SUMMARY

[0004] In accordance with one example, a method of reducing lead corrosion in an internal combustion engine lubricated with a lubricating oil composition is described herein. In one aspect, the disclosure provides a method of reducing lead corrosion in an internal combustion engine lubricated with a lubricating oil composition, the method comprising supplying to the internal combustion engine a lubricating oil composition including i) a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source; ii) a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups, wherein the nitrogen-free organic friction modifier has pendant hydroxyl groups obtained from a fatty acid reacted with an alkanol; iii) a boron-containing compound selected from boric acid or boronic acid having the structure X-B-$(OH)_2$ wherein X is a hydroxyl group, a linear or branched alkyl group, a cyclic hydrocarbyl group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and iv) a major amount of a base oil or a blend of base oils of lubricating viscosity; wherein the lubricating oil composition includes 250 ppm to 350 ppm of boron provided by the boron-containing compound per each 1 weight percent of the nitrogen-free organic friction modifier. In one example, the method includes supplying to the internal combustion engine a lubricating oil composition including a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source, a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups, and a major amount of a base oil or a blend of base oils of lubricating viscosity. The lubricating oil composition includes an admixture of the boron-containing compound selected from boric acid or boronic acid.

[0005] In other examples, the methods of the previous paragraph may be combined with optional features or steps in any combination thereof. These optional features and/or steps including one or more of the following: wherein the nitrogen-free organic friction modifier has pendant hydroxyl groups obtained from a fatty acid reacted with an alkanol; and/or wherein the lubricating oil composition includes about 250 ppm to about 350 ppm of boron provided by the boron-containing compound per each 1 weight percent of the nitrogen-free organic friction modifier; and/or wherein the lubricating oil composition exhibits no more than about 500 ppm of lead corrosion per each 1 weight percent of the nitrogen-free organic friction modifier as measured by ASTM D6594; and/or wherein the hydrocarbyl substituted succinimide dispersant is boronated from a source of boron separate from the boron-containing compound; and/or wherein the boron-containing compound has the structure X-B-$(OH)_2$ wherein X is a hydroxyl group, a linear or branched alkyl group, a cyclic hydrocarbyl group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and/or wherein the boron-containing compound is a boronic acid with X being a linear or branched C1 to C10 group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and/or wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of fatty acids; and/or wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of oleic acid; and/or wherein the nitrogen-free organic friction modifier includes glycerol monooleate; and/or wherein the lubricating oil composition includes about 100 ppm to about 300 ppm of boron provided by the boron-containing compound, up to about 10 weight percent of the hydrocarbyl substituted succinimide dispersant, and up to about 1 weight percent of the nitrogen-free organic friction modifier.

[0006] In another example or approach, a lubricating oil composition for reducing lead corrosion in an internal combustion engine is described herein. In one aspect, the disclosure provides a lubricating oil composition for reducing lead corrosion in an internal combustion engine, the lubricating oil composition comprising: i) a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source; ii) a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups, wherein the nitrogen-free organic friction modifier has pendant hydroxyl groups obtained from a fatty acid reacted with an alkanol; iii) a boron-containing compound selected from boric acid or boronic acid having the structure X-B-$(OH)_2$ wherein X is a hydroxyl group, a linear or branched alkyl group, a cyclic hydrocarbyl group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and iv) a major amount of a base oil or blend of base oils of lubricating viscosity; wherein the lubricating oil composition includes 250 ppm to 350 ppm of boron provided by the boron-containing compound per each 1 weight percent of the nitrogen-free organic friction modifier. In one example, the lubricating oil composition includes at least an admixture of a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source; a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups; a boron-containing compound selected from boric acid or boronic acid; and a major amount of a base oil or blend of base oils of lubricating viscosity.

[0007] In other examples, the composition of the previous paragraph may be combined with optional features or limitations in any combination thereof. These optional features and/or limitations including one or more of the following: wherein the nitrogen-free organic friction modifier has pendant hydroxyl groups obtained from a fatty acid reacted with an alkanol; and/or wherein the lubricating oil composition includes about 250 ppm to about 350 ppm of boron provided by the boron-containing compound per each 1 weight percent of the nitrogen-free organic friction modifier; and/or wherein the lubricating oil composition exhibits no more than about 500 ppm of lead corrosion per each 1 weight percent of the nitrogen-free organic friction modifier as measured by ASTM D6594; and/or wherein the hydrocarbyl substituted succinimide dispersant is boronated from a source of boron separate from the boron-containing compound; and/or wherein the boron-containing compound has the structure X-B-$(OH)_2$ wherein X is a hydroxyl group, a linear or branched alkyl group, a cyclic hydrocarbyl group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and/or wherein the boron-containing compound is a boronic acid with X being a linear or branched C1 to C10 group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and/or wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of fatty acids; and/or wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of oleic acid; and/or wherein the nitrogen-free organic friction modifier includes glycerol monooleate; and/or wherein the lubricating oil composition includes about 100 to about 300 ppm of boron provided from the boron-containing compound, up to about 10 weight percent of the hydrocarbyl substituted succinimide dispersant, and up to about 1 weight percent of the nitrogen-free organic friction modifier; and/or wherein the lubricating oil composition is a passenger car motor oil.

[0008] In yet another example or approach, the use of a lubricating oil composition for

reducing lead corrosion in an internal combustion engine is described herein. In one example, the use of a lubricating oil composition includes using at least an admixture of a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source; a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups; a boron-containing compound selected from boric acid or boronic acid; and a major amount of a base oil or blend of base oils of lubricating viscosity to reduce lead corrosion in an internal combustion engine. Additionally, the use of the lubricating oil composition may also include any further example as described in this Summary,

TERMS

[0009] The following definitions of terms are provided in order to clarify the meanings of certain terms as used herein.

[00010] The terms "oil composition," "lubrication composition," "lubricating oil composition," "lubricating oil," "lubricant composition," "lubricating composition," "fully formulated lubricant composition," "lubricant," "crankcase oil," "crankcase lubricant," "engine oil," "engine lubricant," "motor oil," and "motor lubricant" are considered synonymous, fully interchangeable terminology referring to the finished lubrication product comprising a major amount of a base oil plus a minor amount of an additive composition.

[00011] As used herein, the terms "additive package," "additive concentrate," "additive composition," "engine oil additive package," "engine oil additive concentrate," "crankcase additive package," "crankcase additive concentrate," "motor oil additive package," "motor oil concentrate," are considered synonymous, fully interchangeable terminology referring the portion of the lubricating oil composition excluding the major amount of base oil stock mixture. The additive package may or may not include the viscosity index improver or pour point depressant.

[00012] As used herein, "lead corrosion" refers to the change in lead concentration of a lubricant over the course of an evaluation performed pursuant to ASTM D6594. Lead concentration may be measured via ICP pursuant to ASTM D5185.

[00013] The term "overbased" relates to metal salts, such as metal salts of sulfonates, carboxylates, salicylates, and/or phenates, wherein the amount of metal present exceeds the stoichiometric amount. Such salts may have a conversion level in excess of 100% (i.e., they may comprise more than 100% of the theoretical amount of metal needed to convert the acid to its "normal," "neutral" salt). The expression "metal ratio," often abbreviated as MR, is used to

1. A method of reducing lead corrosion in an internal combustion engine lubricated with a lubricating oil composition, the method comprising supplying to the internal combustion engine a lubricating oil composition including

i) a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source;

ii) a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups, wherein the nitrogen-free organic friction modifier has pendant hydroxyl groups obtained from a fatty acid reacted with an alkanol;

iii) a boron-containing compound selected from boric acid or boronic acid having the structure $X\text{-}B\text{-}(OH)_2$ wherein X is a hydroxyl group, a linear or branched alkyl group, a cyclic hydrocarbyl group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and

iv) a major amount of a base oil or a blend of base oils of lubricating viscosity;

wherein the lubricating oil composition includes 250 ppm to 350 ppm of boron provided by the boron-containing compound per each 1 weight percent of the nitrogen-free organic friction modifier.

2. The method of reducing lead corrosion in an internal combustion engine of claim 1, wherein the hydrocarbyl substituted succinimide dispersant is boronated from a source of boron separate from the boron-containing compound; and/or wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of fatty acids.

3. The method of reducing lead corrosion in an internal combustion engine of claim 1, wherein the lubricating oil composition exhibits no more than 500 ppm of lead corrosion per each 1 weight percent of the nitrogen-free organic friction modifier as measured by ASTM D6594.

4. The method of reducing lead corrosion in an internal combustion engine of claim 2, wherein the boron-containing compound is a boronic acid with X being a linear or branched C1 to C10 group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof.

5. The method of reducing lead corrosion in an internal combustion engine of claim 2, wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of oleic acid.

6. The method of reducing lead corrosion in an internal combustion engine of claim 5, wherein the nitrogen-free organic friction modifier includes glycerol monooleate.

7. The method of reducing lead corrosion in an internal combustion engine of claim 1, wherein the lubricating oil composition includes 100 ppm to 300 ppm of boron provided by the boron-containing compound, up to 10 weight percent of the hydrocarbyl substituted succinimide dispersant, and up to 1 weight percent of the nitrogen-free organic friction modifier.

8. A lubricating oil composition for reducing lead corrosion in an internal combustion engine, the lubricating oil composition comprising:

i) a hydrocarbyl substituted succinimide dispersant obtained from a hydrocarbyl substituted acylating agent reacted with a nitrogen source;

ii) a nitrogen-free organic friction modifier having carboxylic acid and/or hydroxyl groups, wherein the nitrogen-free organic friction modifier has pendant hydroxyl groups obtained from a fatty acid reacted with an alkanol;

iii) a boron-containing compound selected from boric acid or boronic acid having the structure $X\text{-}B\text{-}(OH)_2$ wherein X is a hydroxyl group, a linear or branched alkyl group, a cyclic hydrocarbyl group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof; and

iv) a major amount of a base oil or blend of base oils of lubricating viscosity;

wherein the lubricating oil composition includes 250 ppm to 350 ppm of boron provided by the boron-containing compound per each 1 weight percent of the nitrogen-free organic friction modifier.

9. The lubricating oil composition for reducing lead corrosion of claim 8, wherein the lubricating oil composition exhibits no more than about 500 ppm of lead corrosion per each 1 weight percent of the nitrogen-free organic friction modifier as measured by ASTM D6594.

10. The lubricating oil composition for reducing lead corrosion of claim 8, wherein the hydrocarbyl substituted succinimide dispersant is boronated from a source of boron separate from the boron-containing compound; and/or wherein the nitrogen-free organic friction modifier includes a blend of mono- and di-esters of fatty acids.

11. The lubricating oil composition for reducing lead corrosion of claim 10, wherein the boron-containing compound is a boronic acid with X being a linear or branched C1 to C10 group, one or more aromatic groups, a benzofuranyl group, a dibenzofuranyl group, or combinations thereof.

12. The lubricating oil composition for reducing lead corrosion of claim 8, wherein the lubricating oil composition includes 100 to 300 ppm of boron provided from the boron-containing compound, up to 10 weight percent of the hydrocarbyl substituted succinimide dispersant, and up to 1 weight percent of the nitrogen-free organic friction modifier.