SUMMARY

PROBLEM TO BE SOLVED BY THE DISCLOSURE

[0005] Although fuel efficiency can be improved by using the conjugated diene-based polymer prepared by the technique disclosed in Patent Document 1 and compounding a filler such as silica, processability is insufficient, leading to a demand for an improvement in processability.

[0006] The present disclosure has been made in consideration of the above problem. An object of the present disclosure is to provide a conjugated diene-based polymer which has high fuel efficiency and can provide a cross-linked rubber having high processability. Another object of the present disclosure is to provide a conjugated diene-based polymer composition prepared from such a conjugated diene-based polymer, a cross-linked rubber, and a tire, and provide a method of preparing such a conjugated diene-based polymer.

MEANS FOR SOLVING PROBLEMS

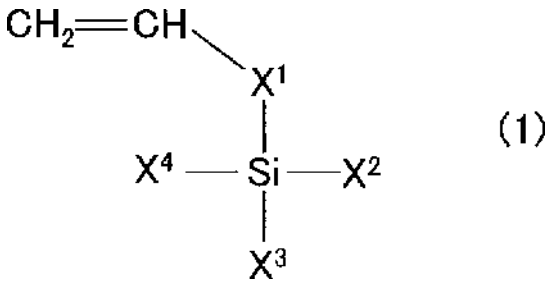
[0007] The present inventors, who have conducted extensive research to achieve the above object, have found that the above objects can be achieved by controlling the shrinkage factor of high molecular weight molecules in a conjugated diene-based polymer, the degree of adsorption thereof onto silica, and the degree of adsorption of medium molecular weight molecules onto silica within specific ranges, and thus have completed the present disclosure.

[0008] Specifically, in an example, the present disclosure provides a conjugated diene-based polymer comprising at least conjugated diene monomer units, and having a shrinkage factor of high molecular weight molecules of 0.4 to 0.8, a degree of adsorption of high molecular weight molecules onto silica of 75% or less, and a degree of adsorption of

molecules onto silica of 40 to 100%.

[0008a] In an aspect, there is provided a conjugated diene-based polymer comprising at least conjugated diene monomer units, and having a shrinkage factor of high molecular weight molecules of 0.4 to 0.8, a degree of adsorption of high molecular weight molecules onto silica of 75% or less, and a degree of adsorption of medium molecular weight molecules onto silica of 40 to 100%, wherein

the conjugated diene-based polymer contains units of a vinyl compound having a functional group interactive with silica, and the vinyl compound having a functional group interactive with silica is a compound represented by General Formula (1)



(1)

where X^1 represents a chemical single bod or hydrocarbylene group, and X^2, X^3, and X^4 each independently represent a substituted amino group, a hydrocarbyloxy group or an optionally substituted hydrocarbyl group.

[0009] In the conjugated diene-based polymer according to the present disclosure, the shrinkage factor of medium molecular weight molecules is preferably 0.8 to 1.2.

In the conjugated diene-based polymer according to the present disclosure, the degree of adsorption of high molecular weight molecules onto silica is preferably 10 to 70%.

The conjugated diene-based polymer according to the present disclosure preferably has two or more peak values of molecular weight.

The conjugated diene-based polymer according to the present disclosure is preferably a copolymer containing the conjugated diene monomer units and aromatic vinyl monomer units.

In the conjugated diene-based polymer according to the present disclosure, the molecular weight Mp_{LOW} of low molecular weight molecules is preferably in the range of 100,000 to 190,000.

[0010] In another aspect, the present disclosure provides a conjugated diene-based polymer composition comprising the conjugated diene-based polymer as defined above and a filler.

In another aspect, the present disclosure also provides a cross-linked rubber prepared by cross-linking the conjugated diene-based polymer composition as defined above. In another aspect, there is provided a tire comprising the cross-linked rubber as defined above.

[0011] Furthermore, in another example, the present disclosure provides a method of preparing a conjugated diene-based polymer, comprising:

a first step of polymerizing a monomer containing a conjugated diene compound in an inert solvent in the presence of a polymerization initiator to prepare a solution containing polymer chains having an active terminal;

a second step of partially converting the polymer chains having an active terminal prepared in the first step into coupled polymer chains by a coupling reaction to prepare a solution containing the polymer chains having an active terminal and the coupled polymer chains; and

a third step of further polymerizing the polymer chains having an

active terminal with a monomer containing the conjugated diene compound after the coupling reaction is performed in the second step,

wherein in at least one of the first step and the third step, the monomer used in the polymerization is a monomer containing a vinyl compound having a functional group interactive with silica in addition to the conjugated diene compound.

[0011a] In another aspect, there is provided a method of preparing a conjugated diene-based polymer, comprising:

a first step of polymerizing a monomer containing a conjugated diene compound in an inert solvent in the presence of a polymerization initiator to prepare a solution containing polymer chains having an active terminal;

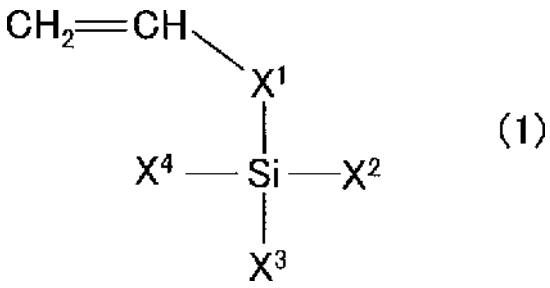
a second step of partially converting the polymer chains having an active terminal prepared in the first step into coupled polymer chains by a coupling reaction to prepare a solution containing the polymer chains having an active terminal and the coupled polymer chains; and

a third step of further polymerizing the polymer chains having an active terminal with a monomer containing the conjugated diene compound after the coupling reaction is performed in the second step,

wherein in at least one of the first step and the third step, the monomer used in the polymerization is a monomer containing a vinyl compound having a functional group interactive with silica in addition to the conjugated diene compound,

the ratio of the monomer containing a vinyl compound having a functional group interactive with silica is 0.001 to 10.000% by weight in 100% by weight of the total monomer amount, and

the vinyl compound having a functional group interactive with silica is a compound represented by General Formula (1)



(1)

where X^1 represents a chemical single bond or a hydrocarbylene group, and X^2, X^3, and X^4 each independently represent a substituted amino group, a hydrocarbyloxy group, or an optionally substituted hydrocarbyl group.

[0012] In the method of preparing the conjugated diene-based polymer according to the present disclosure, preferably, the polymerization initiator is further added at any one of timings of during the polymerization in the first step, at the start of the polymerization in the third step, and during the polymerization in the third step.

EFFECTS OF THE DISCLOSURE

[0013] The present disclosure can provide a conjugated diene-based polymer which has high processability and can provide a cross-linked rubber having high fuel efficiency. The present disclosure can also provide a conjugated diene-based polymer composition prepared from such a conjugated diene-based polymer, a cross-linked rubber, and a tire, as well as a method of preparing such a conjugated diene-based polymer.

BRIEF DESCRIPTION OF DRAWINGS

[0014] FIGs. 1(A) and 1(B) are graphs showing one exemplary GPC chart when the conjugated diene-based polymer according to the present invention has a unimodal distribution.

FIGs. 2(A) and 2(B) are graphs showing one exemplary GPC chart when the conjugated diene-based polymer according to the present invention has a bimodal distribution.

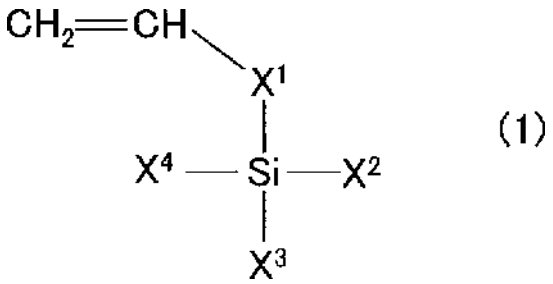
FIGs. 3(A) and 3(B) are graphs showing one exemplary GPC chart when

the conjugated diene-based polymer according to the present invention has a bimodal distribution.

CLAIMS

1. A conjugated diene-based polymer comprising at least conjugated diene monomer units, and having a shrinkage factor of high molecular weight molecules of 0.4 to 0.8, a degree of adsorption of high molecular weight molecules onto silica of 75% or less, and a degree of adsorption of medium molecular weight molecules onto silica of 40 to 100%, wherein

the conjugated diene-based polymer contains units of a vinyl compound having a functional group interactive with silica, and the vinyl compound having a functional group interactive with silica is a compound represented by General Formula (1)



(1)

where X^1 represents a chemical single bod or hydrocarbylene group, and X^2, X^3, and X^4 each independently represent a substituted amino group, a hydrocarbyloxy group or an optionally substituted hydrocarbyl group.

2. The conjugated diene-based polymer according to claim 1, wherein the shrinkage factor of medium molecular weight molecules is 0.8 to 1.2.

3. The conjugated diene-based polymer according to claim 1 or 2, wherein the degree of adsorption of high molecular weight molecules onto silica is 10 to 70%.

4. The conjugated diene-based polymer according to any one of claims 1 to 3, wherein the conjugated diene-based polymer has two or more peak values of molecular weight.

5. The conjugated diene-based polymer according to any one of claims 1 to 4, wherein the conjugated diene-based polymer is a copolymer containing the conjugated diene monomer units and aromatic vinyl monomer units.

6. The conjugated diene-based polymer according to any one of claim 1 to 5, wherein the molecular weight $Mp_{_LOW}$ of low molecular weight molecules is in the range of 70,000 to 190,000.

7. A conjugated diene-based polymer composition comprising the conjugated diene-based polymer according to any one of claims 1 to 6, and a filler.

8. A cross-linked rubber prepared by cross-linking the conjugated diene-based polymer composition according to claim 7.

9. A tire comprising the cross-linked rubber according to claim 8.

10. A method of preparing a conjugated diene-based polymer, comprising:

a first step of polymerizing a monomer containing a conjugated diene compound in an inert solvent in the presence of a polymerization initiator to prepare a solution containing polymer chains having an active terminal;

a second step of partially converting the polymer chains having an

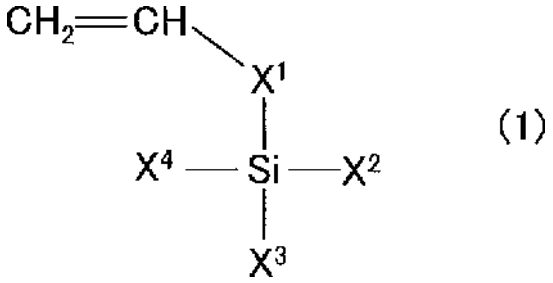
active terminal prepared in the first step into coupled polymer chains by a coupling reaction to prepare a solution containing the polymer chains having an active terminal and the coupled polymer chains; and

a third step of further polymerizing the polymer chains having an active terminal with a monomer containing the conjugated diene compound after the coupling reaction is performed in the second step,

wherein in at least one of the first step and the third step, the monomer used in the polymerization is a monomer containing a vinyl compound having a functional group interactive with silica in addition to the conjugated diene compound,

the ratio of the monomer containing a vinyl compound having a functional group interactive with silica is 0.001 to 10.000% by weight in 100% by weight of the total monomer amount, and

the vinyl compound having a functional group interactive with silica is a compound represented by General Formula (1)



(1)

where X^1 represents a chemical single bond or a hydrocarbylene group, and X^2, X^3, and X^4 each independently represent a substituted amino group, a hydrocarbyloxy group, or an optionally substituted hydrocarbyl group.

11. The method of preparing a conjugated diene-based polymer according to claim 10, wherein the polymerization initiator is further added at any one of timings of during the polymerization in the first step, at the start of the polymerization in the third step, and during the

polymerization in the third step.