CLAIMS

What is claimed is:

1. A method for producing a polydiene, the method comprising the steps of:

(i) forming an active catalyst by combining a lanthanide-containing compound, an alkylating agent, and a halogen source in the substantial absence of an organosulfide; and

(ii) polymerizing conjugated diene monomer in the presence of the active catalyst and an organosulfide.

2. The method of claim 1, where the alkylating agent includes an aluminoxane and an organoaluminum compound represented by the formula AlR_nX_{3-n}, where each R, which may be the same or different, is a monovalent organic group that is attached to the aluminum atom via a carbon atom, where each X, which may be the same or different, is a hydrogen atom, a halogen atom, a carboxylate group, an alkoxide group, or an aryloxide group, and where n is an integer of 1 to 3.

3. The method of claim 1, where the active catalyst is preformed.

4. The method of claim 3, where the active catalyst is preformed in the presence of conjugated diene monomer, and where the amount of the lanthanide-containing compound employed in said step of forming an active catalyst is greater than 2 mmol of lanthanide-containing compound per 100 g of monomer.

5. The method of claim 1, where the active catalyst employed in said step of polymerizing includes less than 2 mmol of lanthanide-containing compound per 100 g of conjugated diene monomer.

6. The method of claim 1, where said step of forming takes place in the presence of less than 10 mole of the organosulfide per mole of lanthanide metal in said lanthanide-containing compound.

7. The method of claim 1, where said step of forming takes place in the complete absence of an organosulfide.

8. The method of claim 1, where the active catalyst is formed *in situ* in the presence of the conjugated diene monomer by introducing less than 2 mmol of lanthanide-containing compound per 100 g of the conjugated diene monomer.

9. The method of claim 1, where the alkylating agent includes methylaluminoxane.

10. The method of claim 9, where the halogen source includes a bromine-containing compound.

11. The method of claim 1, where said step of polymerizing takes place within a polymerization mixture including less than 20% by weight of organic solvent based upon the total weight of the polymerization mixture.

12. The method of claim 1, where the organosulfide is defined by the formula:

R-S-R

where each R is independently a monovalent organic group, or where two R groups combine to form a divalent group.

13. The method of claim 12, where the organosulfide is selected from the group consiting of dialkyl sulfides, dicycloalkyl sulfides, diaryl sulfides, alkyl cycloalkyl

sulfides, alkyl aryl sulfides, and cycloalkyl aryl sulfides, cyclic non-aromatic sulfides, and aromatic sulfides.

14. The method of claim 1, where the molar ratio of the organosulfide to the lanthanide-containing compound is from about 1 to about 120.

15. The method of claim 1, where said step of polymerizing produces a polydiene having a reactive chain end, and further comprising the step of reacting a functionalizing agent with the reactive chain end.

16. The method of claim 1, further comprising the step of introducing the organosulfide to the active catalyst prior to said step of polymerizing.

17. The method of claim 1, further comprising the step of directly and individually introducing the organosulfide to the conjugated diene monomer.

18. A method for producing a polydiene, the method comprising the steps of:

(i) preparing a preformed catalyst by introducing a lanthanide-containing compound, an alkylating agent, a halogen source, and optionally monomer;

(ii) independent of step (i), introducing a organosulfide; and

(iii) polymerizing the conjugated diene monomer with the preformed catalyst.

19. The method of claim 18, where the alkylating agent includes methylaluminoxane.

20. The method of claim 18, where the polydiene is a cis-1,4-polubutadiene having a cis-1,4-linkage content of greater than 97%, a 1,2-linkage content of less than 2%, and a molecular weight distribution of less than 2.5; and where at least 60% of the polymer chains of the polydiene possess a reactive end.

21. The method of claim 18, where said step of polymerizing takes place within a polymerization mixture including less than 20% by weight of organic solvent based upon the total weight of the polymerization mixture.

22. The method of claim 18, where the molar ratio of the organosulfide to the lanthanide-containing compound is from about 1to about 120.

23. The method of claim 18, where said step of polymerizing produces a polydiene having a reactive chain end, and further comprising the step of reacting a functionalizing agent with the reactive chain end.

24. The method of claim 18, where said step of introducing the organosulfide includes directly and individually introducing the organosulfide to the conjugated diene monomer.

25. The method of claim 18, further comprising the step of introducing an organosulfide to the preformed catalyst prior to said step (ii), and thereby said step (ii) includes simultaneously introducing the organosulfide and the preformed catalyst within a single stream to the conjugated diene monomer.

26. The method of claim 18, where said step of introducing an organosulfide to conjugated diene monomer forms an organosulfide/monomer blend, and where said step of polymerizing the conjugated diene monomer takes place within the organosulfide/monomer blend.

27. The method of claim 18, where the organosulfide and the preformed catalyst are introduced to the conjugated diene monomer simultaneously.

28. The method of claim 27, where the organosulfide and the preformed catalyst are introduced to the conjugated diene monomer within a single stream.

29. The method of claim 27, where the organosulfide and the preformed catalyst are introduced separately and individually to the conjugated diene monomer.

30. The method of claim 18, where the preformed catalyst is introduced to the conjugated diene monomer after said step of introducing an organosulfide to the conjugated diene monomer.

31. The method of claim 18, where the preformed catalyst is introduced to the conjugated diene monomer prior to said step of introducing a organosulfide to the conjugated diene monomer.

32. The method of claim 27, further comprising the step of isolating the polydiene, and further comprising the step of preparing a vulcanizable composition with polydiene.

33. The method of claim 32, further comprising the step of fabricating a tire using the vulcanizable composition.

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(i) forming an active catalyst by combining a lanthanide-containing compound, an alkylating agent, and a halogen source in the substantial absence of an organosulfide; and

(ii) polymerizing conjugated diene monomer in the presence of the active catalyst and an organosulfide.

2. The method of claim 1, where the active catalyst is preformed.

3. The method of claim 2, where the active catalyst is preformed in the presence of conjugated diene monomer, and where the amount of the lanthanide-containing compound employed in said step of forming an active catalyst is greater than 2 mmol of lanthanide-containing compound per 100 g of monomer.

4. The method of claim 1, where the active catalyst employed in said step of polymerizing includes less than 2 mmol of lanthanide-containing compound per 100 g of conjugated diene monomer.

5. The method of claim 1, where said step of forming takes place in the presence of less than 10 mole of the organosulfide per mole of lanthanide metal in said lanthanide-containing compound.

6. The method of claim 1, where said step of forming takes place in the complete absence of an organosulfide.

7. The method of claim 1, where the active catalyst is formed *in situ* in the presence of the conjugated diene monomer by introducing less than 2 mmol of lanthanide-containing compound per 100 g of the conjugated diene monomer.

8. The method of claim 1, where the alkylating agent includes methylaluminoxane.

9. The method of claim 8, where the halogen source includes a bromine-containing compound.

10. The method of claim 1, where said step of polymerizing takes place within a polymerization mixture including less than 20% by weight of organic solvent based upon the total weight of the polymerization mixture.

11. The method of claim 1, where the organosulfide is defined by the formula:

R-S-R

where each R is independently a monovalent organic group, or where two R groups combine to form a divalent group.

12. The method of claim 1, where the molar ratio of the organosulfide to the lanthanide-containing compound is from about 1 to about 120.

13. The method of claim 1, where said step of polymerizing produces a polydiene having a reactive chain end, and further comprising the step of reacting a functionalizing agent with the reactive chain end.

14. The method of claim 1, further comprising the step of introducing the organosulfide to the active catalyst prior to said step of polymerizing.

15. The method of claim 1, further comprising the step of directly and individually introducing the organosulfide to the conjugated diene monomer.

16. A method for producing a polydiene, the method comprising the steps of:

(i) preparing a preformed catalyst by introducing a lanthanide-containing compound, an alkylating agent, a halogen source, and optionally monomer;

(ii) independent of step (i), introducing a organosulfide; and

(iii) polymerizing conjugated diene monomer with the preformed catalyst in the presence of the organosulfide.

17. The method of claim 16, where said step of introducing an organosulfide to conjugated diene monomer forms an organosulfide/monomer blend, and where said step of polymerizing the conjugated diene monomer takes place within the organosulfide/monomer blend.

18. The method of claim 16, where the organosulfide and the preformed catalyst are introduced to the conjugated diene monomer simultaneously.

19. The method of claim 18, where the organosulfide and the preformed catalyst are introduced to the conjugated diene monomer within a single stream.

20. The method of claim 18, where the organosulfide and the preformed catalyst are introduced separately and individually to the conjugated diene monomer.

21. The method of claim 16, where the preformed catalyst is introduced to the conjugated diene monomer after said step of introducing an organosulfide to the conjugated diene monomer.

22. The method of claim 16, where the preformed catalyst is introduced to the conjugated diene monomer prior to said step of introducing a organosulfide to the conjugated diene monomer.