[0014] The term "alkyl" as employed herein refers to straight, branched, and/or substituted saturated chain radicals of from 1 to 100 carbon atoms.

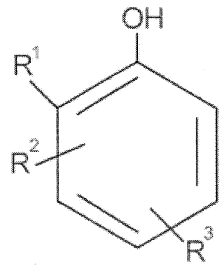
[0015] The term "alkenyl" as employed herein refers to straight, branched, and/or substituted unsaturated chain radicals of from 3 to 10 carbon atoms.

[0016] The term "aryl" as employed herein refers to single and multi-ring aromatic compounds that may include alkyl, alkenyl, alkylaryl, amino, hydroxyl, and alkoxy substituents.

[0017] The term "soluble" or "dispersible" refers to a component or composition that may be suspended or dissolved in a lubricating base oil such that it remains substantially suspended or dissolved in the oil without noticeable precipitation of the component or composition from the oil.

The Phenolic Compound

[0018] The phenolic compound ~~that is reacted with the aldehyde and the amine~~ may be represented by the following formula:



wherein R^1, R^2, and R^3 are independently selected from the group consisting of hydrogen, an alkyl group, an alkenyl group, an alkoxy group, an aminic group having from 1 to 24 carbon atoms, and an aryl group having from 6 to 24 carbon atoms. It is desirable that at least one of R^1, R^2, and R^3 have a sufficient number of carbon atoms such that the reaction product made with the phenolic compound is substantially soluble or dispersible in a lubricating oil composition. In one embodiment, the phenolic compound may be represented by the formula:

75° to about 175° C. The time required for completion of the reaction usually varies from about 1 to about 8 hours, varying of course with the specific reactants chosen, the scale of the reaction, and the reaction temperature.

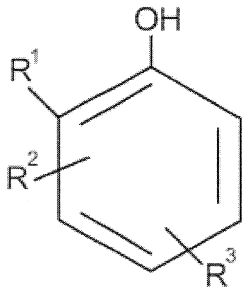
[0022] As to the molar range of ~~components (a):(b):(c)~~phenolic compound, amine and aldehyde which may be used to prepare the intermediate product, the range may fall within 0.5-5:1:0.5-5. An exemplary intermediate product may be the condensation product of nonylphenol:ethylenediamine:paraformaldehyde using a molar ratio of 2:1:2. The condensation reaction may be conducted in the presence of a catalyst. Suitable catalysts include, but are not limited to, any amine-containing catalyst or an acid. Examples of useful catalysts include 3-(dimethylamino)propylamine, ethylenediamine, and sulfuric acid. In one embodiment, the catalyst is 3-(dimethylamino)propylamine.

[0023] The amount of catalyst used in the condensation reaction may be about 0.2 to about 2%, by weight, based upon the weights of all components in the reaction mixture. A useful amount of catalyst is about 0.5 to about 1%, by weight, based upon the weights of all components in the reaction mixture.

[0024] In a second step of the reaction, the intermediate product may be reacted with an acylating agent or an electrophilic compound to provide a reaction product that may be neutralized or overbased to provide the sulfur-free lubricant additive. The acylating agents may be selected from mono-, di-, tri- and tetra-carboxylic acids and anhydrides that may contain a hydrocarbyl substituent. In one embodiment, the acylating agent may be an alkenyl succinic anhydride containing up to 32 carbon atoms. Unsaturated carboxylic reagents that may be used as acylating agents may include fatty acids and unsaturated carboxylic acids per se and functional derivatives thereof, such as anhydrides, esters, amides, imides, salts, acyl halides, and nitriles. Examples of useful unsaturated monobasic acids include, but are not limited to, acrylic acid, methacrylic acid, cinnamic acid, crotonic acid, and 2-phenylpropenoic acid. Polybasic unsaturated carboxylic acids include, but are not limited to, maleic acid, fumaric acid, mesaconic acid, itaconic acid, and citraconic acid; their anhydrides may be used. For example, in an embodiment maleic anhydride may be used. Reactive equivalents of such anhydrides include, but are not limited to, the above-mentioned derivative, e.g., acids, esters, half esters, amides, imides, salts, acyl halides, and nitriles, which may also serve as acylating agents. Another suitable acid may be glyoxylic acid. Reactive equivalents of glyoxylic acid, including esters and lactones may also be used. The

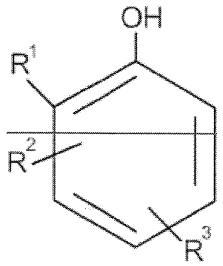
What is Claimed is:

1. A sulfur-free ~~metal or ammonium~~ salt detergent additive that is a reaction product of:
(a) an intermediate product of a phenolic compound, ~~reacted with~~ an aldehyde and an amine, wherein the phenolic compound comprises a compound of the formula:



wherein R_1, R_2, and R_3 are independently selected from the group consisting of hydrogen, an alkyl group, an alkenyl group, an alkoxy group, an aminic group having from 1 to 24 carbon atoms, and an aryl group having from 6 to 24 carbon atoms; with
(b) a compound selected from the group consisting of an acylating agent, an electrophilic compound, and mixtures thereof, and
(c) a compound selected from an alkali or alkaline earth metal ~~or ammonium compound~~and a basic nitrogen-containing compound to provide an overbased or neutral sulfur-free salt detergent additive.

~~2. The sulfur-free detergent additive of claim 1, wherein the phenolic compound comprises a compound of the formula:~~



~~wherein R^1, R^2, and R^3 are independently selected from the group consisting of hydrogen, an alkyl group, an alkenyl group, an alkoxy group, an aminic group having from 1 to 24 carbon atoms, and an aryl group having from 6 to 24 carbon atoms.~~

~~3~~2. The sulfur-free salt detergent additive of claim 1, wherein the aldehyde comprises formaldehyde.

~~4~~3. The sulfur-free salt detergent additive of claim 1, wherein the amine comprises a mono- or polyamine.

~~5~~4. The sulfur-free salt detergent additive of claim 1, wherein component (b) is selected from the group consisting of maleic acid or anhydride, succinic acid or anhydride, alkenyl succinic acid or anhydride, and halo-carboxylic acid.

~~6. The sulfur-free detergent additive of claim 1, wherein the metal is selected from alkali and alkaline earth metals.~~

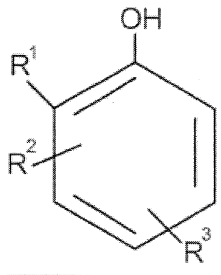
~~7~~5. The sulfur-free salt detergent additive of claim ~~6~~1, wherein the ~~reaction product~~sulfur-free salt detergent is an overbased ~~to provide~~ calcium or magnesium salt of the reaction product.

~~8~~6. The sulfur-free salt detergent additive of claim 1, wherein the ~~reaction product~~sulfur-free salt detergent is ~~neutralized with a basic nitrogen-containing compound to form an~~ a neutral ammonium salt of the reaction product.

~~9~~7. A lubricant composition comprising a base oil and from about 1 to about 5 wt.% of the sulfur-free salt detergent additive of claim 1.

~~10~~8. A method for making a sulfur-free~~, metal or ammonium~~ salt compound for use as a detergent additive component of a lubricant composition comprising:

reacting ~~(a)~~ a phenolic compound with ~~(b)~~ an aldehyde, and ~~(c)~~ an amine to provide an intermediate product, wherein the phenolic compound comprises a compound of the formula:

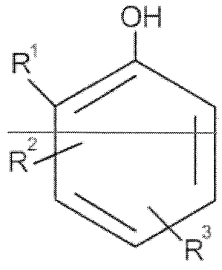


wherein R^1, R^2, and R^3 are independently selected from the group consisting of hydrogen, an alkyl group, an alkenyl group, an alkoxy group, an aminic group having from 1 to 24 carbon atoms, and an aryl group having from 6 to 24 carbon atoms;

subsequently reacting the intermediate product with ~~(d)~~(b) a compound selected from the group consisting of an acylating agent, an electrophilic compound, and mixtures thereof to provide a reaction product adduct, and

neutralizing or overbasing the reaction product adduct with (c) a basic nitrogen-contaning compound or a metal ~~or ammonium compound~~selected from alkali and alkaline earth metals to provide the detergent additive component.

~~11. The method of claim 10, wherein the phenolic compound comprises a compound of the formula:~~



~~wherein R^1, R^2, and R^3 are independently selected from the group consisting of hydrogen, an alkyl group, an alkenyl group, an alkoxy group, an aminic group having from 1 to 24 carbon atoms, and an aryl group having from 6 to 24 carbon atoms.~~

~~12~~9. The method of claim ~~10~~8, ~~further~~ comprising overbasing the reaction product adduct to provide an overbased ~~alkali or alkaline earth metal~~calcium or magnesium salt adduct.

~~13~~10. The method of claim ~~10~~8, wherein component ~~(d)~~(b) is selected from the group consisting of maleic acid or anhydride, succinic acid or anhydride, and halo-carboxylic acid.

~~14~~11. The method of claim ~~10~~8, wherein the amine comprises a mono- or polyamine.

12. The method of claim 8, comprising neutralizing the reaction product adduct with a basic nitrogen-containing compound to provide an ammonium salt of the reaction product adduct.

~~15~~13. A lubricant composition comprising the sulfur-free ~~metal or ammonium~~ salt detergent additive of claim 1 and one or more additional additives selected from the group consisting of a polymeric viscosity modifier, a detergent, an antioxidant, a dispersant, a rust inhibitor, an antiwear agent, a boron-containing compound, a friction modifier, a pour-point depressant, and an antifoaming agent.

~~16~~14. A method for lubricating an internal combustion engine comprising adding the lubricant composition of claim ~~15~~13 to a crankcase of said engine.

~~17~~15. The method of claim ~~16~~14, wherein the engine comprises a heavy duty diesel engine.

~~18~~16. A lubricating oil concentrate comprising the sulfur-free ~~metal or ammonium~~ salt detergent additive of claim 1 and one or more additional additives selected from the group consisting of a polymeric viscosity modifier, a detergent, an antioxidant, a dispersant, a rust inhibitor, an antiwear agent, a boron-containing compound, a friction modifier, a pour-point depressant, and an antifoaming agent.