1,3-butadiene, isoprene and styrene.

9. The method according to claim 8, wherein the one or more chain end modifying agents are represented by the following Formulas 8, 9, 10, 11, 12, 13, 14, 15 and 16 and Lewis base adducts thereof:



Formula 8

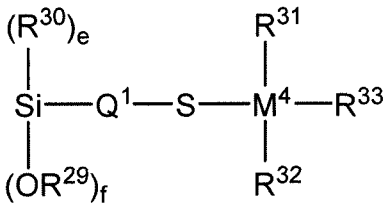
wherein M^3 is a silicon atom or a tin atom;

T is at least divalent and is selected from (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and (C_1-C_{18}) alkyl, wherein each group is optionally substituted with one or more groups selected from di(C_1-C_7 hydrocarbyl)amino, bis(tri(C_1-C_{12} alkyl)silyl)amino, tris(C_1-C_7 hydrocarbyl)silyl, (C_7-C_{18}) alkylaryl and (C_6-C_{18}) aryl;

R^{23} and R^{26} are each independently selected from (C_1-C_4) alkyl;

R^{24}, R^{25}, R^{27} and R^{28} are each independently selected from (C_1-C_{18}) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl;

a and c are each independently selected from 0, 1 and 2; b and d are each independently selected from 1, 2 and 3; a+b=3; and c+d=3;



Formula 9

wherein M^4 is a silicon atom or a tin atom;

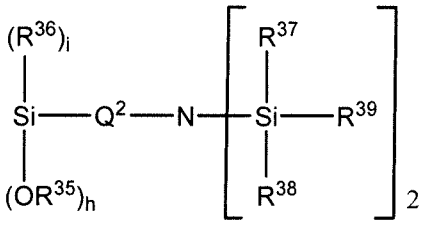
Q^1 is at least divalent and is selected from (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and (C_1-C_{18}) alkyl, wherein each group is optionally substituted with one or more groups selected from di(C_1-C_7 hydrocarbyl)amino, bis(tri(C_1-C_{12} alkyl)silyl)amino, tris(C_1-C_7 hydrocarbyl)silyl, (C_7-C_{18}) alkylaryl and (C_6-C_{18}) aryl;

R^{29} is independently selected from (C_1-C_4) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl;

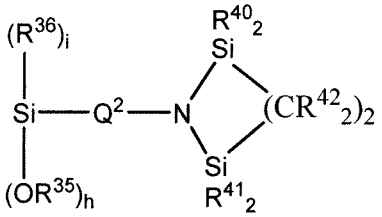
R^{31}, R^{32} and R^{33} are each independently selected from (C_1-C_{18}) alkyl, (C_1-C_{18}) alkoxy, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl;

R^{30} is independently selected from (C_1-C_{18}) alkyl, (C_1-C_{18}) alkoxy, (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and R^{34}-$(C_2H_4O)_g$-O-, wherein R^{34} is selected from (C_5-C_{23}) alkyl, (C_5-C_{23}) alkoxy, (C_6-C_{18}) aryl and (C_7-C_{25}) alkylaryl and g is selected from 4, 5 and 6;

e is selected from 0, 1 and 2; f is selected from 1, 2 and 3; and e+f=3;



Formula 10



Formula 11

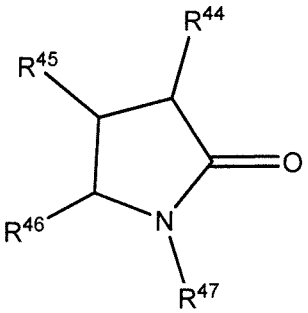
wherein Q^2 is at least divalent and is selected from (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and (C_1-C_{18}) alkyl, wherein each group is optionally substituted with one or more groups selected from di(C_1-C_7 hydrocarbyl)amino, bis(tri(C_1-C_{12} alkyl)silyl)amino, tris(C_1-C_7 hydrocarbyl)silyl, (C_7-C_{18}) alkylaryl and (C_6-C_{18}) aryl;

R^{35} is independently selected from (C_1-C_4) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl;

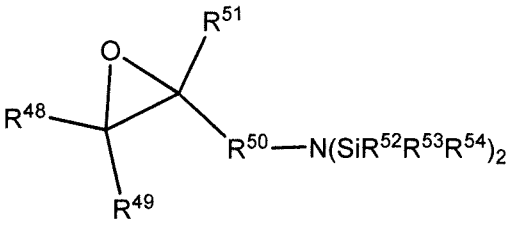
R^{37}, R^{38}, R^{39}, R^{40}, R^{41} and R^{42} are each independently selected from (C_1-C_{18}) alkyl, (C_1-C_{18}) alkoxy, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl;

R^{36} is independently selected from (C_1-C_{18}) alkyl, (C_1-C_{18}) alkoxy, (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and R^{43}-$(C_2H_4O)_j$-O-, wherein R^{43} is selected from (C_5-C_{23}) alkyl, (C_5-C_{23}) alkoxy, (C_6-C_{18}) aryl and (C_7-C_{25}) alkylaryl; and j is selected from the 4, 5 and 6;

i is selected from 0, 1 and 2; h is selected from 1, 2 and 3; and i+h=3;



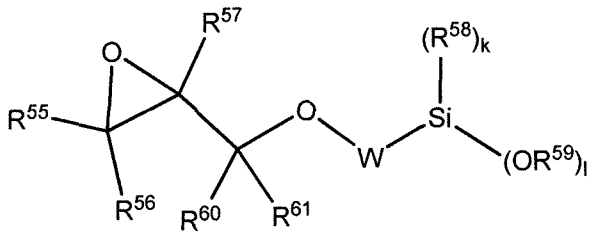
Formula 12



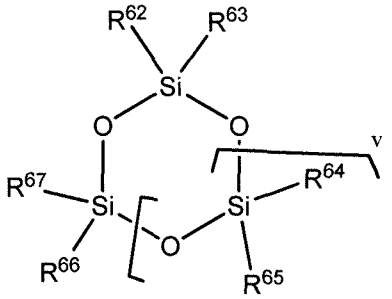
Formula 13,

wherein R^{44}, R^{45}, R^{46}, R^{47}, R^{48}, R^{49}, R^{51}, R^{52}, R^{53} and R^{54} are each independently selected from hydrogen, (C_1-C_{16}) alkyl, (C_6-C_{16}) aryl and (C_7-C_{16}) alkylaryl; and

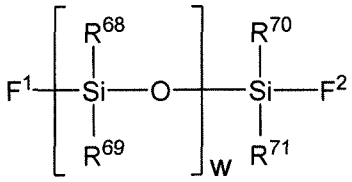
R^{50} is at least divalent and is selected from (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and (C_1-C_{18}) alkyl, wherein each group is optionally substituted with one or more groups selected from di(C_1-C_7 hydrocarbyl)amino, bis(tri(C_1-C_{12} alkyl)silyl)amino, tris(C_1-C_7 hydrocarbyl)silyl, (C_7-C_{18}) alkylaryl and (C_6-C_{18}) aryl;



Formula 14



Formula 15,



Formula 16

wherein R^{55}, R^{56}, R^{57}, R^{58}, R^{60}, R^{61}, R^{62}, R^{63}, R^{64}, R^{65}, R^{66}, R^{67}, R^{68}, R^{69}, R^{70} and R^{71} are each independently selected from hydrogen, (C_1-C_{16}) alkyl, (C_6-C_{16}) aryl and (C_7-C_{16}) alkylaryl;

R^{59} is selected from (C_1-C_4) alkyl, (C_6-C_{18}) aryl and (C_7-C_{18}) alkylaryl;

W is at least divalent and is selected from (C_6-C_{18}) aryl, (C_7-C_{18}) alkylaryl and (C_1-C_{18}) alkyl, wherein each group is optionally substituted with one or more groups selected from di(C_1-C_7 hydrocarbyl)amino, bis(tri(C_1-C_{12} alkyl)silyl)amino, tris(C_1-C_7 hydrocarbyl)silyl, (C_7-C_{18}) alkylaryl and (C_6-C_{18}) aryl;

k is selected from 0, 1 and 2; l is selected from 1, 2 and 3; k+l=3; and v is selected from 1 to 20; and

F^1 and F^2 are independently selected from hydrogen, hydroxy, chlorine, bromine, iodine, $-SiR^{52}R^{53}R^{54}$, wherein R^{52}, R^{53}, R^{54} are the same or different and are as defined for Formulas 12 and 13, vinyl, (C_6-C_{16}) aryl, (C_7-C_{16}) alkylaryl and (C_1-C_{16}) alkyl, wherein each hydrocarbyl group is optionally substituted with one or more groups selected from hydroxyl, di(C_1-C_7 hydrocarbyl)amino, bis(tri(C_1-C_{12} alkyl)silyl)amino and an epoxy group.

10. A polymer obtainable by method as defined in claims 8 or 9.

11. A polymer composition comprising the polymer as defined in claim 10 and one or more further components selected from (i) components which are added to or formed as a result of the polymerization process used for making said polymer and (ii) components which remain after solvent removal from the polymerization process, and optionally comprising one or more components selected from extender oils, stabilizers and further polymers and optionally

comprising one or more fillers, in particular selected from carbon black, carbon nanotubes, graphite, graphene, silica, carbon-silica dual-phase filler, clays calcium carbonate, magnesium carbonate, lignin, glass, particle-based fillers, and starch-based fillers.

12. The polymer composition as defined in claim 11, further comprising one or more vulcanizing agents.

13. A vulcanized polymer composition which is obtained by vulcanizing the polymer composition as defined in claim 12.

14. A method of making a vulcanized polymer composition, comprising the step of vulcanizing the polymer composition as defined in claim 13.

15. An article comprising at least one component formed from the vulcanized polymer composition as defined in claim 13.