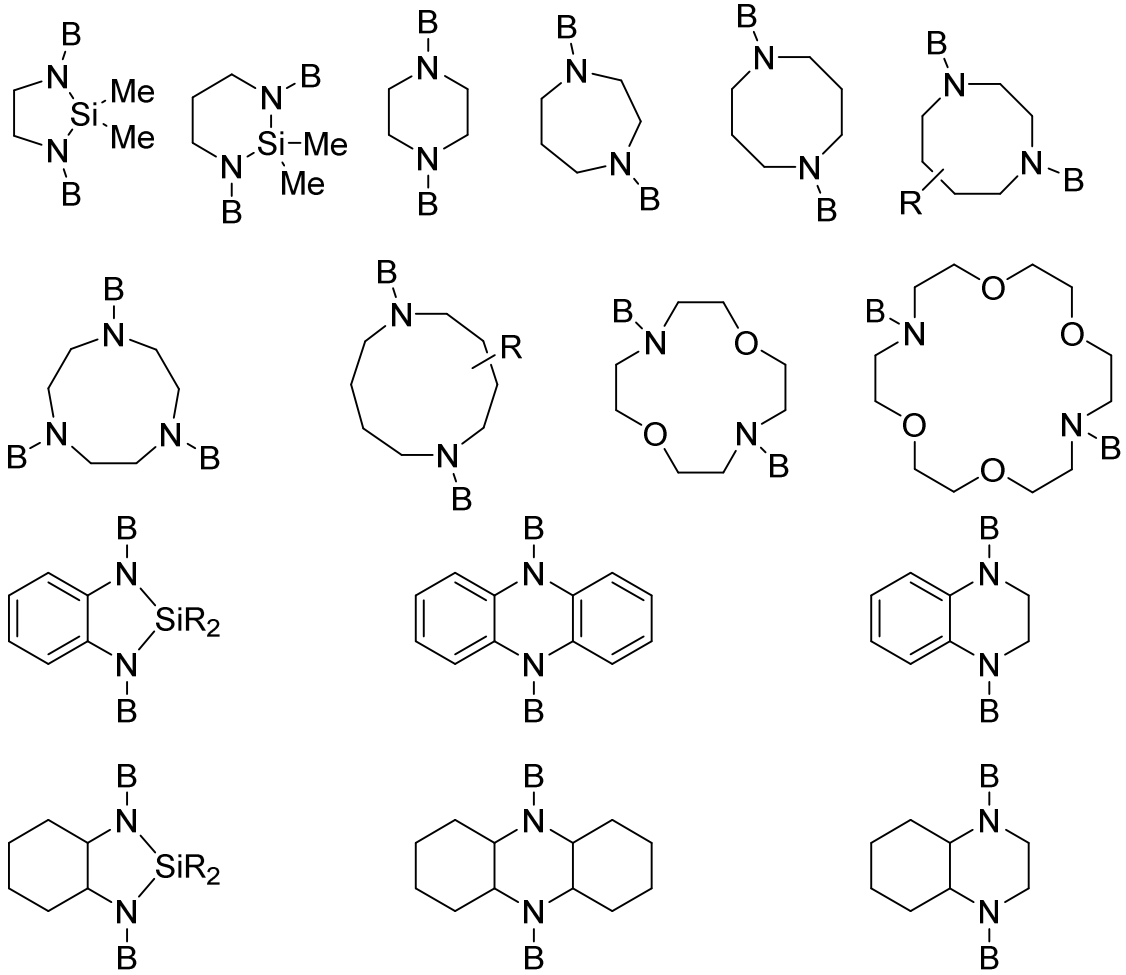
CLAIMS

1. A multivinylaminosilane which is a compound selected from



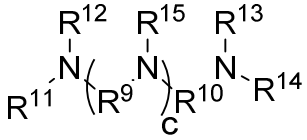
wherein

each B is independently selected from a group -Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl, and

R is a C_1-C_6 alkyl group;

and

from the following Formulas 1-1 and 1-3 to 1-5:



(Formula 1-1)

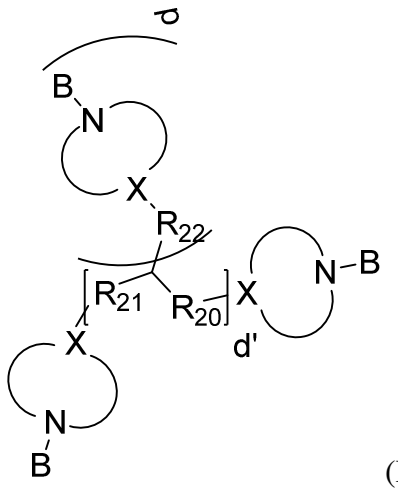
wherein

each of R^{11}, R^{12}, R^{13}, R^{14} and R^{15} is independently selected from C_1-C_{18} alkyl, C_6-C_{18} aryl, optionally C_1-C_4 alkyl-substituted C_3-C_{12} heteroaryl, C_7-C_{18} aralkyl, -Si(R^6)(R^7)(R^8),

wherein each of R^6, R^7 and R^8 is independently selected from methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, and -Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, ethyl, propyl, butyl, hexyl, octyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl, and at least two of R^{11}, R^{12}, R^{13}, R^{14} and R^{15} are -Si(R^1)(R^2)(R^3),

each of R^9 and R^{10} is independently selected from ethylene (-C_2H_4-), propylene (-C_3H_6-) and butylene (-C_4H_8-), phenylene and -$(CH_2)_{a'}$-C_6H_5-$(CH_2)_{b'}$-, wherein each of a' and b' is an integer independently selected from 0 and 1, and

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



(Formula 1-3)

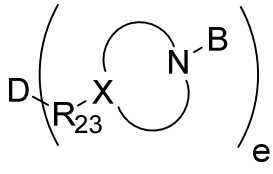
wherein

each B is independently selected from a group -Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl,

each of R^{20}, R^{21} and R^{22} is independently selected from a single bond and a C_1-C_{10} alkylene group,

d is an integer selected from 0, 1 and 2, and d' is an integer selected from 0 and 1, wherein d is 0 when d' is 0,

each group –N<>X- is independently selected from a 5- to 10-membered heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom of the ring with a C_1-C_6 alkyl group, wherein each X is independently selected from -N-, -C= and –CH-, and heteroatomic groups other than the two groups N and X expressly shown in Formula 1-3 are selected from -N=, >NR^{16}, -O-, -S- and >Si$R^{17}R^{18}$, wherein R^{16} is selected from C_1-C_6 alkyl, group B as defined above, phenyl and benzyl, wherein each of R^{17} and R^{18} is independently selected from C_1-C_6 alkyl, phenyl and benzyl;



(Formula 1-4)

wherein

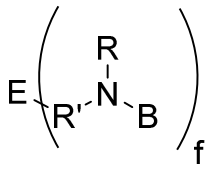
each B is independently selected from a group -Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl,

D is a 5- to 10-membered carbocyclic or heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom of the ring with a C_1-C_6 alkyl group, wherein heteroatomic groups are selected from –N=, >NR^{16}, -O-, -S- and >Si$R^{17}R^{18}$, wherein R^{16} is selected from C_1-C_6 alkyl, group B as defined above, phenyl and benzyl, and each of R^{17} and R^{18} is independently selected from C_1-C_6 alkyl and phenyl,

each group –N<>X- is independently selected from a 5- to 10-membered heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom of the ring with a C_1-C_6 alkyl group, wherein each X is independently selected from -N-, -C= and –CH-,

R^{23} is selected from a single bond and a C_1-C_{10} alkylene group, and

e is an integer selected from 2, 3 and 4;



(Formula 1-5)

wherein

each B is independently selected from a group -Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl,

E is a 6- to 10-membered cycloaliphatic or aromatic group,

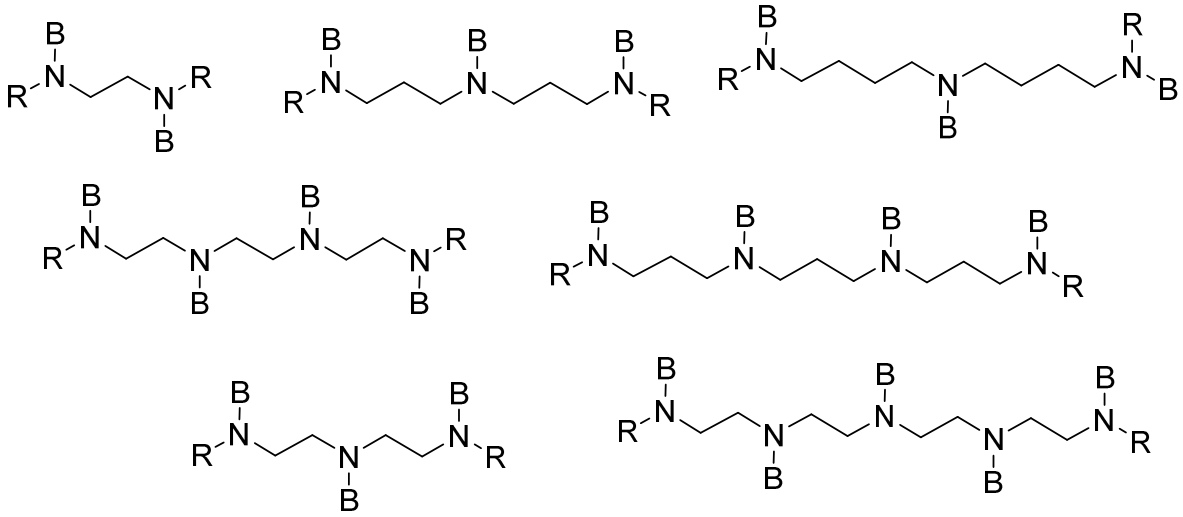
each R’ is independently selected from a single bond and C_1-C_2 alkylene,

each R is independently selected from group B as defined above, C_1-C_4 alkyl and benzyl, and

f is an integer selected from 2 and 3.

2. The multivinylaminosilane according to claim 1, wherein in Formula 1-1 each of R^{11}, R^{12}, R^{13}, R^{14} and R^{15} is independently selected from methyl and -Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, ethyl, propyl, butyl, hexyl, octyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl, each of R^9 and R^{10} is ethylene; and c is an integer selected from 0, 1, 2 and 3.

3. The multivinylaminosilane according to claim 1, which is selected from

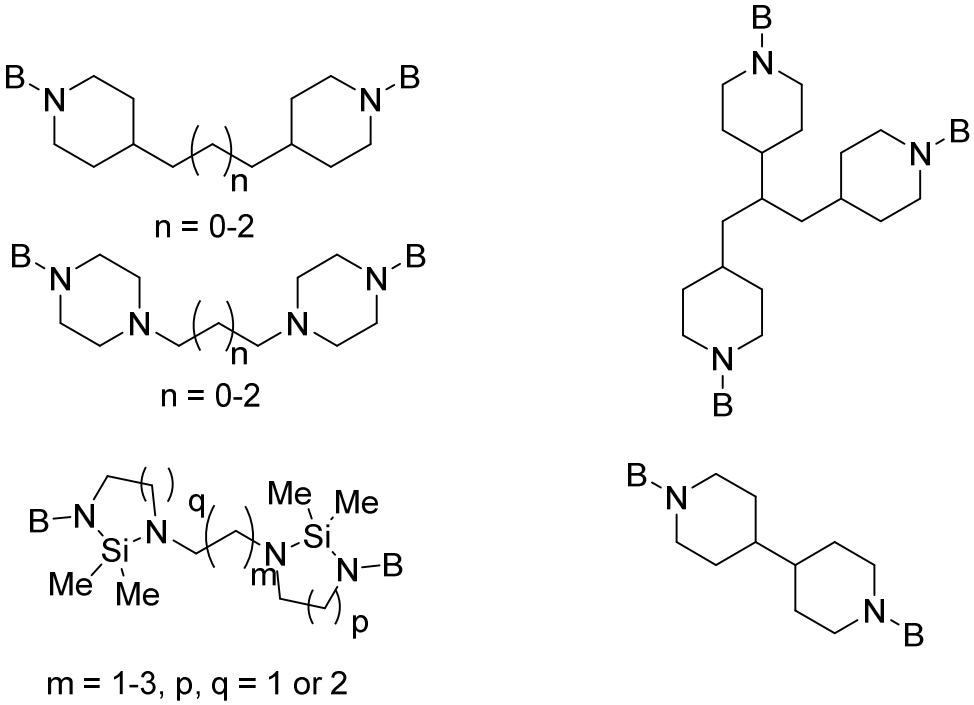


wherein

each B is independently selected from-Si(R^1)(R^2)(R^3), wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, ethyl, propyl, butyl, hexyl, octyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl, and

each R is independently selected from B as defined above, C_1-C_6 alkyl and benzyl;

and



wherein each B is as defined above.

4. The multivinylaminosilane according to claim 1, wherein in Formula 1-4 D is selected from cyclopentyl, cyclohexyl, phenyl and tetrahydrofuranyl; each group –N<>X- is selected from piperidinyl and piperazinyl; R^{23} is a single bond; and e is an integer selected from 2 and 3.

5. The multivinylaminosilane according to claim 1, wherein in Formula 1-5 E is selected from cyclohexyl and phenyl; R' is a single bond; R is selected from group B as defined in claim 1, C_1-C_4 alkyl and benzyl; and f is an integer selected from 2 and 3.

6. A process for preparing the multivinylaminosilane as defined in claim 1, said process comprising reacting an amine with a silane of the following Formula 2 in the presence of a base:

$$X\text{-}Si(R^1)(R^2)(R^3) \qquad \text{(Formula 2)}$$

wherein

X is selected from Cl, Br, I, trifluoromethanesulfonate (OTf) and tosylate (OTos),

R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl; and

the amine is a compound having at least two groups independently selected from a primary amino group and a secondary amino group.

7. An initiator compound obtainable by reacting a multivinylaminosilane of the following Formula 1 with an organo-alkali metal compound

$$(A)\text{—}B_n \qquad \text{(Formula 1)}$$

wherein

A is an organic group having at least two amino groups,

each B is independently selected from a group $-Si(R^1)(R^2)(R^3)$, wherein R^1, R^2 and R^3 are each independently selected from vinyl, butadienyl, methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, with the proviso that at least one of R^1, R^2 and R^3 is selected from vinyl and butadienyl, wherein each group B is a substituent of an amino group of group A,

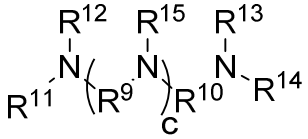
at least two of the amino groups of group A are each substituted with at least one group B,

n is an integer of at least 2, and

all amino groups in group A are tertiary amino groups.

8. The initiator compound according to claim 7, wherein the organo-alkali metal compound is selected from methyllithium, ethyllithium, n-butyllithium, s-butyllithium, t-octyllithium, isopropyllithium, phenyllithium, cyclohexyllithium, 2-butyllithium, 4-phenylbutyllithium, t-butyldimethylsilyloxypropyllithium, dialkylaminopropyllithium, N-morpholinopropyllithium, sodium biphenylide, sodium naphthalenide and potassium naphthalenide.

9. The initiator compound according to claim 7 or 8, wherein the multivinylaminosilane is a compound selected from the following Formulas 1-1 to 1-5:



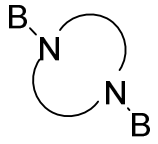
(Formula 1-1)

wherein

each of R^{11}, R^{12}, R^{13}, R^{14} and R^{15} is independently selected from group B as defined in claim 7, C_1-C_{18} alkyl, C_6-C_{18} aryl, optionally C_1-C_4 alkyl-substituted C_3-C_{12} heteroaryl, C_7-C_{18} aralkyl, and -Si(R^6)(R^7)(R^8), wherein each of R^6, R^7 and R^8 is independently selected from methyl, ethyl, propyl, butyl, hexyl, octyl, phenyl and benzyl, and wherein at least two of R^{11}, R^{12}, R^{13}, R^{14} and R^{15} are group B,

each of R^9 and R^{10} is independently selected from ethylene (-C_2H_4-), propylene (-C_3H_6-) and butylene (-C_4H_8-), phenylene and -$(CH_2)_{a'}$-C_6H_5-$(CH_2)_{b'}$-, wherein each of a' and b' is an integer independently selected from 0 and 1, and

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

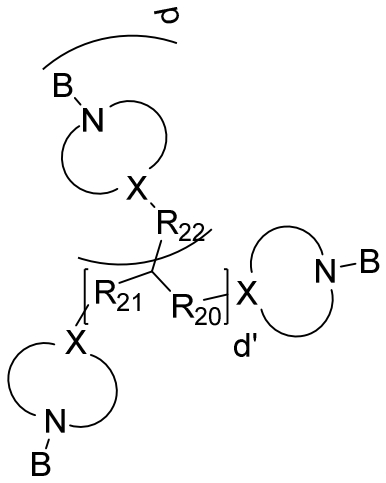


(Formula 1-2)

wherein

group B is as defined in claim 7,

the group -N<>N- is a 5- to 18-membered heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom of the ring with a C_1-C_6 alkyl group, wherein heteroatomic groups other than the two N atoms expressly shown in Formula 1-2 are selected from –N=, >NR^{16}, -O-, -S- and >Si$R^{17}R^{18}$, wherein R^{16} is selected from group B as defined in claim 7, C_1-C_6 alkyl, phenyl and benzyl, and each of R^{17} and R^{18} is independently selected from C_1-C_6 alkyl, phenyl and benzyl;



(Formula 1-3)

wherein

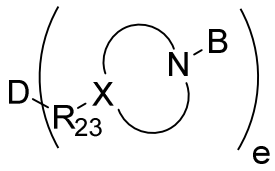
group B is as defined in claim 7,

each of R^{20}, R^{21} and R^{22} is independently selected from a single bond and a C_1-C_{10} alkylene group,

d is an integer selected from 0, 1 and 2, and d' is an integer selected from 0 and 1, wherein d is 0 when d' is 0,

each group –N<>X- is independently selected from a 5- to 10-membered heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom

of the ring with a C_1-C_6 alkyl group, wherein each X is independently selected from -N-, -C= and –CH-, and heteroatomic groups other than the two groups N and X expressly shown in Formula 1-3 are selected from -N=, >NR^{16}, -O-, -S- and >$SiR^{17}R^{18}$, wherein R^{16} is selected from C_1-C_6 alkyl, group B as defined in claim 7, phenyl and benzyl, and each of R^{17} and R^{18} is independently selected from C_1-C_6 alkyl, phenyl and benzyl;



(Formula 1-4)

wherein

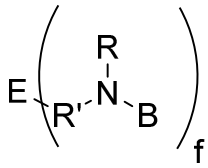
group B is as defined in claim 7,

D is a 5- to 10-membered carbocyclic or heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom of the ring with a C_1-C_6 alkyl group, wherein heteroatomic groups are selected from –N=, >NR^{16}, -O-, -S- and >$SiR^{17}R^{18}$, wherein R^{16} is selected from C_1-C_6 alkyl, group B as defined in claim 7, phenyl and benzyl, each of R^{17} and R^{18} is independently selected from C_1-C_6 alkyl and phenyl,

each group –N<>X- is independently selected from a 5- to 10-membered heterocyclic group which may be saturated or unsaturated and which may be substituted on any carbon atom of the ring with a C_1-C_6 alkyl group, wherein each X is independently selected from -N-, -C= and –CH-,

R^{23} is selected from a single bond and a C_1-C_{10} alkylene group, and

e is an integer selected from 2, 3 and 4;



(Formula 1-5)

wherein

group B is as defined in claim 7,

E is a 6- to 10-membered cycloaliphatic or aromatic group,

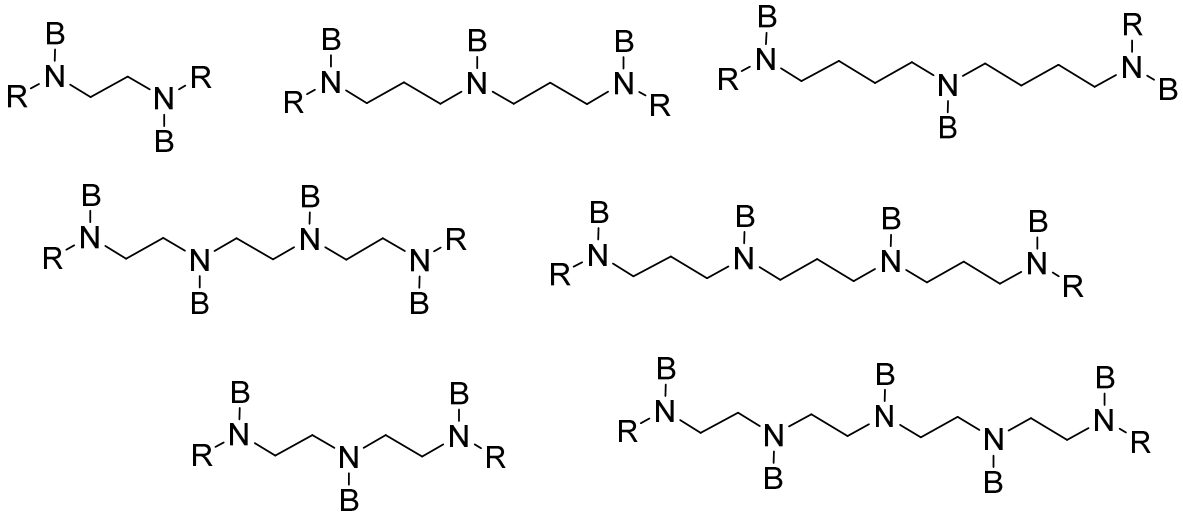
each R’ is independently selected from a single bond and C_1-C_2 alkylene,

each R is independently selected from group B as defined in claim 7, C_1-C_4 alkyl and benzyl, and

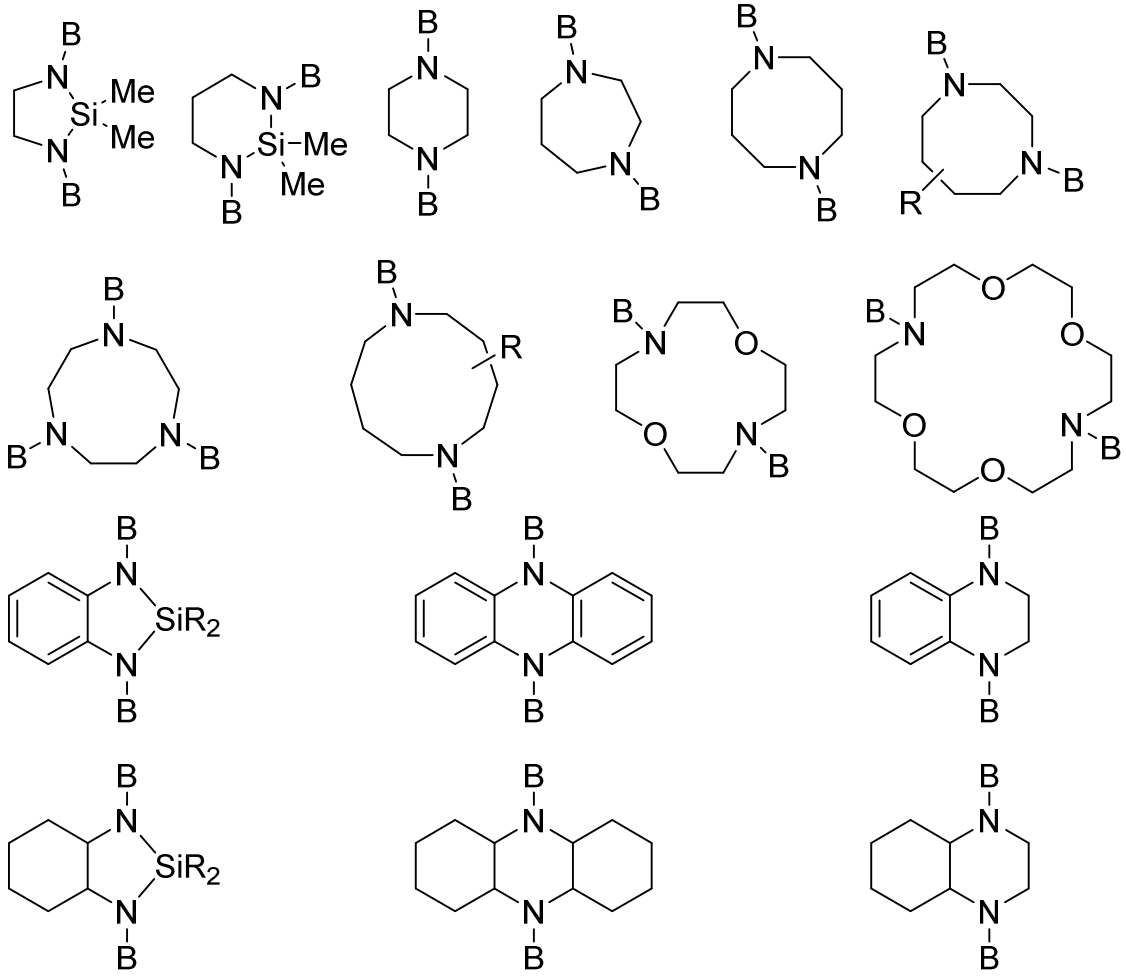
f is an integer selected from 2 and 3.

10. The initiator compound according to claim 9, wherein in Formula 1-1 each of R^{11}, R^{12}, R^{13}, R^{14} and R^{15} is independently selected from group B as defined in claim 7 and methyl, each of R^9 and R^{10} is ethylene, and c is an integer selected from 0, 1, 2 and 3.

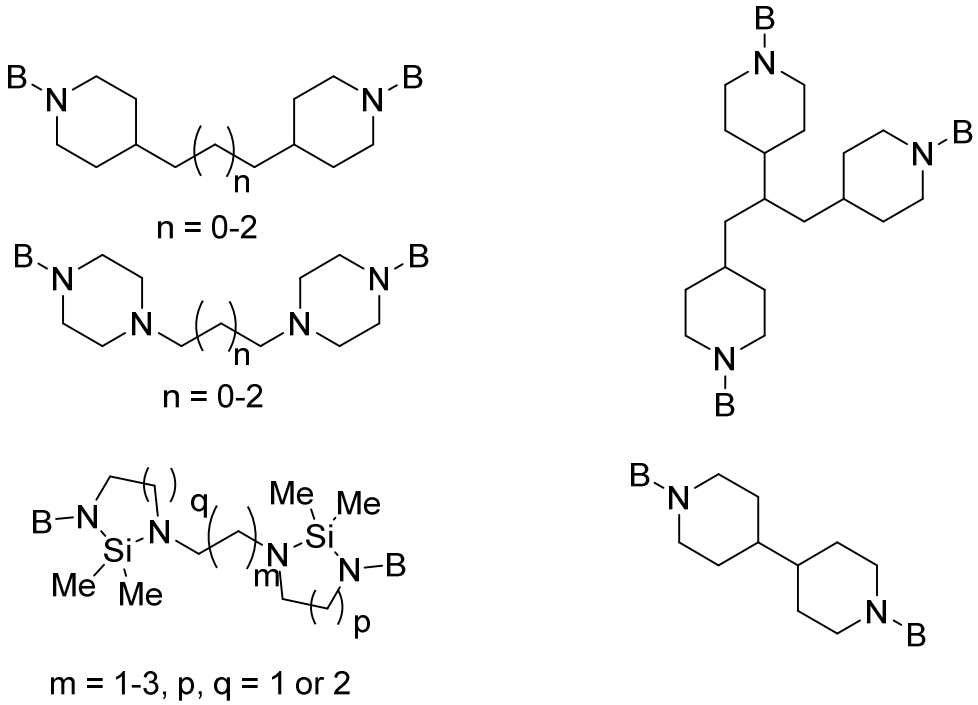
11. The initiator compound according to claim 9, wherein the multivinylaminosilane is selected from



wherein group B is as defined in claim 7 and R is independently selected from group B, C_1-C_6 alkyl and benzyl;



wherein R is a C_1-C_6 alkyl group and group B is as defined in claim 7; and



wherein B is as defined in claim 7.

12. The initiator compound according to claim 9, wherein in Formula 1-4 D is selected from cyclopentyl, cyclohexyl, phenyl and tetrahydrofuranyl; each group –N<>X- is selected from piperidinyl and piperazinyl; R^{23} is a single bond; and e is an integer selected from 2 and 3.

13. The initiator compound according to claim 9, wherein in Formula 1-5 E is selected from cyclohexyl and phenyl; R' is a single bond; R is selected from group B as defined in claim 7, C_1-C_4 alkyl and benzyl; and f is an integer selected from 2 and 3.

14. Use of the multivinylaminosilane of Formula 1 as defined in any one of claims 7 and 9 to 13 as a branching agent for introducing branching in an elastomeric conjugated diene polymer.

15. A process for preparing a branched elastomeric polymer, said process comprising:

polymerizing at least one conjugated diene and a multivinylaminosilane of Formula 1 as defined in any one of claims 7 and 9 to 13 in the presence of an initiator compound,

polymerizing at least one conjugated diene in the presence of an initiator compound according to any one of claims 7 to 13, or

reacting a living polymer, obtainable by anionically polymerizing at least one conjugated diene, with a multivinylaminosilane of Formula 1 as defined in any one of claims 7 and 9 to 13.

16. A branched elastomeric polymer obtainable by a process as defined in claim 15.

17. A non-vulcanized polymer composition comprising the branched elastomeric polymer as defined in claim 16 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, (ii) components which remain after solvent removal from the polymerization process, and (iii)

components which are added to the polymer after completion of the polymer manufacturing process.

18. The non-vulcanized polymer composition according to claim 17 which comprises one or more fillers.

19. The non-vulcanized polymer composition according to claim 17 or 18, which comprises one or more vulcanizing agents.

20. A vulcanized polymer composition which is obtained by vulcanizing the non-vulcanized polymer composition as defined in claim 19.

21. A process for preparing a vulcanized polymer composition, said process comprising vulcanizing the non-vulcanized polymer composition as defined in claim 19.

22. An article comprising at least one component formed from the vulcanized polymer composition as defined in claim 20, which article is selected from a tire, a tire tread, a tire side wall, a tire carcass, a belt, a gasket, a seal, a vibration damper, a footwear component, a golf ball and a hose.