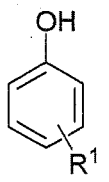
CLAIMS

What is claimed is:

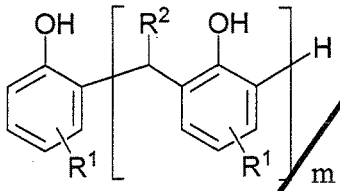
1. A method of making a sulfurized metal alkyl phenate composition comprising the steps of:

(a) reacting a phenol compound of Formula (I):



(I)

wherein R^1 is alkyl, alkylaryl, or arylalkyl, in the presence of a catalyst with an aldehyde having formula R^2-CHO to form a phenolic resin of Formula (II):



(II); and

(b) reacting the phenolic resin wherein m is an integer from 1 to 50; R^1 is as defined above; and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl simultaneously with at least one metal base and a first sulfurizing agent to form a sulfurized metal alkyl phenate.

2. The method of claim 1, wherein R^1 is alkyl.

3. The method of any one of the preceding claims, wherein R^1 is a dodecyl group at the 4-position of the phenolic ring.

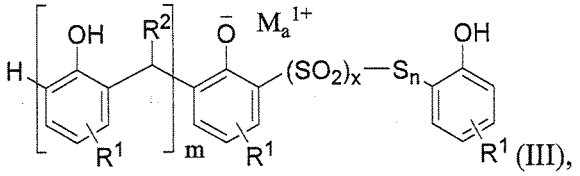
4. The method of any one of the preceding claims, wherein R^2 is H.

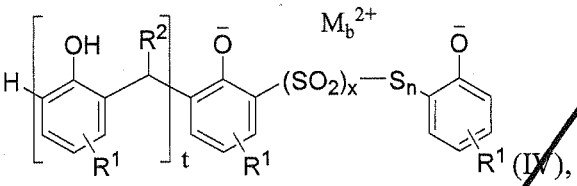
5. The method of any one of the preceding claims, wherein the at least one metal base is calcium hydroxide or calcium oxide.

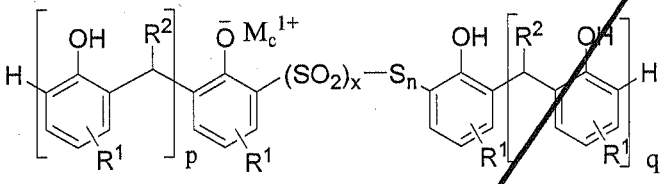
6. The method of any one of the preceding claims, wherein the first sulfurizing agent is sulfur.

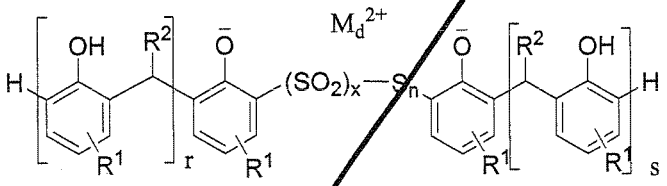
7. The method of any one of the preceding claims, wherein the catalyst is an acid.

8. The method of any one of the preceding claims, wherein the sulfurized metal alkyl phenate composition comprises at least one of Formulae (III) - (VI):


(III),


(IV),


(V), and


(VI),

wherein each of M_a^{1+} and M_c^{1+} is independently a monovalent metal ion; each of M_b^{2+} and M_d^{2+} is independently a divalent metal ion; each of m, n, p, q, r, s and t is independently an integer from 1 to 50; x is an integer from 0 to 2; R^1 is alkyl, alkylaryl, or arylalkyl; and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl.

9. The method of claim 8, wherein n is 1.

10. The method of any one of claims 8 to 9, wherein the sulfurized metal alkyl phenate composition comprises at least one of Formulae (IV) and (VI) where each of M_b^{2+} and M_d^{2+} is independently an alkaline earth metal ion.

11. The method of claim 10, wherein the alkaline earth metal ion is calcium ion.

12. The method of any one of claims 8 to 11, wherein R^1 is a $C_{12}H_{25}$ alkyl group at the 4-position of the phenolic ring; and R^2 is H.

13. The method of any one of claims 8 to 12, wherein each of r, s and t is 1.

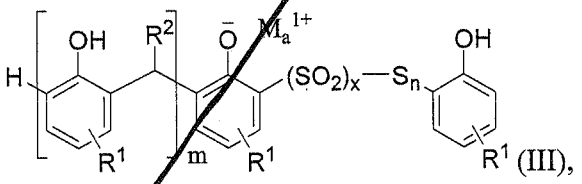
14. The method of any one of the preceding claims, wherein the sulfurized metal alkyl phenate composition comprises the unreacted phenol compound of Formula (I), a metal salt thereof or a combination thereof and wherein the total amount of the unreacted phenol compound and the metal salt thereof is less than about 5 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition.

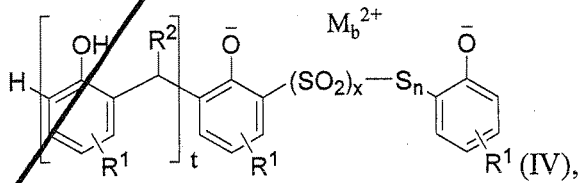
15. The method of any one of the preceding claims further comprising reacting the sulfurized metal alkyl phenate composition with a second sulfurizing agent to lower the total amount of the unreacted phenol compound of Formula (I) and a metal salt thereof to less than about 2.0 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition.

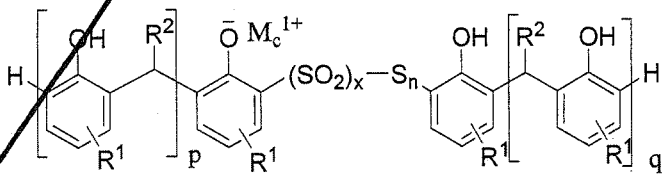
16. The method of claim 15, wherein the second sulfurizing agent is sulfur.

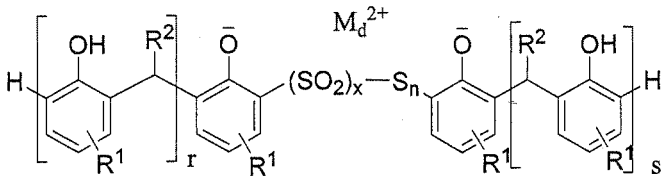
17. The method of any one of the preceding claims further comprising contacting the sulfurized metal alkyl phenate composition with carbon dioxide.

18. A sulfurized metal alkyl phenate composition comprising at least one of Formulae (III) - (VI):

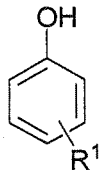

(III),


(IV),


(V), and


(VI),

wherein the total amount of a phenol compound of Formula (I):



(I)

and a metal salt thereof in the sulfurized metal alkyl phenate composition is less than about 2.0 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition, and wherein each of M_a^{1+} and M_c^{1+} is independently a monovalent metal ion; each of M_b^{2+} and M_d^{2+} is independently a divalent metal ion; each of m, n, p, q, r, s and t is independently an integer from 1 to 50; x is an integer from 0 to 2; R^1 is alkyl, alkylaryl, or arylalkyl; and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl.

19. The sulfurized metal alkyl phenate composition of claim 18 comprising at least one of Formulae (IV) and (VI), wherein each of M_b^{2+} and M_d^{2+} is independently an alkaline earth metal ion.

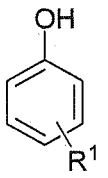
20. The sulfurized metal alkyl phenate composition of claim 19, wherein the alkaline earth metal ion is calcium.

21. The sulfurized metal alkyl phenate composition of any one of claims 18 to 20, wherein R^1 is a $C_{12}H_{25}$ alkyl group at the 4-position of the phenolic ring; and R^2 is H.

22. The sulfurized metal alkyl phenate composition of any one of claims 18 to 21, wherein each of n, r, s and t is 1.

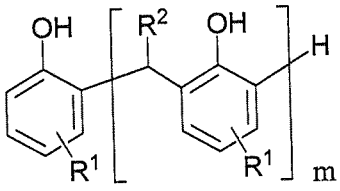
23. A sulfurized metal alkyl phenate composition prepared by a method comprising the steps of:

(a) reacting a phenol compound of Formula (I):



(I)

wherein R^1 is alkyl, alkylaryl, or arylalkyl, in the presence of a catalyst with an aldehyde having formula R^2-CHO to form a phenolic resin of Formula (II):



(II); and

(b) reacting the phenolic resin wherein m is an integer from 1 to 50; R^1 is as defined above, and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl simultaneously with at least one metal base and a first sulfurizing agent to form a sulfurized metal alkyl phenate.

24. The method of claim 23 further comprising reacting the sulfurized metal alkyl phenate composition with a second sulfurizing agent to lower the total amount of the unreacted phenol compound and a metal salt thereof in the sulfurized metal alkyl phenate composition to less than about 2.0 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition.

25. The method of claim 24, wherein the second sulfurizing agent is sulfur.

26. The method of any one of claims 23 to 25, wherein the first sulfurizing agent is sulfur.

27. The method of any one of claims 23 to 26, wherein the at least one metal base is calcium hydroxide or calcium oxide.

28. The method of any one of claims 23 to 27, wherein the catalyst is an acid.

29. The method of any one of claims 23 to 28, wherein R^1 is alkyl

30. The method of any one of claims 23 to 29, wherein R^1 is a dodecyl group at the 4-position of the phenolic ring.

31. The method of any one of claims 23 to 30, wherein R^2 is H.

32. A lubricating oil composition comprising a base oil of lubricating viscosity and a sulfurized metal alkyl phenate composition of any one of claims 18 to 22.

33. A lubricating oil composition comprising a base oil of lubricating viscosity and a sulfurized metal alkyl phenate composition of any one of claims 23 to 31.

34. The lubricating oil composition of claim 32 further comprising at least one additive selected from the group consisting of antioxidants, antiwear agents, detergents, rust inhibitors, demulsifiers, friction modifiers, multi-functional additives, viscosity index improvers, pour point depressants, foam inhibitors, metal deactivators, dispersants, corrosion inhibitors, lubricity improvers, thermal stability improvers, anti-haze additives, icing inhibitors, dyes, markers, static dissipaters, biocides and combinations thereof.

35. The method of any one of claims 1 to 17, further comprising reacting the product of step b with carbon dioxide.

36. The method of claim 35, wherein the reaction with carbon dioxide takes place in the presence of ethylene glycol.

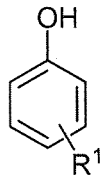
37. An overbased sulfurized metal alkyl phenate composition prepared by the method of any one of claims 35 to 36.

38. A lubricating oil composition comprising a major amount of a base oil of lubricating viscosity and the overbased sulfurized metal alkyl phenate composition of claim 37.

CLAIMS

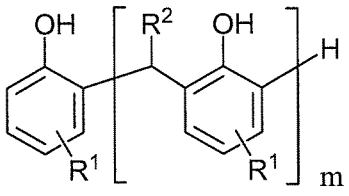
1. A method of making a sulfurized metal alkyl phenate composition comprising the steps of:

(a) reacting a phenol compound of Formula (I):



(I)

wherein R^1 is alkyl, alkylaryl, or arylalkyl, in the presence of a catalyst with an aldehyde having formula R^2-CHO to form a phenolic resin of Formula (II):



(II); ~~and~~

(b) reacting the phenolic resin wherein m is an integer from 1 to 50; R^1 is as defined above; and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl simultaneously with at least one metal base and a first sulfurizing agent to form a sulfurized metal alkyl phenate; and

(c) reacting the sulfurized metal alkyl phenate composition with a second sulfurizing agent to lower the total amount of the unreacted phenol compound of Formula (I) and a metal salt thereof to less than 2.0 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition.

2. The method of claim 1, wherein R^1 is alkyl.

3. The method of any one of the preceding claims, wherein R^1 is a dodecyl group at the 4-position of the phenolic ring.

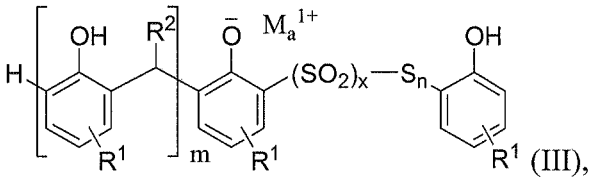
4. The method of any one of the preceding claims, wherein R^2 is H.

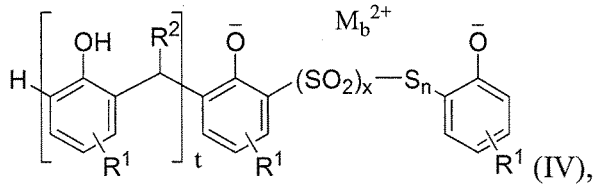
5. The method of any one of the preceding claims, wherein the at least one metal base is calcium hydroxide or calcium oxide.

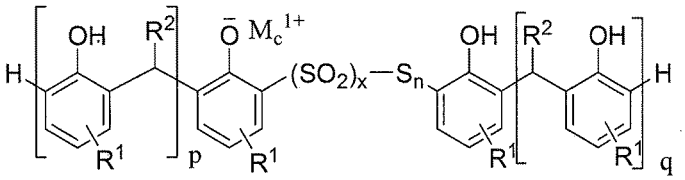
6. The method of any one of the preceding claims, wherein the first sulfurizing agent is sulfur.

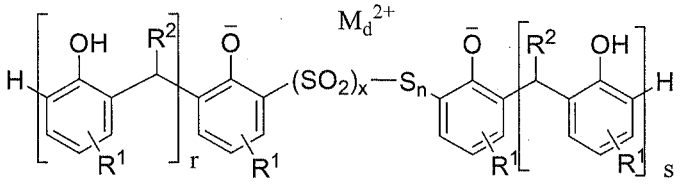
7. The method of any one of the preceding claims, wherein the catalyst is an acid.

8. The method of any one of the preceding claims, wherein the sulfurized metal alkyl phenate composition comprises at least one of Formulae (III) - (VI):


(III),


(IV),


(V), and


(VI),

wherein each of M_a^{1+} and M_c^{1+} is independently a monovalent metal ion; each of M_b^{2+} and M_d^{2+} is independently a divalent metal ion; each of m, n, p, q, r, s and t is independently an integer from 1 to 50; x is an integer from 0 to 2; R^1 is alkyl, alkylaryl, or arylalkyl; and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl.

9. The method of claim 8, wherein n is 1.

10. The method of any one of claims 8 or 9, wherein the sulfurized metal alkyl phenate composition comprises at least one of Formulae (IV) and (VI) where each of M_b^{2+} and M_d^{2+} is independently an alkaline earth metal ion.

11. The method of claim 10, wherein the alkaline earth metal ion is calcium ion.

12. The method of any one of claims 8 to 11, wherein R^1 is a $C_{12}H_{25}$ alkyl group at the 4-position of the phenolic ring; and R^2 is H.

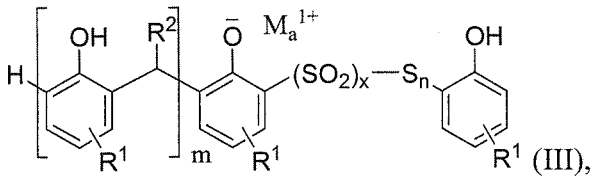
13. The method of any one of claims 8 to 12, wherein each of r, s and t is 1.

14. The method of any one of the preceding claims, wherein the sulfurized metal alkyl phenate composition comprises the unreacted phenol compound of Formula (I), a metal salt thereof or a combination thereof and wherein the total amount of the unreacted phenol compound and the metal salt thereof is less than 5 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition.

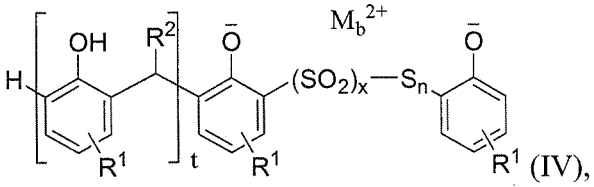
15. The method of claim 1, wherein the second sulfurizing agent is sulfur.

16. The method of any one of the preceding claims further comprising contacting the sulfurized metal alkyl phenate composition with carbon dioxide.

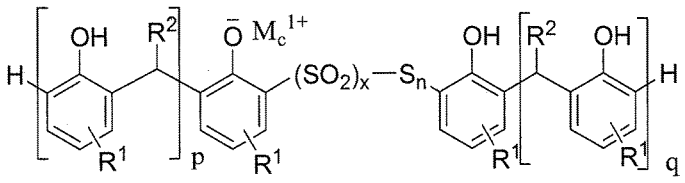
17. A sulfurized metal alkyl phenate composition comprising at least one of Formulae (III) - (VI):



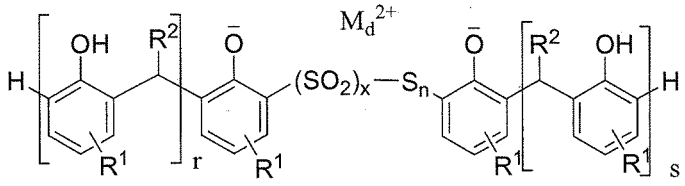
(III),



(IV),

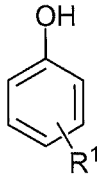


(V), and



(VI),

wherein the total amount of a phenol compound of Formula (I):



(I)

and a metal salt thereof in the sulfurized metal alkyl phenate composition is less than 2.0 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition, and wherein each of M_a^{1+} and M_c^{1+} is independently a monovalent metal ion; each of M_b^{2+} and M_d^{2+} is independently a divalent metal ion; each of m, n, p, q, r, s and t is independently an integer from 1 to 50; x is an integer from 0 to 2; R^1 is alkyl, alkylaryl, or arylalkyl; and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl.

18. The sulfurized metal alkyl phenate composition of claim 17 comprising at least one of Formulae (IV) and (VI), wherein each of M_b^{2+} and M_d^{2+} is independently an alkaline earth metal ion.

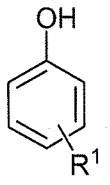
19. The sulfurized metal alkyl phenate composition of claim 18, wherein the alkaline earth metal ion is calcium.

20. The sulfurized metal alkyl phenate composition of any one of claims 17 to 19, wherein R^1 is a $C_{12}H_{25}$ alkyl group at the 4-position of the phenolic ring; and R^2 is H.

21. The sulfurized metal alkyl phenate composition of any one of claims 17 to 19, wherein each of n, r, s and t is 1.

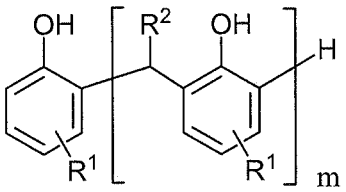
22. A sulfurized metal alkyl phenate composition prepared by a method comprising the steps of:

(a) reacting a phenol compound of Formula (I):



(I)

wherein R^1 is alkyl, alkylaryl, or arylalkyl, in the presence of a catalyst with an aldehyde having formula R^2-CHO to form a phenolic resin of Formula (II):



(II);

(b) reacting the phenolic resin wherein m is an integer from 1 to 50; R^1 is as defined above, and R^2 is H, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkylaryl or arylalkyl simultaneously with at least one metal base and a first sulfurizing agent to form a sulfurized metal alkyl phenate; and

(c) reacting the sulfurized metal alkyl phenate composition with a second sulfurizing agent to lower the total amount of the unreacted phenol compound and a metal salt thereof in the sulfurized metal alkyl phenate composition to less than 2.0 wt.%, based on the total weight of the sulfurized metal alkyl phenate composition.

23. The sulfurized metal alkyl phenate composition of claim 22, wherein the second sulfurizing agent is sulfur.

24. The sulfurized metal alkyl phenate composition of any one of claims 22-23, wherein the first sulfurizing agent is sulfur.

25. The sulfurized metal alkyl phenate composition of any one of claims 22-24, wherein the at least one metal base is calcium hydroxide or calcium oxide.

26. The sulfurized metal alkyl phenate composition of any one of claims 22-25, wherein the catalyst is an acid.

27. The sulfurized metal alkyl phenate composition of any one of claims 22-26, wherein R^1 is alkyl

28. The sulfurized metal alkyl phenate composition of any one of claims 22-27, wherein R^1 is a dodecyl group at the 4-position of the phenolic ring.

29. The sulfurized metal alkyl phenate composition of any one of claims 22-29, wherein R^2 is H.

30. A lubricating oil composition comprising a base oil of lubricating viscosity and a sulfurized metal alkyl phenate composition of any one of claims 17-21.

31. A lubricating oil composition comprising a base oil of lubricating viscosity and a sulfurized metal alkyl phenate composition of any one of claims 22-29.

32. The lubricating oil composition of claim 30 further comprising at least one additive selected from the group consisting of antioxidants, antiwear agents, detergents, rust inhibitors, demulsifiers, friction modifiers, multi-functional additives, viscosity index improvers, pour point depressants, foam inhibitors, metal deactivators, dispersants, corrosion inhibitors, lubricity improvers, thermal stability improvers, anti-haze additives, icing inhibitors, dyes, markers, static dissipaters, biocides and combinations thereof.

33. The method of any one of claims 1 to 16, further comprising reacting the product of step b with carbon dioxide.

34. The method of claim 33, wherein the reaction with carbon dioxide takes place in the presence of ethylene glycol.

35. An overbased sulfurized metal alkyl phenate composition prepared by the method of any one of claims 33-34.

36. A lubricating oil composition comprising a major amount of a base oil of lubricating viscosity and the overbased sulfurized metal alkyl phenate composition of claim 35.