CLAIMS

1. A copolymer of a 1,3-diene and of an olefin selected from the group consisting of an α-olefin having at least three carbon atoms, ethylene and mixtures thereof, which copolymer bears a functional group F^1 at one of its chain ends, the functional group F^1 being an alkoxysilyl or silanol function, and the copolymer is different from a copolymer of a 1,3-diene and a vinylaromatic monomer.

2. The copolymer according to Claim 1, in which the functional group F^1 is of formula (II-a) or formula (II-b):

$$Si(OR^1)_{3-f}(R^2)_f \qquad \text{(II-a)}$$

$$Si(OH)(R^2)_2 \qquad \text{(II-b)}$$

in which:
the R^1 symbols, which are identical or different, represent an alkyl,
the R^2 symbols, which are identical or different, represent a hydrogen atom, a hydrocarbon chain or a hydrocarbon chain substituted by a chemical function F^2,
f is an integer ranging from 0 to 2.

3. The copolymer according to Claim 2, in which the R^1 symbols represent an alkyl having at most 6 carbon atoms.

4. The copolymer according to Claim 2, in which the R^2 symbols represent an alkyl having at most 6 carbon atoms or an alkanediyl chain having at most 6 carbon atoms and substituted by a chemical function F^2.

5. The copolymer according to Claim 2, in which the alkyl represented by the R^1 and R^2 symbols is a methyl or an ethyl.

6. The copolymer according to Claim 2, in which the chemical function F^2 is a primary, secondary or tertiary amine function or a thiol function, the primary or secondary amine or thiol function being protected by a protecting group or being unprotected.

7. The copolymer according to Claim 6, in which the protecting group is a trimethylsilyl or tert-butyldimethylsilyl.

8. The copolymer according to Claim 1, in which the functional group F^1 is dimethoxymethylsilyl, dimethoxyethylsilyl, diethoxymethysilyl, diethoxyethysilyl, 3-(N,N-dimethylamino)propyldimethoxysilyl, 3-(N,N-dimethylamino)propyldiethoxysilyl, 3-aminopropyldimethoxysilyl, 3-aminopropyldiethoxysilyl, 3-thiopropyldimethoxysilyl, 3-thiopropyldiethoxysilyl, methoxydimethylsilyl, methoxydiethylsilyl, ethoxydimethysilyl,

ethoxydiethysilyl, 3-(N,N-dimethylamino)propylmethoxymethylsilyl, 3-(N,N-dimethylamino)propylmethoxyethylsilyl, 3-(N,N-dimethylamino)propylethoxymethylsilyl, 3-(N,N-dimethylamino)propylethoxyethylsilyl, 3-aminopropylmethoxymethylsilyl, 3-aminopropylmethoxyethylsilyl, 3-aminopropylethoxymethylsilyl, 3-aminopropylethoxyethylsilyl, 3-thiopropylmethoxymethylsilyl, 3-thiopropylethoxymethylsilyl, 3-thiopropylmethoxyethylsilyl, or 3-thiopropylethoxyethylsilyl, or the functional group F^1 is the protected form of the amine or thiol function of 3-aminopropyldimethoxysilyl, 3-aminopropyldiethoxysilyl, 3-thiopropyldimethoxysilyl, 3-thiopropyldiethoxysilyl, 3-aminopropylmethoxymethylsilyl, 3-aminopropylmethoxyethylsilyl, 3-aminopropylethoxymethylsilyl, 3-aminopropylethoxyethylsilyl, 3-thiopropylmethoxymethylsilyl, 3-thiopropylethoxymethylsilyl, 3-thiopropylmethoxyethylsilyl, or 3-thiopropylethoxyethylsilyl.

9. The copolymer according to Claim 1, in which the functional group F^1 is dimethylsilanol, diethylsilanol, 3-(N,N-dimethylamino)propylmethylsilanol, 3-(N,N-dimethylamino)propylethylsilanol, 3-aminopropylmethylsilanol, 3-aminopropylethylsilanol, 3-thiopropylethylsilanol, or 3-thiopropylmethylsilanol, or the functional group F^1 is the protected form of the amine or thiol function of 3-aminopropylmethylsilanol, 3-aminopropylethylsilanol, 3-thiopropylethylsilanol, or 3-thiopropylmethylsilanol.

10. The copolymer according to Claim 2, in which the functional group F^1 is of formula (II-a) in which f is equal to 1.

11. The copolymer according to Claim 1, in which the 1,3-diene is 1,3-butadiene, isoprene or a mixture thereof.

12. The copolymer according to Claim 1, in which the olefin is ethylene or a mixture of ethylene and an α-olefin having at least three carbon atoms.

13. The copolymer according to Claim 1, in which the 1,3-diene units represent at least 35 mol % of the monomer units of the copolymer.

14. The copolymer according to Claim 1, in which the 1,3-diene units represent less than 35 mol % of the monomer units of the copolymer.

15. The copolymer according to Claim 1, in which the ethylene units represent more than 50 mol % of the monomer units of the copolymer.

16. The copolymer according to Claim 1, in which the 1,3-diene units contain more than 80 mol % of moieties resulting from a trans-1,4 insertion of 1,3-diene into the copolymer chain.

17. The copolymer according to Claim 1, which copolymer is a copolymer of 1,3-butadiene and ethylene or a terpolymer of 1,3-butadiene, ethylene and an α-olefin having at least three carbon atoms.

18. The copolymer according to Claim 17, in which the α-olefin having at least three carbon atoms is an aliphatic α-olefin having 3 to 18 carbon atoms.

19. The copolymer according to Claim 17, in which the α-olefin is styrene, a styrene substituted with one or more alkyl groups at the para, meta or ortho position or mixtures thereof.

20. The copolymer according to Claim 1, in which the functional group F^1 is attached directly via a covalent bond to the end unit of the copolymer.

21. A process for preparing a copolymer defined according to Claim 1,
which process comprises the following steps:

a) the copolymerization of a monomer mixture containing the 1,3-diene and the olefin in the presence of a catalytic system comprising an organomagnesium compound and a metallocene catalyst comprising the moiety of formula (I-1) or (I-2):

$$P(Cp^1)(Cp^2)Met \quad (I\text{-}1)$$

$$(Cp^1)(Cp^2)Met \quad (I\text{-}2)$$

Met being a group 4 metal atom or a rare-earth metal atom,

P being a group that bridges the two groups Cp^1 and Cp^2, and that comprises at least one silicon or carbon atom,

Cp^1 and Cp^2, which are identical or different, being selected from the group consisting of cyclopentadienyl groups, indenyl groups and fluorenyl groups, wherein the groups are substituted or unsubstituted,

b) the reaction of a functionalizing agent, a compound of formula (II), with the copolymer obtained in step a),

$$Si(Fc^1)_{4-g}(Rc^2)_g \qquad (II)$$

the Fc^1 symbols, which are identical or different, representing an alkoxy group or a halogen,

the Rc^2 symbols, which are identical or different, representing a hydrogen atom, a hydrocarbon chain or a hydrocarbon chain substituted by a chemical function Fc^2,

g being an integer ranging from 0 to 2, and

c) optionally a hydrolysis reaction.

22. The process according to Claim 21, in which the metallocene is of formula (I-1a) or (I-2a):

$$\{P(Cp^1)(Cp^2)Met\text{-}G\}_b \qquad (I\text{-}1a)$$

$$(Cp^1)(Cp^2)MetG \qquad (I\text{-}2a)$$

in which

Met represents a rare-earth metal atom,
the G symbol denoting a halogen X selected from the group consisting of chlorine, fluorine, bromine and iodine, or a group comprising the borohydride moiety BH_4,
b is equal to 1 or 2.

23. The process according to Claim 22, in which the G symbol denotes chlorine or the group of formula (III):

$$(BH_4)_{(1+c)}\text{-}L_c\text{-}N_x \qquad (III)$$

in which

L represents an alkali metal selected from the group consisting of lithium, sodium and potassium,

N represents a molecule of an ether,

x is equal to or greater than 0,

c, an integer, is equal to or greater than 0.

24. The process according to Claim 21, in which the Met symbol represents a neodymium atom.

25. The process according to Claim 21, in which P denotes the $SiMe_2$ group.

26. The process according to Claim 21, in which Cp^1 represents a substituted or unsubstituted cyclopentadienyl group and Cp^2 represents a substituted or unsubstituted fluorenyl group.

27. The process according to Claim 21, in which the metallocene catalyst is of formula (III-3a), (III-3b) or (III-3c):

$[Me_2Si(C_5H_4)(C_{13}H_8)NdCl]$ (III-3a)

$[Me_2Si(C_5H_4)(C_{13}H_8)Nd(BH_4)_2Li(THF)]$ (III-3b)

$[Me_2Si(C_5H_4)(C_{13}H_8)Nd(BH_4)(THF)]$ (III-3c).

28. The process according to Claim 21, in which the organomagnesium compound is a dialkylmagnesium compound or an alkylmagnesium halide.

29. The process according to Claim 21, in which at least one of the Fc^1 symbols represents an alkoxy group.

30. The process according to Claim 21, in which at least two of the Fc^1 symbols represent an alkoxy group.

31. The process according to Claim 21 in which at least three of the Fc^1 symbols represent an alkoxy group.

32. The process according to Claim 21, in which the alkoxy group is a methoxy or an ethoxy.

33. The process according to Claim 21, in which the Rc^2 symbols represent an alkyl having at most 6 carbon atoms or an alkanediyl chain having at most 6 carbon atoms and substituted by a chemical function Fc^2.

34. The process according to Claim 21, in which the chemical function Fc^2 is a primary amine function protected by a protecting group, a secondary amine function protected by a protecting group, a tertiary amine function, or a thiol function protected by a protecting group.

35. The process according to Claim 34, in which the protecting group is a trimethylsilyl or tert-butyldimethylsilyl.

36. The process according to Claim 21, in which the functionalizing agent is dimethoxydimethylsilane, diethoxydimethylsilane, dimethoxydiethylsilane, diethoxydiethylsilane, (N,N-dimethyl-3-aminopropyl)methyldimethoxysilane, (N,N-dimethyl-3-aminopropyl)methyldiethoxysilane, (N,N-dimethyl-3-aminopropyl)ethyldimethoxysilane, (N,N-dimethyl-3-aminopropyl)ethyldiethoxysilane, 3-methoxy-3,8,8,9,9-pentamethyl-2-oxa-7-thia-3,8-disiladecane, trimethoxymethylsilane, triethoxymethylsilane, trimethoxyethylsilane, triethoxyethylsilane, (N,N-dimethyl-aminopropyl)trimethoxysilane, (N,N-dimethylaminopropyl)triethoxysilane, (N-(3-trimethoxysilyl)propyl)-N-(trimethylsilyl)silanamine, (N-(3-triethoxysilyl)propyl)-N-(trimethylsilyl)silanamine or 3,3-dimethoxy-8,8,9,9-tetramethyl-2-oxa-7-thia-3,8-disiladecane.

37. The copolymer according to claim 18, in which the α-olefin having at least three carbon atoms is propene, 1-butene, 1-hexene, 1-octene, 1-hexadecene or mixtures thereof.