Claims

[Claim 1] A method for producing a modified conjugated diene polymer obtained by modifying a conjugated diene polymer that is obtained by polymerizing a conjugated diene compound or polymerizing a conjugated diene compound and an aromatic vinyl compound, the method comprising a first modification step wherein an unsaturated binding site at least either in the skeleton or at the side chain of the conjugated diene polymer is reacted with a first compound having a group 4 or 13 element of the periodic table.

[Claim 2] The method for producing a modified conjugated diene polymer according to claim 1, wherein the first compound is a compound having titanium, zirconium, boron, or aluminum.

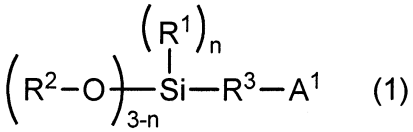
[Claim 3] The method for producing a modified conjugated diene polymer according to claim 1 or 2, wherein the first compound is a compound having a boron-hydrogen bond.

[Claim 4] The method for producing a modified conjugated diene polymer according to any one of claims 1 to 3, which further comprises a second modification step wherein the conjugated diene polymer after modification with the first compound is reacted with a second compound having a functional group that interacts with silica.

[Claim 5] The method for producing a modified conjugated diene polymer according to any one of claims 1 to 4, wherein the conjugated diene polymer is a polymer obtained by polymerization in the presence of an alkali metal compound or an alkaline earth metal compound and which further comprises, before the first modification step, an end modification step wherein an active end of the conjugated diene polymer is reacted with a third compound having a functional group that interacts with silica.

[Claim 6] The method for producing a modified conjugated diene polymer according to claim 5, wherein the third compound is at least one selected from the group consisting of:
(I) a compound (a-1) represented by the following formula (1),
(II) a compound (a-2) having, in the molecule, at least one functional group (x1) selected from the group consisting of a cyclic ether group and a (thio)carbonyl group and a group (x2) different from the functional group (x1), which has at least one atom selected from the group consisting of a nitrogen atom, a phosphorus atom, an oxygen atom, and a sulfur atom and does not have an active hydrogen, and
(III) a compound (a-3) having two or more iso(thio)cyanate groups in the molecule:

[Chem 1]



(1)

wherein A^1 is a monovalent functional group which has at least one atom selected from the group consisting of a nitrogen atom, a phosphorus atom, and a sulfur atom, does not have an active hydrogen, and binds to R^3 with the nitrogen atom, the phosphorus atom, or the sulfur atom; R^1 and R^2 are each a hydrocarbyl group, R^3 is a hydrocarbylene group, and n is an integer of 0 to 2, provided that, in the case where R^1 and R^2 exist in plurality, a plurality of the groups R^1 and R^2 may be each the same or different.

[Claim 7] A modified conjugated diene polymer, which is obtained by polymerizing a conjugated diene compound or polymerizing a conjugated diene compound and an aromatic vinyl compound to obtain a conjugated diene polymer and subsequently reacting an unsaturated binding site at least either in the skeleton or at the side chain of the conjugated diene polymer with a first compound having a group 4 or 13 element of the periodic table.

[Claim 8] A polymer composition comprising the modified conjugated diene polymer obtained by the production method according to any one of claims 1 to 6 or the modified conjugated diene polymer according to claim 7, silica, and a crosslinking agent.

[Claim 9] A crosslinked polymer obtained by cross-linking the polymer composition according to claim 8.

[Claim 10] A tire using the crosslinked polymer according to claim 9 at least as a material of a tread or a side wall.

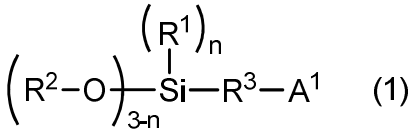
Claims

[Claim 1] A method for producing a modified conjugated diene polymer obtained by modifying a conjugated diene polymer that is obtained by polymerizing a conjugated diene compound or polymerizing a conjugated diene compound and an aromatic vinyl compound, the method comprising a first modification step wherein an unsaturated binding site at least either in the skeleton or at the side chain of the conjugated diene polymer is reacted with a first compound having a group 4 or 13 element of the periodic table, and a second modification step wherein the conjugated diene polymer after modification with the first compound is reacted with a second compound having a functional group that interacts with silica, wherein the conjugated diene polymer is a polymer obtained by polymerization in the presence of an alkali metal compound or an alkaline earth metal compound and which further comprises, before the first modification step, an end modification step wherein an active end of the conjugated diene polymer is reacted with a third compound having a functional group that interacts with silica.

[Claim 2] The method for producing a modified conjugated diene polymer according to claim 1, wherein the first compound is a compound having titanium, zirconium, boron, or aluminum.

[Claim 3] The method for producing a modified conjugated diene polymer according to claim 1 or 2, wherein the first compound is a compound having a boron-hydrogen bond.

[Claim 4] The method for producing a modified conjugated diene polymer according to any one of claims 1 to 3, wherein the third compound is at least one selected from the group consisting of:
(I) a compound (a-1) represented by the following formula (1),
(II) a compound (a-2) having, in the molecule, at least one functional group (x1) selected from the group consisting of a cyclic ether group and a (thio)carbonyl group and a group (x2) different from the functional group (x1), which has at least one atom selected from the group consisting of a nitrogen atom, a phosphorus atom, an oxygen atom, and a sulfur atom and does not have an active hydrogen, and
(III) a compound (a-3) having two or more iso(thio)cyanate groups in the molecule:
[Chem 1]



(1)

wherein A^1 is a monovalent functional group which has at least one atom selected from the group consisting of a nitrogen atom, a phosphorus atom, and a sulfur atom, does not have an active hydrogen, and binds to R^3 with the nitrogen atom, the phosphorus atom, or the sulfur atom; R^1 and R^2 are each a hydrocarbyl group, R^3 is a hydrocarbylene group, and n is an integer of 0 to 2, provided that, in the case where R^1 and R^2 exist in plurality, a plurality of the groups R^1 and R^2 may be each the same or different.

[Claim 5] A method for producing a polymer composition comprising mixing the modified conjugated diene polymer obtained by the production method according to any one of claims 1 to 4, silica, and a crosslinking agent.

[Claim 6] A method for producing a crosslinked polymer comprising cross-linking the polymer composition obtained by the production method according to claim 5.

[Claim 7] A method for producing a tire by using the crosslinked polymer obtained by the production method according to claim 6 at least as a material of a tread or a side wall.