

LUBRICANT COMPOSITIONS AND METHODS OF LUBRICATING INTERNAL COMBUSTION ENGINES

[0001] By-products of the oxidative and thermal decomposition of organic components in lubricating compositions used in mechanical devices contribute to the decline in performance of the lubricating composition, for example, by causing undesirable increased viscosity. Therefore, antioxidant additives are important for lubricant compositions to aid in preventing or retarding oxidative and thermal decomposition.

[0002] One class of known antioxidant compounds is substituted diarylamine compounds. The substituted diarylamine compounds help reduce oxidation breakdown and improve cleanliness in the lubricating composition. However, substituted diarylamine compounds have recently come under some scrutiny by chemical regulatory agencies and use of these antioxidants may be required to be reduced or eliminated in future lubricant compositions. In addition, for lubricating compositions used for spark ignition or compression ignition engines, there are also limits placed on sulfated ash, phosphorous, and sulfur ("SAPS") content, to reduce the impact of meal ash on exhaust aftertreatment devices and to reduce emission of particular matter. Upper limits on the amounts of such metal-containing additives, such as zinc dialkylphosphate and metal containing detergents present challenges to compensate for the control of bulk oxidation as well as the resulting viscosity increase. It would be desirable to provide a metal-free, ashless additive that assists with oxidation and deposit control as well as the resulting increase in viscosity in a lubricating composition.

[0003] US Patent Application US20170081609 disclosed technology related to hydroxy functionalized ashless additives useful in engine oil compositions due to their ability to reduce deposits, particularly deposits seen in turbocharged direct injection (TDI) engines. The described additives include ashless saturated compounds having a long chain hydrocarbyl polymer terminated by a hydroxyl group. While this disclosure teaches a hydroxy terminated hydrocarbyl group, it does not address solutions for viscosity increase in lubricating oils resulting from oxidation.

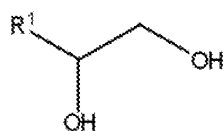
Summary

[0004] The present invention provides a lubricating composition comprising (a) an oil of lubricating viscosity; (b) 1 wt% to 5 wt% of a branched diol; (c) less than 3 wt % (less

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than 2.5% or less than 2%) of an aryl amine antioxidant; and (d) 0.5 wt% to 8 wt% or 1 wt% to 6 wt% or 1.75 wt% to 5 wt% of a dispersant. In one embodiment, the oil of lubricating viscosity comprises at least 40% by weight of Group I, Group II, or Group III base oils or mixtures thereof and contains less than 50% by weight of a polyalphaolefin base oil.

[0005] In one embodiment, present invention provides a lubricating composition comprising (a) an oil of lubricating viscosity, (b) 1 wt% to 5 wt% of a branched diol of Formula I:



where R¹ is an alkyl chain having 4 to 10 carbon atoms; (c) less than 3 wt % (less than 2.5% or less than 2%) of an aryl amine antioxidant; and (d) 0.5 wt% to 8 wt% or 1 wt% to 6 wt% or 1.75 wt% to 5 wt% of a dispersant. In one embodiment, dispersants useful in the present invention include polyisobutylene succinimide dispersants.

[0006] The present invention also provides a method of lubricating an internal combustion engine, wherein the method comprises operating the engine with a lubricant composition comprising as described herein. In another embodiment, the present invention provides a method of decomposing peroxide in a lubricating composition used to lubricate an internal combustion engine comprising supplying to the internal combustion engine the lubricating composition as described herein. In another embodiment, the present invention provides for the use of a lubricating composition as described herein for oxidation and deposit control in an internal combustion engine.

Detailed Description of the Invention

Oil of Lubricating Viscosity

[0007] The lubricating composition of the present invention comprises an oil of lubricating viscosity. Such oils include natural and synthetic oils, oil derived from hydrocracking, hydrogenation, and hydrofinishing, unrefined, refined, re-refined oils or mixtures thereof. A more detailed description of unrefined, refined and rerefined oils is provided in International Publication W02008/147704, paragraphs [0054] to [0056] (a similar disclosure is provided in US Patent Publication 2010/ 0197536, see [0072] to

[0073]). Amore detailed description of natural and synthetic lubricating oils is described in paragraphs [0058] to [0059] respectively of W02008/ 147704 (a similar disclosure is provided in US Patent Publication 2010/0197536, see [0075] to [0076]). Synthetic oils may also be produced by Fischer-Tropsch reactions and typically may be hydroisomerized Fischer-Tropsch hydrocarbons or waxes. In one embodiment, oils may be prepared by a Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid oils.

[0008] Oils of lubricating viscosity may also be defined as specified in the April 2008 version of “Appendix E—API Base Oil Interchangeability Guidelines for Passenger Car Motor Oils and Diesel Engine Oils”, section 1.3 Subheading 1.3. “Base Stock Categories”. The API Guidelines are also summarized in U.S. Pat. No. 7,285,516 (see column 11, line 64 to column 12, line 10). The five base oil groups are as follows:

Base Oil Category	Sulfur (%)	Saturates (%)	Viscosity Index
Group I	>0.03 and/or	<90	80 to 120
Group II	≤0.03 and	≥90	80 to 120
Group III	≤0.03 and	≥90	≥120
Group IV	All polyalphaolefins (PAO)		
Group V	All others not included in Groups I, II, III, or IV		

[0009] The amount of the oil of lubricating viscosity present in the lubricating composition is typically the balance remaining after subtracting from 100 weight % (wt %) the sum of the amount of the compound of the invention and the other performance additives.

[0010] The lubricating composition may be in the form of a concentrate and/or a fully formulated lubricant. If the lubricating composition of the invention (comprising the additives disclosed herein) is in the form of a concentrate which may be combined with additional oil to form, in whole or in part, a finished lubricant, the ratio of the of these additives to the oil of lubricating viscosity and/or to diluent oil include the ranges of 1:99 to 99:1 by weight, or 80:20 to 10:90 by weight.

[0011] In one embodiment, the base oil has a kinematic viscosity at 100° C. from 2 mm²/s (centi Stokes-cSt) to 16 mm²/s, from 3 mm²/s to 10 mm²/s, or even from 4 mm²/s to 8 mm²/s.

[0012] Base oil solvency may be measured as the ability of unadditized base oil to act as a solvent for polar constituents. In general, base oil solvency decreases as the base oil

group moves from Group I to Group IV (PAO). That is, solvency of base oil may be ranked as follows for oil of a given kinematic viscosity: Group I>Group II>Group III>Group IV. Base oil solvency also decreases as the viscosity increases within a base oil group; base oil of low viscosity tends to have better solvency than similar base oil of higher viscosity. Base oil solvency may be measured by aniline point (ASTM D611).

[0013] In one embodiment of the present invention, the base oil component of the lubricating composition comprises at least 30 wt %, at least 40 wt%, at least 50 wt%, at least 60 wt%, at least 70 wt%, or at least 80 wt% of a Group I, Group II, or a Group III base oil or mixtures thereof. In addition, the lubricant composition comprises less than 50 wt % or less than 40 wt%, or less than 30 wt%, or less than 20 wt% of Group IV (i.e., polyalphaolefin) base oil. In another embodiment, the base oil comprises less than 10 wt % of Group IV base oil. In one embodiment, the lubricating composition is substantially free of (i.e., contains less than 0.5 wt %) of a Group IV (polyalphaolefin) base oil.

[0014] Ester base fluids, which are characterized as Group V oils, have high levels of solvency as a result of their polar nature. Addition of low levels (typically less than 10 wt %) of ester to a lubricating composition may significantly increase the resulting solvency of the base oil mixture. Esters may be broadly grouped into two categories: synthetic and natural. An ester base fluid would have a kinematic viscosity at 100° C. suitable for use in an engine oil lubricant, such as between 2 cSt and 30 cSt, or from 3 cSt to 20 cSt, or even from 4 cSt to 12 cSt.

[0015] Synthetic esters may comprise esters of dicarboxylic acids (e.g., phthalic acid, succinic acid, alkyl succinic acids and alkenyl succinic acids, maleic acid, azelaic acid, suberic acid, sebacic acid, fumaric acid, adipic acid, linoleic acid dimer, malonic acid, alkyl malonic acids, and alkenyl malonic acids) with any of variety of monohydric alcohols (e.g., butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, ethylene glycol, diethylene glycol monoether, and propylene glycol). Specific examples of these esters include dibutyl adipate, di(2-ethylhexyl) sebacate, di-n-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, the 2-ethylhexyl diester of linoleic acid dimer, and the complex ester formed by reacting one mole of sebacic acid with two moles of tetraethylene glycol and two moles of 2-ethylhexanoic acid. Other synthetic esters include those made from C5 to C12 monocarboxylic acids and polyols and polyol ethers such as neopentyl glycol,

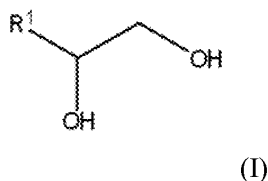
trimethylolpropane, pentaerythritol, dipentaerythritol, and tripentaerythritol. Esters can also be monoesters of monocarboxylic acids and monohydric alcohols.

[0016] Natural (or bio-derived) esters refer to materials derived from a renewable biological resource, organism, or entity, distinct from materials derived from petroleum or equivalent raw materials. Natural esters include fatty acid triglycerides, hydrolyzed or partially hydrolyzed triglycerides, or transesterified triglyceride esters, such as fatty acid methyl ester (or FAME). Suitable triglycerides include, but are not limited to, palm oil, soybean oil, sunflower oil, rapeseed oil, olive oil, linseed oil, and related materials. Other sources of triglycerides include, but are not limited to, algae, animal tallow, and zooplankton. Methods for producing bio-lubricants from natural triglycerides are described in, e.g., United States Patent Publication 2011/0009300A1.

Branched Diol

[0017] The lubricating composition of the present invention also contains a branched diol. Suitable alcohols are described below.

[0018] In one embodiment, the branched diol used in the present invention has the structure of Formula I:



where R¹ is an alkyl chain having 4 to 10 carbon atoms. Examples of alcohols which may be used in the present invention are summarized in the table below, where the alcohols have the formula of Formula I:

R ¹	Name
C4	1,2-hexanediol
C6	1,2-octanediol
C8	1,2-decanediol
C10	1,2-dodecanediol

[0019] The lubricating composition of the present invention may contain from 1 wt% up to 5% wt %, for example, 1 wt% to 3 wt% or even 2 wt% to 3 wt% of a saturated primary monohydric alcohol as described herein or mixtures thereof.

Aryl Amine Antioxidant

[0020] In one embodiment, the lubricant composition of the present invention includes an aryl amine antioxidant, such as arylamines, diarylamines, alkylated arylamines, or alkylated diaryl amines. In one embodiment of the present invention, the aryl amine antioxidant comprises or consists of a hydrocarbyl substituted diphenylamine. The hydrocarbyl substituted diphenylamine may include mono- or di- C4 to C16-, or C6 to C12-, or C9- alkyl diphenylamine. For example, the hydrocarbyl substituted diphenylamine may be octyl diphenylamine, or di-octyl diphenylamine, dinonyl diphenylamine, typically dinonyl diphenylamine.

[0021] The diarylamine or alkylated diarylamine may be a phenyl- α -naphthylamine (PANA), an alkylated diphenylamine, or an alkylated phenylnaphthylamine, or mixtures thereof. The alkylated diphenylamine may include di-nonylated diphenylamine, nonyl diphenylamine, octyl diphenylamine, di-octylated diphenylamine, di-decylated diphenylamine, decyl diphenylamine and mixtures thereof. In one embodiment, the diphenylamine may include nonyl diphenylamine, dinonyl diphenylamine, octyl diphenylamine, dioctyl diphenylamine, or mixtures thereof. In one embodiment the alkylated diphenylamine may include nonyl diphenylamine, or dinonyl diphenylamine. The alkylated diarylamine may include octyl, di-octyl, nonyl, di-nonyl, decyl or di-decyl phenylnaphthylamines.

[0022] When present the aryl amine antioxidant may be present in amounts of less than or equal to 3.0 wt %, less than or equal to 2.5 wt %, less than or equal to 2.0 wt%, less than or equal to 1.5 wt%, or less than equal to 1.0 wt %, of the lubricant additive composition. In one embodiment, the hydrocarbyl substituted diphenylamine is present from 0.1 to 3.0 wt %, or from 0.3 to 2.0 wt %, or from 0.1 to 2.0 wt %, or from 0.1 to 1.0 wt %. In some embodiments, the lubricant composition is substantially free of aryl amine antioxidants. In another embodiment, the lubricant composition is substantially free of hydrocarbyl substituted diphenylamines.

Dispersants

[0023] The lubricating composition of the present invention also contains a dispersant. Suitable dispersants may include carboxylic, amine, Mannich, post-treated, and polymeric dispersant. Dispersants are often known as ashless-type dispersants because, prior to mixing in a lubricating oil composition, they do not contain ash-forming metals

and they do not normally contribute any ash forming metals when added to a lubricant and polymeric dispersants. Ashless type dispersants are characterized by a polar group attached to a relatively high molecular weight hydrocarbon chain. Typical ashless dispersants include carboxylic dispersants, such as, for example, N-substituted long chain alkenyl succinimides. Examples of N-substituted long chain alkenyl succinimides include polyisobutylene (PIB) succinimide with number average molecular weight of the PIB substituent in the range 350 to 5000, or 500 to 3000. Succinimide dispersants and their preparation are disclosed, for instance in U.S. Pat. No. 4,234,435.

[0024] Succinimide dispersants are typically the imide formed from a polyamine, typically a poly(ethyleneamine) or an aromatic polyamine, such as amino diphenylamine (ADPA).

[0025] In one embodiment, the additional additives present in the lubricant composition may further include an amine dispersant, such as, for example, the reaction product of a PIB succinic anhydride and an amine, preferably a polyamine, and preferably an aliphatic polyamine, such as ethylene polyamine (i.e., a poly(ethyleneamine)), a propylene polyamine, a butylene polyamine, or a mixture of two or more thereof. The aliphatic polyamine may be ethylene polyamine. The aliphatic polyamine may be selected from ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenehexamine, polyamine still bottoms, or a mixture of two or more thereof.

[0026] In one embodiment, the dispersant may be at least one PIB succinimide dispersant derived from PIB with number average molecular weight in the range 350 to 5000, or 500 to 3000. The PIB succinimide may be used alone or in combination with other dispersants.

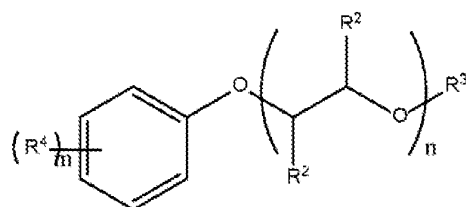
[0027] Another class of ashless dispersant is Mannich bases. Mannich dispersants are the reaction products of alkyl phenols with aldehydes (especially formaldehyde) and amines (especially polyalkylene polyamines). The alkyl group typically contains at least 30 carbon atoms.

[0028] Any of the described dispersants may also be post-treated by conventional methods by a reaction with any of a variety of agents. Among these are boron, urea, thiourea, dimercaptotriazoles, carbon disulfide, aldehydes, ketones, carboxylic acids, hydrocarbon-substituted succinic anhydrides, maleic anhydride, nitriles, epoxides, phosphorus compounds and/or metal compounds.

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[0029] The optional dispersant can also be a polymeric dispersant. Polymeric dispersants are interpolymers of oilsolubilizing monomers such as decyl methacrylate, vinyl decyl ether and high molecular weight olefins with monomers containing polar substituents, e.g., aminoalkylacrylates or acrylamides and poly-(oxyethylene)-substituted acrylates.

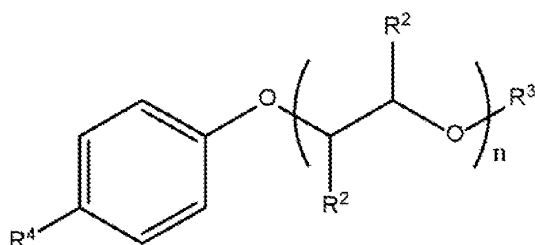
[0030] In one embodiment, the dispersant may comprise an oxyalkylated hydrocarbyl phenol. For example, the oxyalkylated hydrocarbyl phenol may be represented by Formula V:



FORMULA V

wherein each R^2 is independently hydrogen or a hydrocarbyl group of 1 to 6 carbon atoms; R^3 is hydrogen, a hydrocarbyl group of 1 to 24 carbon atoms, or an acyl group represented by -C(=O)R^5 , R^5 is a hydrocarbyl group of 1 to 24 carbon atoms each R^4 is independently a hydrocarbyl group of 1 to 220, or 20 to 220, wherein at least one R^4 contains 25 to 200, or 35 to 180 or 40 to 180 to 60 to 180 or 40 to 96 carbon atoms; $n = 1$ to 10; and $m = 1$ to 3.

[0031] In other embodiments, The R^4 group of Formula V above may be located in the para position relative to the oxyalkylated group, and the resultant formula is represented by the structure:



wherein variables R^2 to R^5 , and n, are defined previously.

[0032] Some example dispersants which may be used in the present invention are summarized in the following table:

Pib Type	Mn	Succination Process	MAA:PIB	Amine	%N (oil free)	%B (oil free)
High Vinylidene ^B	1000	Thermal	1.3:1	PEA ^C	3.8	0.81
High Vinylidene ^B	1000	Thermal	1.3:1	PEA ^C	2.13	--
High Vinylidene ^B	1000	Thermal	1.3:1	PEA ^C	3	--
High Vinylidene ^B	2200	Thermal	1.3:1	PEA ^C	1.89	
High Vinylidene ^B	1500	Thermal	1.3:1	TETA ^F	1.41	
High Vinylidene ^B	2000	Thermal	1.7:1	PEA ^C	1.46	0.81
High Vinylidene ^B	1000	Thermal	1.3:1	TEPA ^D	4.7	0
High Vinylidene ^B	2000	Thermal	1.7:1	PEA ^C	1.48	
Conventional	2000	Chlorination	1.5:1	PEA ^C	2.32	--
Conventional	1000	Chlorination	1:1	THAM ^E / PEA ^C	3.58	--
Conventional	1000	Chlorination	1:1	PEA ^C	3.71	3.06
Conventional	1000	Chlorination	1:1	PEA ^C	1.77	--
Conventional	1000	Chlorination	1:1	MPOEL ^A	--	--

^A Pentaerythritol

^B >75% alpha vinylidene olefin end group

^C Polyethylene amine bottoms

^D Tetraethylene tetramine

^E Tris-hydroxymethyl aminomethane

^F Triethyltetramine

[0033] The lubricating composition of the present invention contains of 0.5 wt% to 8 wt% or 1 wt% to 6 wt% or 1.75 wt% to 5 wt% dispersant, which may comprise one or more of the dispersants described herein.

Other Antioxidants

[0034] Other ashless antioxidants which may be present in addition to or instead of the arylamine antioxidant may comprise one or more phenols, hindered phenols, sulfurized olefins, or mixtures thereof.

[0035] The phenolic antioxidant may be a simple alkyl phenol, a hindered phenol, or coupled phenolic compounds. Hindered phenol antioxidants often contain a secondary butyl and/or a tertiary butyl group as a sterically hindering group. The phenol group may be further substituted with a hydrocarbyl group (typically linear or branched alkyl) and/or a bridging group linking to a second aromatic group. Examples of suitable hindered phenol

antioxidants include 2,6-di-tert-butylphenol, 4-methyl-2,6-di-tert-butylphenol, 4-ethyl-2,6-di-tert-butylphenol, 4-propyl-2,6-di-tert-butylphenol or 4-butyl-2,6-di-tert-butylphenol, 4-dodecyl-2,6-di-tert-butylphenol, or butyl 3-(3,5-ditert-butyl-4-hydroxyphenyl)propanoate. In one embodiment, the hindered phenol antioxidant may be an ester and may include, e.g., Irganox™ L-135 from Ciba.

[0036] Coupled phenols often contain two alkylphenols coupled with alkylene groups to form bisphenol compounds. Examples of suitable coupled phenol compounds include 4,4'-methylene bis-(2,6-di-tert-butyl phenol), 4-methyl-2,6-di-tert-butylphenol, 2,2'-bis-(6-tert-butyl-4-heptylphenol); 4,4'-bis(2,6-di-tert-butyl phenol), 2,2'-methylenebis(4-methyl-6-tert-butylphenol), and 2,2'-methylene bis(4-ethyl-6-tert-butylphenol).

[0037] Phenols of the invention also include polyhydric aromatic compounds and their derivatives. Examples of suitable polyhydric aromatic compounds include esters and amides of gallic acid, 2,5-dihydroxybenzoic acid, 2,6-dihydroxybenzoic acid, 1,4-dihydroxy-2-naphthoic acid, 3,5-dihydroxynaphthoic acid, 3,7-dihydroxy naphthoic acid, and mixtures thereof.

[0038] In one embodiment, the phenolic antioxidant comprises a hindered phenol. In another embodiment the hindered phenol is derived from 2,6-ditertbutyl phenol.

[0039] In one embodiment the lubricating composition of the invention comprises a phenolic antioxidant in a range of 0.01 wt % to 5 wt %, or 0.1 wt % to 4 wt %, or 0.2 wt % to 3 wt %, or 0.5 wt % to 2 wt % of the lubricating composition.

[0040] Sulfurized olefins are well known commercial materials, and those which are substantially nitrogen-free, that is, not containing nitrogen functionality, are readily available. The olefinic compounds which may be sulfurized are diverse in nature. They contain at least one olefinic double bond, which is defined as a non-aromatic double bond; that is, one connecting two aliphatic carbon atoms. These materials generally have sulfide linkages having 1 to 10 sulfur atoms, for instance, 1 to 4, or 1 or 2. In one embodiment, the lubricating composition of the invention comprises a sulfurized olefin in a range 0.2 weight percent to 2.5 weight percent, or 0.5 weight percent to 2.0 weight percent, or 0.7 weight percent to 1.5 weight percent.

[0041] Antioxidants other than arylamine antioxidants may be used instead of or in addition to the arylamine antioxidant and may be used separately or in combination. In one embodiment of the invention, two or more different antioxidants are used in combination,

such that there is at least 0.1 weight percent of each of the at least two antioxidants and wherein the combined amount of the ashless antioxidants is 0.5 to 5 weight percent. In one embodiment, there may be at least 0.25 to 3 weight percent of each ashless antioxidant. In one embodiment, there may be 1.0 to 5.0 weight percent of one or more ashless antioxidants, or 1.4 to 3.0 weight percent of one or more antioxidants.

Other Performance Additives

[0042] The compositions of the invention may optionally comprise one or more other additional performance additives. These additional performance additives may include, but are not limited to, one or more dispersants, including borated dispersants, anti-wear additives, detergents, metal deactivators, viscosity modifiers, detergents, friction modifiers, antiwear agents, corrosion inhibitors, dispersant viscosity modifiers, extreme pressure agents, foam inhibitors, demulsifiers, pour point depressants, seal swelling agents, and any combination or mixture thereof. Typically, fully-formulated lubricating oil will contain one or more of these performance additives, and often a package of multiple performance additives.

[0043] In one embodiment, the invention provides a lubricating composition further comprising a detergent. In one embodiment, the detergent may be an alkali or alkaline earth metal sulfonate detergent, an alkali or alkaline earth metal salicylate detergent, an alkali or alkali earth metal salixarate detergent, or an alkali or alkaline earth metal phenate detergent. The detergent may be an overbased detergent. Overbased detergents, otherwise referred to as overbased or superbased salts, are characterized by a metal content in excess of that which would be necessary for neutralization according to the stoichiometry of the metal and the particular acidic organic compound reacted with the metal. Overbased detergents are known in the art and the lubricating composition of the present invention may contain detergents that are now known or hereafter developed and understood to be useful in the present invention to those skilled in the art.

[0044] In one embodiment, the detergent may comprise an overbased metal-containing sulfonate detergent. Overbased metal-containing sulfonate detergents may include calcium salts, magnesium salts, sodium salts, or mixtures thereof of one or more sulfonates. Other useful metals may include titanium and zirconium. Overbased sulfonates typically have a total base number of 250 to 600, or 300 to 500. In one embodiment, the sulfonate detergent may be predominantly a linear alkylbenzene

sulfonate detergent having a metal ratio of at least 8 as is described in paragraphs [0026] to [0037] of US Patent Publication 2005065045 (and granted as US 7,407,919). The linear alkyl group may be attached to the benzene ring anywhere along the linear chain of the alkyl group, but often in the 2, 3 or 4 position of the linear chain, and in some instances, predominantly in the 2 position, resulting in the linear alkylbenzene sulfonate detergent.

[0045] In one embodiment, the lubricating composition may comprise an alkali or alkaline earth metal salicylate detergent or salixarate detergent or mixture thereof. The metal containing salicylate or salixarate detergent may be an overbased detergent. Useful salicylate and salixarate detergents may include calcium salts, magnesium salts, sodium salts or mixtures thereof. Other useful metals may include titanium and zirconium.

[0046] In one embodiment, the lubricating composition may contain a metal containing sulfur coupled alkyl phenol compound. Such compounds may be exemplified by alkali and alkaline earth metal containing phenate detergents, such as magnesium phenate detergents, calcium phenate detergents and sodium phenate detergents and further including overbased metal containing phenate detergents, all of which are known in the art.

[0047] Examples of detergents which may be used in the present invention are summarized in the table below:

Metal	TBN (oil free)	Substrate
Mg	690	Sulfonate (BBC-1)*
Ca	170	Sulfonate (BBC-1)
Ca	485	Salicylate
Ca	235	Salixarate
Ca	304	Salicylate
Na	700	Sulfonate (BBC-1)
Ca	690	Sulfonate (BBC-1)

* Mono- C20-24 alkylbenzene

[0048] In one embodiment, the detergent comprises or consists of a calcium detergent. In another embodiment, the detergent may comprise a mixture of calcium and magnesium containing detergents such as those disclosed herein where the detergent mixture may provide 800 to 1300 ppm calcium and 450 to 800 ppm magnesium and in another embodiment 900 to 1200 ppm calcium and 500 to 750 ppm magnesium.

[0049] According to some embodiments, the total amount of soap contributed by the detergent may be from about 0.08 or 1.0 to less than 0.9 or 0.7 or 0.5 or 0.4 or 0.3 or 0.25 wt. % with respect to the lubricating composition. The lubricating composition may be free or substantially free of phenate soap. As used herein the term "soap" means the surfactant portion of a detergent and does not include a metal base, such as calcium carbonate. The soap term may also be referred to as a detergent substrate. For example, the sulfonate detergents described herein, the soap or substrate may be a neutral salt of an alkylbenzenesulfonic acid.

[0050] Metal-containing detergents may also contribute sulfated ash to a lubricating composition. Sulfated ash may be determined by ASTM D874. In one embodiment, the lubricating composition of the invention comprises a metal-containing detergent in an amount to deliver at least 0.4 wt. % sulfated ash to the total composition. In another embodiment, the metal-containing detergent is present in an amount to deliver at least 0.6 wt. % sulfated ash, or at least 0.75 wt. % sulfated ash, or even at least 0.9 wt. % sulfated ash to the lubricating composition.

[0051] In some embodiments, the lubricating compositions of the present invention may contain an organophosphorous anti-wear agent. The organo-phosphorus anti-wear agent may be a metal free organo-phosphorus anti-wear agent. The organo-phosphorus agent may contain sulfur or may be sulfur-free. Sulfur-free phosphorus-containing antiwear agents may be phosphites, phosphonates, alkylphosphate esters, amine or ammonium phosphate salts, or mixtures thereof.

[0052] Phosphorus esters such as the dihydrocarbon and trihydrocarbon phosphites, e.g., dibutyl phosphite, diheptyl phosphite, dicyclohexyl phosphite, pentylphenyl phosphite; dipentylphenyl phosphite, tridecyl phosphite, distearyl phosphite and polypropylene substituted phenol phosphite; metal thiocarbamates such as zinc dioctyldithiocarbamate and barium heptylphenol diacid; amine salts of alkyl and dialkylphosphoric acids or derivatives including, for example, the amine salt of a reaction product of a dialkyldithiophosphoric acid with propylene oxide and subsequently followed by a further reaction with P₂O₅; and mixtures thereof (as described in US 3,197,405).

[0053] Amine phosphates may be amine salts of (i) monohydrocarbylphosphoric acid, (ii) dihydrocarbylphosphoric acid, (iii) hydroxy-substituted di-ester of phosphoric acid, or (iv) phosphorylated hydroxy-substituted di- or tri-ester of phosphoric acid. The

amine salt of a sulfur-free phosphorus-containing compound may be salts of primary amines, secondary amines, tertiary amines, or mixtures thereof.

[0054] Amine phosphate salts may be derived from mono- or di- hydrocarbyl phosphoric acid (typically alkyl phosphoric acid), or mixtures thereof. The alkyl of the mono- or di- hydrocarbyl phosphoric acid may comprise linear or branched alkyl groups of 3 to 36 carbon atoms. The hydrocarbyl group of the linear or branched hydrocarbylphosphoric acid may contain 4 to 30, or 8 to 20 carbon atoms. Examples of a suitable hydrocarbyl group of the hydrocarbyl phosphoric acid may include isopropyl, n-butyl, sec-butyl, amyl, 4-methyl-2-pentyl (i.e., methylamyl), n-hexyl, n-heptyl, n-octyl, iso-octyl, 2-ethylhexyl, nonyl, 2-propylheptyl, decyl, dodecyl, tetradecyl, hexadecyl, octadecyl, oleyl, or combinations thereof. In one embodiment, the phosphate is a mixture of mono- and di- (2-ethyl)hexylphosphate.

[0055] Examples of suitable primary amines include ethylamine, propylamine, butylamine, 2-ethylhexylamine, octylamine, and dodecylamine, as well as such fatty amines as n-octylamine, n-decylamine, n-dodecylamine, n-tetradecylamine, n-hexadecylamine, n-octadecylamine and oleyamine. Other useful fatty amines include commercially available fatty amines such as "Armeen®." amines (products available from Akzo Chemicals, Chicago, Ill.), such as Armeen C, Armeen O, Armeen O L, Armeen T, Armeen H T, Armeen S and Armeen S D, wherein the letter designation relates to the fatty group, such as coco, oleyl, tallow, or stearyl groups.

[0056] In one embodiment, the metal-free phosphorus anti-wear agent may be present in the lubricant composition in amount of 0.01 to 5 wt %, or 0.1 to 3.2 wt %, or 0.35 to 1.8 wt %, or 0.5 to 1.5 wt %, or 0.5 to 0.9 wt %. In one embodiment, the metal-free phosphorus anti-wear agent may be present in an amount to provide 0.01 wt % to 0.15 wt % phosphorus, or 0.01 to 0.08 wt % phosphorus, or 0.025 to 0.065 wt % phosphorus to the composition.

[0057] In another embodiment, the lubricating composition of the present invention is free of or substantially free of phosphorous or phosphorous containing agents.

[0058] In one embodiment, the invention provides a lubricating composition which further includes an ashless antiwear agent different from the organo-phosphorus antiwear agent described above. Examples of suitable antiwear agents include hydroxy-carboxylic acid derivatives such as esters, amides, imides or amine or ammonium salt, sulfurized

olefins, thiocarbamate-containing compounds, such as thiocarbamate esters, thiocarbamate amides, thiocarbamic ethers, alkylene-coupled thiocarbamates, and bis(S-alkyldithiocarbamyl) disulphides.

[0059] In one embodiment, an ashless antiwear agent may include a compound derived from a hydroxycarboxylic acid. In one embodiment the ashless antiwear agent is derived from at least one of hydroxy-polycarboxylic acid di-ester, a hydroxy-polycarboxylic acid di-amide, a hydroxy-polycarboxylic acid imide, and a hydroxy-polycarboxylic acid ester amide. In one embodiment the ashless antiwear agent is derived from a hydroxy-polycarboxylic acid imide.

[0060] Examples of a suitable a hydroxycarboxylic acid include citric acid, tartaric acid, lactic acid, glycolic acid, hydroxy-propionic acid, hydroxyglutaric acid, or mixtures thereof. In one embodiment ashless antiwear agent is derived from tartaric acid, citric acid, hydroxy-succinic acid, dihydroxy mono-acids, mono-hydroxy diacids, or mixtures thereof. In one embodiment the ashless antiwear agent includes a compound derived from tartaric acid or citric acid. In one embodiment the ashless antiwear agent includes a compound derived from tartaric acid.

[0061] US Patent Application 2005/198894 discloses suitable hydroxycarboxylic acid compounds, and methods of preparing the same.

[0062] Canadian Patent 1 183 125; US Patent Publication numbers 2006/0183647 and US-2006-0079413; U.S. Patent Application No. 60/867,402; and British Patent 2 105743 A. all disclose examples of suitable tartaric acid derivatives. The antiwear agent may in one embodiment include a tartrate or tartramide as disclosed in International Publication WO 2006/044411 or Canadian Patent CA 1 183 125. The tartrate or tartramide may contain alkyl-ester groups, where the sum of carbon atoms on the alkyl groups is at least 8. The antiwear agent may in one embodiment include a citrate.

[0063] An ashless phosphorus-free antiwear agent may be present at 0.1 to 5 wt %, 0.1 wt % to 3 wt %, or 0.2 to 3 or 0.1 wt % to 1.5 wt %, or 0.5 wt % to 1.1 wt % of the lubricating composition.

[0064] In one embodiment, the invention may also provide a lubricating composition which further includes a metal dialkyldithiophosphate. Typically, the metal dialkyldithiophosphate may be a zinc dialkyldithiophosphate (ZDDP), or mixtures thereof. Zinc dialkyldithiophosphates are known in the art. The zinc dialkyldithiophosphate may

be present at 0 wt % to 3 wt %, or 0.1 wt % to 1.5 wt %, or 0.5 wt % to 0.9 wt % of the lubricating composition. In another embodiment, ZDDP is present in amounts such that the total zinc contributed to the lubricant composition does not exceed 0.15 weight percent of the composition, for example, zinc may be presents in amounts of from 0 wt % to 0.15 wt %, or even less than 0.14 wt %, or even less than 0.11 wt %, or even less than 0.09 wt%, or even less than 0.07 wt%, or even less than 0.05 wt%, or even less than 0.03 wt% and in another embodiment 0.01 wt % to 0.14 wt %. In another embodiment, the lubricating composition is substantially free of zinc.

[0065] The zinc dialkyldithiophosphate may be derived from primary alcohols, secondary alcohols, or combinations thereof. Typically, they are derived from primary and secondary alcohols containing 3 to 12 carbon atoms and combinations thereof. In one embodiment the zinc alkyldithiophosphate comprises at least 25 mol % secondary alkyl groups, or at least 40 mol % secondary alkyl groups, or at least 75 mol % secondary alkyl groups, or at least 90 mol % secondary alkyl groups.

[0066] Polymeric viscosity index improvers, also referred to as viscosity modifiers (VM) or dispersant viscosity modifiers (DVM, may be useful in the compositions disclosed herein. The dispersant viscosity modifier may be generally understood to be a functionalized, i.e., derivatized, form of a polymer similar to that of the polymeric viscosity modifier. The polymeric viscosity modifier may be an olefin (co)polymer, a poly(meth)acrylate (PMA), or mixtures thereof. In one embodiment, the polymeric viscosity modifier is an olefin (co)polymer or dispersant viscosity modifier derived therefrom.

[0067] The olefin polymer may be derived from isobutylene or isoprene. In one embodiment, the olefin polymer is prepared from ethylene and a higher olefin within the range of C3-C10 alpha-mono-olefins, for example, the olefin polymer may be prepared from ethylene and propylene.

[0068] Useful olefin polymers, in particular, ethylene-a-olefin copolymers have a number average molecular weight ranging from 4500 to 500,000, for example, 5000 to 100,000, or 7500 to 60,000, or 8000 to 45,000.

[0069] The formation of functionalized ethylene-a-olefin copolymer is well known in the art, for instance those described in U.S. Patent US 7,790,661 column 2, line 48 to column 10, line 38. Additional detailed descriptions of similar functionalized ethylene-a-

olefin copolymers are found in International Publication W02006/015130 or U.S. Patents 4,863,623; 6,107,257; 6,107,258; 6,117,825; and US 7,790,661. In one embodiment, the functionalized ethylene-a-olefin copolymer may include those described in U.S. Patent 4,863,623 (see column 2, line 15 to column 3, line 52) or in International Publication W02006/015130 (see page 2, paragraph [0008] and preparative examples are described paragraphs [0065] to [0073]).

[0070] In one embodiment, the lubricating composition comprises a dispersant viscosity modifier (DVM). The DVM may comprise an olefin polymer that has been modified by the addition of a polar moiety.

[0071] The olefin polymers are functionalized by modifying the polymer by the addition of a polar moiety. In one useful embodiment, the functionalized copolymer is the reaction product of an olefin polymer grafted with an acylating agent. In one embodiment, the acylating agent may be an ethylenically unsaturated acylating agent. Useful acylating agents are typically α,β -unsaturated compounds having at least one ethylenic bond (prior to reaction) and at least one, for example two, carboxylic acid (or its anhydride) groups or a polar group which is convertible into said carboxyl groups by oxidation or hydrolysis. The acylating agent grafts onto the olefin polymer to give two carboxylic acid functionalities. Examples of useful acylating agents include maleic anhydride, chlormaleic anhydride, itaconic anhydride, or the reactive equivalents thereof, for example, the corresponding dicarboxylic acids, such as maleic acid, fumaric acid, cinnamic acid, (meth)acrylic acid, the esters of these compounds and the acid chlorides of these compounds.

[0072] In one embodiment, the functionalized ethylene-a-olefin copolymer comprises an olefin copolymer grafted with the acyl group, which is further functionalized with a hydrocarbyl amine, a hydrocarbyl alcohol group, amino- or hydroxy- terminated polyether compounds, and mixtures thereof.

[0073] In one embodiment, the hydrocarbyl amine may be selected from aromatic amines, aliphatic amines, and mixtures thereof. In one embodiment, the hydrocarbyl amine component may comprise at least one aromatic amine containing at least one amino group capable of condensing with said acyl group to provide a pendant group and at least one additional group comprising at least one nitrogen, oxygen, or sulfur atom, wherein said aromatic amine is selected from the group consisting of (i) a nitrosubstituted aniline, (ii) an

amine comprising two aromatic moieties linked by a C(0)NR- group, a -C(0)O- group, an -O- group, an N=N- group, or an -802- group where R is hydrogen or hydrocarbyl, one of said aromatic moieties bearing said condensable amino group, (iii) an aminoquinoline, (iv) an aminobenzimidazole, (v) an N,N- dialkylphenylenediamine, (vi), an aminodiphenyl amine (also N-phenylphenylenediamine), (vii) a ring-substituted benzylamine, and (viii) a methylene-coupled dimer of aminodiphenyl amine.

[0074] In one embodiment, lubricating composition may comprise a poly(meth)acrylate polymeric viscosity modifier. As used herein, the term “(meth)acrylate” and its cognates means either methacrylate or acrylate, as will be readily understood.

[0075] In one embodiment, the poly(meth)acrylate polymer is prepared from a monomer mixture comprising (meth)acrylate monomers having alkyl groups of varying length. The (meth)acrylate monomers may contain alkyl groups that are straight chain or branched chain groups. The alkyl groups may contain 1 to 24 carbon atoms, for example, 1 to 20 carbon atoms.

[0076] In one embodiment, the poly(meth)acrylate polymer comprises a dispersant monomer; dispersant monomers include those monomers which may copolymerize with (meth)acrylate monomers and contain one or more heteroatoms in addition to the carbonyl group of the (meth)acrylate. The dispersant monomer may contain a nitrogen-containing group, an oxygen-containing group, or mixtures thereof.

[0077] Dispersant monomers may be present in an amount up to 5 mol percent of the monomer composition of the (meth)acrylate polymer. In one embodiment, the poly(meth)acrylate is present in an amount 0 to 5 mol percent, 0.5 to 4 mol percent, or 0.8 to 3 mol percent of the polymer composition. In one embodiment, the poly(meth)acrylate is free of or substantially free of dispersant monomers.

[0078] In one embodiment, the poly(meth)acrylate polymer (P) is a block or tapered block copolymer that comprises at least one polymer block (B1) that is insoluble or substantially insoluble in the base oil and a second polymer block (B2) that is soluble or substantially soluble in the base oil.

[0079] In one embodiment, the poly(meth)acrylate polymers may have an architecture selected from linear, branched, hyper-branched, cross-linked, star (also referred to as “radial”), or combinations thereof. Star or radial refers to multi -armed polymers. Such

polymers include (meth)acrylate-containing polymers comprising 3 or more arms or branches, which, in some embodiments, contain at least about 20, or at least 50 or 100 or 200 or 350 or 500 or 1000 carbon atoms. The arms are generally attached to a multivalent organic moiety which acts as a “core” or “coupling agent.” The multi-armed polymer may be referred to as a radial or star polymer, or even a “comb” polymer, or a polymer otherwise having multiple arms or branches as described herein.

[0080] Linear poly(meth)acrylates, random, block or otherwise, may have weight average molecular weight (Mw) of 1000 to 400,000 Daltons, 1000 to 150,000 Daltons, or 15,000 to 100,000 Daltons. In one embodiment, the poly(meth)acrylate may be a linear block copolymer with a Mw of 5,000 to 40,000 Daltons, or 10,000 to 30,000 Daltons. Radial, cross-linked or star copolymers may be derived from linear random or di-block copolymers with molecular weights as described above. A star polymer may have a weight average molecular weight of 10,000 to 1,500,000 Daltons, or 40,000 to 1,000,000 Daltons, or 300,000 to 850,000 Daltons.

[0081] Another class of polymeric viscosity modifiers is styrene-diene (SD) copolymers, such as styrene isoprene (SI) and styrene butadiene (SBR). Styrenediene copolymers may be linear or radial (star-shaped), and generally contain one or more distinct blocks of styrene attached to one or more distinct blocks of hydrogenated diene.

[0082] In some embodiments, the lubricating compositions may comprise 0.05 wt% to 4 wt%, or 0.08 wt% to 2 wt%, or 0.1 to 1 wt% of the one or more polymeric viscosity modifiers and/or dispersant viscosity modifiers. In other embodiments, the lubricating composition may be free of or substantially free of polymeric viscosity modifiers.

[0083] In one embodiment, the invention provides a lubricating composition further comprising a molybdenum compound. The molybdenum compound may be selected from the group consisting of molybdenum dialkyldithiophosphates, molybdenum dithiocarbamates, amine salts of molybdenum compounds, and mixtures thereof. The molybdenum compound may provide the lubricating composition with 0 to 1000 ppm, or 5 to 1000 ppm, or 10 to 750 ppm, or 5 ppm to 300 ppm, or 20 ppm to 250 ppm of molybdenum.

[0084] In one embodiment, the invention provides a lubricating composition further comprising a friction modifier. Examples of friction modifiers include long chain

fatty acid derivatives of amines, fatty esters, or epoxides; fatty imidazolines such as condensation products of carboxylic acids and polyalkylene-polyamines; amine salts of alkylphosphoric acids; fatty alkyl tartrates; fatty alkyl tartrides; or fatty alkyl tartrides. The term fatty, as used herein, can mean having a C8-22 linear alkyl group.

[0085] Friction modifiers may also encompass materials such as sulfurized fatty compounds and olefins, molybdenum dialkyldithiophosphates, molybdenum dithiocarbamates, sunflower oil or monoester of a polyol and an aliphatic carboxylic acid.

[0086] In one embodiment, the friction modifier may be selected from the group consisting of long chain fatty acid derivatives of amines, long chain fatty esters, or long chain fatty epoxides; fatty imidazolines; amine salts of alkylphosphoric acids; fatty alkyl tartrates; fatty alkyl tartrides; and fatty alkyl tartrides. The friction modifier may be present at 0.05 wt % to 6 wt %, or 0.05 wt % to 4 wt %, or 0.1 wt % to 2 wt % of the lubricating composition.

[0087] In one embodiment, the friction modifier may be a long chain fatty acid ester. In another embodiment the long chain fatty acid ester may be a mono-ester or a diester or a mixture thereof, and in another embodiment the long chain fatty acid ester may be a triglyceride.

[0088] Other performance additives such as corrosion inhibitors include those described in paragraphs 5 to 8 of US Application US05/038319, published as WO2006/047486, octyl octanamide, condensation products of dodecenyl succinic acid or anhydride and a fatty acid such as oleic acid with a polyamine. In one embodiment, the corrosion inhibitors include the Synalox® (a registered trademark of The Dow Chemical Company) corrosion inhibitor. The Synalox® corrosion inhibitor may be a homopolymer or copolymer of propylene oxide. The Synalox® corrosion inhibitor is described in more detail in a product brochure with Form No. 118-01453-0702 AMS, published by The Dow Chemical Company. The product brochure is entitled "SYNALOX Lubricants, High-Performance Polyglycols for Demanding Applications."

[0089] The lubricating composition may further include metal deactivators, including derivatives of benzotriazoles (typically tolyltriazole), dimercaptotriazole derivatives, 1,2,4-triazoles, benzimidazoles, 2-alkyldithiobenzimidazoles, or 2-alkyldithiobenzothiazoles; foam inhibitors, including copolymers of ethyl acrylate and 2-ethylhexylacrylate and copolymers of ethyl acrylate and 2-ethylhexylacrylate and vinyl

acetate; demulsifiers including trialkyl phosphates, polyethylene glycols, polyethylene oxides, polypropylene oxides and (ethylene oxide-propylene oxide) polymers; and pour point depressants, including esters of maleic anhydride-styrene, polymethacrylates, polyacrylates or polyacrylamides.

[0090] Pour point depressants that may be useful in the compositions of the invention further include polyalphaolefins, esters of maleic anhydride-styrene, poly(meth)acrylates, polyacrylates or polyacrylamides.

[0091] In different embodiments, the lubricating composition may have a composition as described in the following table:

	Embodiments (wt %)		
	A	B	C
Alcohol	1 to 8	2 to 6	3 to 5
Aryl amine antioxidant	0 to 3	0 to 2.5	0 to 2
Dispersant	0.5 to 10	1.5 to 8	2 to 7
Detergent	0.3 to 3.0	0.4 to 2.5	0.6 to 1.8
Additional Antioxidant	0.1 to 5	0.3 to 4	1 to 3
Antiwear	0.1 to 3	0.15 to 2	0.2 to 1
Viscosity Modifier	0 to 5	0 to 4	0.2 to 2
Other Performance Additives	0 to 1.0	0.001 to 0.75	0.001 to 0.5
Base Oil	Balance to 100%		

[0092] The invention will be further illustrated by the following examples, which set forth particularly advantageous embodiments. While the examples are provided to illustrate the invention, they are not intended to limit it.

[0093] The Examples contain the following components:

Diols – (summarized below with reference to Formula I)

	R ¹	Name
DIOL1	C4	1,2-hexanediol
DIOL2	C6	1,2-octanediol
DIOL3	C8	1,2-decanediol
DIOL4	C10	1,2-dodecanediol

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Dispersants

	Pib Type	Mn	Succination Process	MAA:PIB	Amine	%N (oil free)	%B (oil free)
D1	High Vinylidene ^B	1000	Thermal	1.3:1	PEA ^C	3.8	0.81
D2	High Vinylidene ^B	1000	Thermal	1.3:1	PEA ^C	2.13	--

^B >75% alpha vinylidene olefin end group^C Polyethylene amine bottomsDetergents

	Metal	TBN (oil free)	Substrate
DT1	Mg	690	Sulfonate (BBC-1)*
DT3	Ca	485	Salicylate

*Mono- C20-24 alkylbenzene

Antiwear Additives

AW1	Zinc alkyldithiophosphate	Secondary alcohols (Isopropyl alcohol/Methyl Isobutyl carbinol) 10% P/11%Zn
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Antioxidants

AO1	C9 substituted diphenyl amine AO
AO2	Sulfurized butadiene/butyl acrylate DA adduct

[0094] Several exemplary lubricating compositions were prepared according to Tables 1 and 2. Table 1 outlines base lubricating composition formulations. Table 2 provides examples of base formulation 1 comprising an top treat of alcohols as described herein.

Table 1: Base Formulations

	Dispersant (wt %)	Detergent (wt %)	Antiwear (wt %)	Antioxidant (wt %)	Others Additives ^A (wt %)	Oxyalkylated Phenol (wt %)	Base Oil Balance to 100%
FORM 1	D1 (1.13) D2 (2.24)	DT1 (0.35) DT3 (0.61)	AW1 (0.7)	AO1 (1.0) AO2 (0.5)	0.35	1.5	Group III

^A Includes Friction modifiers, Corrosion Inhibitors, Viscosity Modifiers, Pour Point Depressant, and antifoams

Table 2: Base formulations with diols

	Formulation from Table 1	Diol	Diol (wt%)
COMP 1	FORM 1	DIOL 1	3
COMP 2	FORM 1	DIOL 2	3
COMP 3	FORM 1	DIOL 3	3
Example 1	FORM 1	DIOL 4	3

[0095] Example 1, formulation 1 and comparative Examples 1-3 were evaluated in the Oxidation Test for Engine Oils Operating in the Presence of Biodiesel Fuel, CEC L-109-14, which is incorporated herein by reference. The oxidation Test for Engine Oils Operating in the Presence of Biodiesel Fuel: CEC L-109-14 Oxidation Test for Engine Oils Operating in the Presence of Biodiesel Fuel is a standard test method for evaluation of viscosity increase and oxidation level of an aged oil in the presence of biodiesel. The test is conducted at 150° C by blowing 10 L/h air through the heated sample for 168 and/or 216 hrs in the presence of 7 wt % B100 (pure biodiesel). Relative Viscosity increase versus time and oxidation (using Fourier Transform Infrared Spectroscopy, or “FTIR”) versus time is measured. The test can be found at www.cectests.org/L109. The test results are shown in Table 3 below.

Table 3: Oxidation Test for Engine Oils Operating in the Presence of Biodiesel Fuel: CEC L-109-14 Oxidation Test

	Oxidation @168 hours (A/cm)	Oxidation @216 Hours (A/cm)	Δ KV 100 @ 168 Hours (%)	Δ KV 100 @ 216 Hours (%)
FORM 1	31	33.8	163.24	892.69
FORM 1	26.6	32	164.4	850.26
FORM 1	36.2	41.1	484.82	TVTM ^A
COMP 1	35.9	39.2	146.15	731.85
COMP 2	36.7	TVTM ^A	830.48	1380.5
COMP 3	38.3	44.6	108.66	1674.55
Example 1	38.2	70.4	70.22	292.51

^A TVTM = Too viscous to measure

[0096] The test results indicate that the lubricant composition containing the claimed alcohols displayed superior viscosity control when compared to their corresponding formulation not comprising the alcohol.

[0097] It is known that some of the materials described above may interact in the final formulation, so that the components of the final formulation may be different from those

that are initially added. The products formed thereby, including the products formed upon employing lubricant composition of the present invention in its intended use, may not be susceptible of easy description. Nevertheless, all such modifications and reaction products are included within the scope of the present invention; the present invention encompasses lubricant composition prepared by admixing the components described above.

[0098] While the invention has been explained in relation to its preferred embodiments, it is to be understood that various modifications thereof will become apparent to those skilled in the art upon reading the specification. Therefore, it is to be understood that the invention disclosed herein is intended to cover such modifications as fall within the scope of the appended claims. Except in the Examples, or where otherwise explicitly indicated or required by context, all numerical quantities in this description specifying amounts of materials, reaction conditions, molecular weights, number of carbon atoms, and the like, are to be understood as modified by the word “about”. As used herein, the term “about” means that a value of a given quantity is within $\pm 20\%$ of the stated value. In other embodiments, the value is within $\pm 15\%$ of the stated value. In other embodiments, the value is within $\pm 10\%$ of the stated value. In other embodiments, the value is within $\pm 5\%$ of the stated value. In other embodiments, the value is within $\pm 2.5\%$ of the stated value. In other embodiments, the value is within $\pm 1\%$ of the stated value. In other embodiments, the value is within a range of the explicitly-described value which would be understood by those of ordinary skill, based on the disclosures provided herein, to perform substantially similarly to compositions including the literal amounts described herein.

[0099] As used herein, “substantially free” means that the amount of the material in question is less than an amount that will affect the relevant performance of the fluid in a measurable way. “Substantially free” may also mean that the material in question is not intentionally added to the composition but does not exclude the presence of such material as contaminants. “Substantially free” may also mean that the material in question may be present in amounts lower than the detection limit of standard test methods now known to those skilled in the art or hereafter developed. In some embodiments, “substantially free” may mean less than 10 ppm by weight or even less than 5 ppm by weight.

[0100] It is to be understood that the upper and lower amount, range, and ratio limits set forth herein may be independently combined, and that any amount within a disclosed

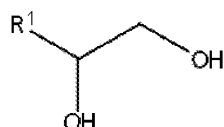
range is contemplated to provide a minimum or maximum of a narrower range in alternative embodiments (with the proviso, of course, that the minimum amount of a range must be lower than the maximum amount of the same range). Similarly, the ranges and amounts for each element of the subject matter disclosed herein may be used together with ranges or amounts for any of the other elements.

[0101] While certain representative embodiments and details have been shown for the purpose of illustrating the subject matter disclosed herein, it will be apparent to those skilled in this art that various changes and modifications may be made therein without departing from the scope of the subject matter. In this regard, the scope of the invention is to be limited only by the following claims.

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Claims

1. A lubricating composition comprising:
 - (a) an oil of lubricating viscosity;
 - (b) 1 wt% to 5 wt% of a branched diol having the formula:



where R¹ is an alkyl chain having 4 to 10 carbon atoms;

- (c) less than 3 wt % (less than 2.5% or less than 2%) of an aryl amine antioxidant; and
 - (d) 0.5 wt% to 8 wt% or 1 wt% to 6 wt% or 1.75 wt% to 5 wt% of a dispersant.
2. The lubricating composition of claim 1, wherein the lubricating composition contains at least 40% by weight of Group I, Group II, or Group III base oils or mixtures thereof.
3. The lubricating composition of claim 1 or 2, wherein the lubricating composition contains less than 50% by weight of a polyalphaolefin base oil.
4. The lubricating composition of any of claims 1 to 3, wherein the lubricating composition contains less than 50 wt%, or less than 40 wt%, or less than 30 wt%, or less than 20 wt% of a polyalphaolefin base oil.
5. The lubricating composition of any preceding claim, wherein the lubricating composition is free of or substantially free of a polyalphaolefin base oil.
6. The lubricating composition of any preceding claim, wherein the aryl amine antioxidant comprises or consists of nonyl-substituted diphenyl amine.

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7. The lubricating composition of any preceding claim, further comprising one or more additional antioxidants.
8. The lubricating composition of claim 5, wherein the one or more additional antioxidants is selected from the group consisting of phenols, hindered phenols, sulfurized olefins, or mixtures thereof.
9. The lubricating composition of any preceding claim, wherein the lubricating composition is substantially free of aryl amine antioxidant.
10. The lubricating composition of any preceding claim, wherein the dispersant comprises a hydrocarbyl succinimide dispersant.
11. The lubricating composition of claim 10, wherein the hydrocarbyl succinimide dispersant is a polyisobutylene succinimide dispersant.
12. The lubricating composition of claim 10 or 11, wherein the polyisobutylene succinimide dispersant is borated.
13. The lubricating composition of any of claims 10 to 12 wherein the dispersant is produced from a direct alkylation process.
14. The lubricating composition of any preceding claim, wherein the dispersant comprises an amine dispersant.
15. The lubricating composition of claim 14, wherein the amine dispersant comprises the reaction product of polyisobutylene succinic anhydride and an amine.
16. The lubricating composition of claim 15, wherein the amine is a polyamine selected from the group consisting of ethylene polyamine, propylene polyamine, butylene polyamine, or a mixture thereof.

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17. The lubricating composition of any preceding claim, wherein the dispersant comprises an oxyalkylated hydrocarbyl phenol.
18. The composition of any preceding claim, wherein the lubricating composition further comprises one or more metal containing detergents.
19. The composition of claim 18, wherein the metal of the metal containing detergent is selected from magnesium, calcium, sodium, and mixtures thereof.
20. The composition of claim 18 or 19, wherein the detergent of the metal containing detergent is selected from sulfonates, phenates, salicylates, salixarates or mixtures thereof.
21. The composition of any of claims 18 to 20, wherein the metal containing detergent comprises a calcium detergent and wherein the calcium detergent is present in an amount sufficient to deliver 500 ppm to 3000 ppm or 1000 ppm to 2500 ppm by weight calcium to the composition.
22. The composition of any of claims 18 to 20, wherein the metal containing detergent comprises a magnesium detergent and wherein the magnesium detergent is present in an amount to deliver up to 500 ppm magnesium to the composition.
23. The composition of any preceding claim further comprising a molybdenum compound.
24. The composition of any preceding claim, wherein the composition comprises phosphorous in amounts of 0.2 wt% or less, or 0.12 wt % or less, or 0.1 wt % or less, or 0.09 wt % or less, or 0.08 wt % or less, or 0.06 wt % or less, 0.05 wt % or less, or 0.03 wt % or less, or even 0.02 wt % or less.
25. The composition of any preceding claim, wherein the composition is substantially free of or free of phosphorous.

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26. The composition of any of claims 1 to 24 further comprising a metal alkylthiophosphate.
27. The composition of claim 26, wherein the metal alkylthiophosphate comprises zinc dialkyldithiophosphate.
28. The composition of claim 27, wherein the zinc dialkyldithiophosphate is present in an amount sufficient to provide from 0.02 to 0.2 wt% zinc to the composition.
29. The composition of any of claims 1 to 27, wherein the composition contains 0.015 wt % or less of zinc.
30. The composition of any of claims 1 to 27, wherein the composition contains zinc in amounts of less than 0.14 wt %, or even less than 0.11 wt %, or even less than 0.09 wt%, or even less than 0.07 wt%, or even less than 0.05 wt%, or even less than 0.03 wt%, or 0.01 wt % to 0.14 wt %.
31. The composition of any of claims 1 to 26, wherein the composition is substantially free of zinc.
32. The composition of any preceding claim, wherein the composition contains 0.1 to 0.4 wt % sulfurized olefins.
33. The composition of any of claims 1 to 31, wherein the lubricating composition is substantially free of or free of sulfurized olefin additives.
34. The composition of any of claims 1 to 33, wherein the composition has a total sulfated ash content of 2 wt % or less, or 1.6 wt % or less, or 1.1 wt % or less, or 1 wt % or less, or 0.8 wt % or less, or 0.6 wt % or less, or 0.5 wt % or less, or 0.05 wt % to 0.9 wt %, or 0.1 wt % to 0.2 wt % or to 0.45.

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35. A method of lubricating an internal combustion engine comprising:
operating said engine with a lubricant composition comprising as recited in claims 1 to 34.
36. A method of decomposing peroxide in a lubricating composition used to lubricate an internal combustion engine comprising:
supplying to said internal combustion engine the lubricating composition as recited in claims 1 to 34.
37. The use of a lubricating composition as recited in claims 1 to 34 for oxidation and deposit control in an internal combustion engine.