

METHOD FOR IMPROVING ENGINE FUEL EFFICIENCY

FIELD

[0001] This disclosure relates to improving fuel efficiency, while maintaining or improving high temperature performance (e.g., high temperature wear, deposit and varnish control), in an engine lubricated with a lubricating oil by including an alkoxylated alcohol component, in the lubricating oil.

BACKGROUND

[0002] Fuel efficiency requirements for passenger vehicles are becoming increasingly more stringent. New legislation in the United States and European Union within the past few years has set fuel economy and emissions targets not readily achievable with today's vehicle and lubricant technology.

[0003] To address these increasing standards, automotive original equipment manufacturers are demanding better fuel economy as a lubricant-related performance characteristic, while maintaining deposit control and oxidative stability requirements. One well known way to increase fuel economy is to decrease the viscosity of the lubricating oil. However, this approach is now reaching the limits of current equipment capabilities and specifications. At a given viscosity, it is well known that adding organic or organo-metallic friction modifiers reduces the surface friction of the lubricating oil and allows for better fuel economy. However these additives often bring with them detrimental effects such as increased deposit formation, seals impacts, or they out-compete the anti-wear components for limited surface sites, thereby not allowing the formation of an anti-wear film, causing increased wear.

[0004] Contemporary lubricants such as engine oils use mixtures of additives such as dispersants, detergents, inhibitors, viscosity index improvers and the like to provide engine cleanliness and durability under a wide range of performance conditions of temperature, pressure, and lubricant service life.

[0005] Lubricant-related performance characteristics such as high temperature deposit control, high temperature varnish control, and fuel economy are extremely advantageous attributes as measured by a variety of bench and engine tests. As indicated above, it is known that adding organic friction modifiers to a lubricant formulation imparts frictional benefits at low temperatures, consequently improving the lubricant fuel economy performance. At high temperatures, however, adding increased levels of organic friction modifier can invite high temperature performance issues. For example, excessive wear, deposits, and varnish are undesirable consequences of high levels of friction modifier in an engine oil formulation at high temperature engine operation.

[0006] U.S. Patent Application Publication No. 2005/0101497 discloses the use of an alkoxyated alcohol, both as an independent additive or in conjunction with one or more other additives, as a friction modifier that resists deterioration and achieves improved friction and friction durability. Power transmission fluids are disclosed that provide improved or lower static friction while maintaining dynamic friction, thus controlling (or decreasing) friction in a stable manner. The power transmission fluids comprise a major amount of a base oil and a minor amount of at least one alkoxyated alcohol.

[0007] A major challenge in engine oil formulation is simultaneously achieving high temperature wear, deposit, and varnish control while also achieving improved fuel economy.

[0008] Despite the advances in lubricant oil formulation technology, there exists a need for an engine oil lubricant that effectively improves fuel economy while maintaining or improving antiwear performance (e.g., high temperature wear, deposit and varnish control).

SUMMARY

[0009] This disclosure relates in part to a method for improving fuel efficiency, while maintaining or improving wear protection (e.g., high temperature wear, deposit and varnish control), in an engine lubricated with a lubricating oil by including at least one alkoxyated alcohol in the lubricating oil. The lubricating oils of this disclosure are

useful in internal combustion engines including direct injection, gasoline and diesel engines.

[0010] This disclosure also relates in part to a method for improving fuel efficiency, while maintaining or improving high temperature wear, deposit and varnish control, in an engine lubricated with a lubricating oil by using as the lubricating oil a formulated oil. The formulated oil has a composition comprising a lubricating oil base stock as a major component; and at least one alkoxyated alcohol, as a minor component. Fuel efficiency is improved and high temperature wear, deposit and varnish control are maintained or improved as compared to high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol.

[0011] This disclosure further relates in part to a lubricating engine oil having a composition comprising a lubricating oil base stock as a major component; and at least one alkoxyated alcohol, as a minor component. Fuel efficiency is improved and high temperature wear, deposit and varnish control are surprisingly maintained or improved as compared to high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol.

[0012] It has been surprisingly found that, in accordance with this disclosure, improvements in fuel economy are obtained without sacrificing engine durability (e.g., while maintaining or improving high temperature wear, deposit and varnish control) in an engine lubricated with a lubricating oil, by including at least one alkoxyated alcohol in the lubricating oil.

[0013] Other objects and advantages of the present disclosure will become apparent from the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Fig. 1 shows formulation details in weight percent based on the total weight percent of the formulation, of formulations used in the Examples.

[0015] Fig. 2 shows the results of bench and engine testing of the formulations used in the Examples.

[0016] Fig. 3 shows MTM Stribeck curves from the Reference 1 formulation and the Example 3 formulation finished oil performance in MTM Stribeck test at 50°C (log and mean speed).

[0017] Fig. 4 shows MTM Stribeck curves from the Reference 1 formulation and the Example 3 formulation finished oil performance in MTM Stribeck test at 100°C (log and mean speed).

[0018] Fig. 5 shows formulation details in weight percent based on the total weight percent of the formulation, of the Reference 3 formulation and the Example 6 formulation. Fig. 5 also shows the results of bench and engine testing of the Reference 3 formulation and the Example 6 formulation.

[0019] Fig. 6 shows formulation details in weight percent based on the total weight percent of the formulation, of the Reference 1, 4 and 5 formulations and the Example 7 and 8 formulations. Fig. 6 also shows the results of bench and engine testing of the Reference 1, 4 and 5 formulations and the Example 7 and 8 formulations.

[0020] Fig. 7 shows formulation details in weight percent based on the total weight percent of the formulation, of the Example 9 and 10 formulations. Fig. 7 also shows the results of bench testing of the Example 9 and 10 formulations.

[0021] Fig. 8 shows formulation details in weight percent based on the total weight percent of the formulation, of the Example 11-22 formulations.

[0022] Fig. 9 shows formulation details in weight percent based on the total weight percent of the formulation, of the Example 23-34 formulations.

[0023] Fig. 10 shows formulation details in weight percent based on the total weight percent of the formulation, of the Example 35-46 formulations.

[0024] Fig. 11 shows formulation details in weight percent based on the total weight percent of the formulation, of the Example 47-58 formulations.

DETAILED DESCRIPTION

[0025] All numerical values within the detailed description and the claims herein are modified by "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

[0026] It has now been found that improved fuel efficiency can be attained, while wear protection is unexpectedly maintained or improved (e.g., high temperature wear, deposit and varnish control), in an engine lubricated with a lubricating oil by using as the lubricating oil a formulated oil that has one or more alkoxylated alcohols. The formulated oil preferably comprises a lubricating oil base stock as a major component, and a metal dialkyl dithio phosphate, at least one alkoxylated alcohol, and a viscosity index improver, as minor components. The lubricating oils of this disclosure are particularly advantageous as passenger vehicle engine oil (PVEO) products.

[0027] The lubricating oils of this disclosure provide excellent engine protection including friction reduction and anti-wear performance. This benefit has been demonstrated for the lubricating oils of this disclosure in the Sequence IIIG/IIIGA (ASTM D7320) and Sequence VID (ASTM D7589) engine tests. The lubricating oils of this disclosure provide improved fuel efficiency. A lower HTHS viscosity engine oil generally provides superior fuel economy to a higher HTHS viscosity product. This benefit has been demonstrated for the lubricating oils of this disclosure in the Sequence VID Fuel Economy (ASTM D7589) engine test.

[0028] The lubricating engine oils of this disclosure have a composition sufficient to pass wear protection requirements of one or more engine tests selected from Sequence IIIG, Sequence VID, and others.

[0029] In comparison with fuel efficiency achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oils containing at least one alkoxyated alcohol of this disclosure can exhibit a fuel efficiency preferably greater than 1.2X, and more preferably greater than 1.3X, as determined by the Sequence VID Fuel Economy (ASTM D7589) engine test. In an embodiment, in comparison with fuel efficiency achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oils containing at least one alkoxyated alcohol of this disclosure can exhibit a fuel efficiency greater than 1.4X, preferably greater than 1.5X, and more preferably greater than 1.6X, as determined by the Sequence VID Fuel Economy (ASTM D7589) engine test.

[0030] In comparison with high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oils containing at least one alkoxyated alcohol of this disclosure can exhibit high temperature wear, deposit and varnish control preferably greater than 1.1X, and more preferably greater than 1.2X, as determined by the Sequence IIIG/IIIGA (ASTM D7320) engine test. In an embodiment, in comparison with high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oils containing at least one alkoxyated alcohol of this disclosure can exhibit a high temperature wear, deposit and varnish control preferably greater than 1.2X, and more preferably greater than 1.3X, as determined by the Sequence IIIG/IIIGA (ASTM D7320) engine test.

[0031] In an embodiment, in comparison with high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oils containing at least one alkoxyated alcohol of this disclosure can exhibit, at the same time, both a fuel

efficiency greater than 1.4X, preferably greater than 1.5X, and more preferably greater than 1.6X, as determined by the Sequence VID Fuel Economy (ASTM D7589) engine test, and high temperature wear, deposit and varnish control preferably greater than 1.2X, and more preferably greater than 1.3X, as determined by the Sequence IIIG/IIIGA (ASTM D7320) engine test.

Lubricating Oil Base Stocks

[0032] A wide range of lubricating base oils is known in the art. Lubricating base oils that are useful in the present disclosure are both natural oils, and synthetic oils, and unconventional oils (or mixtures thereof) can be used unrefined, refined, or rerefined (the latter is also known as reclaimed or reprocessed oil). Unrefined oils are those obtained directly from a natural or synthetic source and used without added purification. These include shale oil obtained directly from retorting operations, petroleum oil obtained directly from primary distillation, and ester oil obtained directly from an esterification process. Refined oils are similar to the oils discussed for unrefined oils except refined oils are subjected to one or more purification steps to improve at least one lubricating oil property. One skilled in the art is familiar with many purification processes. These processes include solvent extraction, secondary distillation, acid extraction, base extraction, filtration, and percolation. Rerefined oils are obtained by processes analogous to refined oils but using an oil that has been previously used as a feed stock.

[0033] Groups I, II, III, IV and V are broad base oil stock categories developed and defined by the American Petroleum Institute (API Publication 1509; www.API.org) to create guidelines for lubricant base oils. Group I base stocks have a viscosity index of between 80 to 120 and contain greater than 0.03% sulfur and/or less than 90% saturates. Group II base stocks have a viscosity index of between 80 to 120, and contain less than or equal to 0.03% sulfur and greater than or equal to 90% saturates. Group III stocks have a viscosity index greater than 120 and contain less than or equal to 0.03 % sulfur and greater than 90% saturates. Group IV includes polyalphaolefins (PAO). Group V base stock includes base stocks not included in Groups I-IV. The table below summarizes properties of each of these five groups.

	Base Oil Properties		
	Saturates	Sulfur	Viscosity Index
Group I	<90 and/or	>0.03% and	≥80 and <120
Group II	≥90 and	≤0.03% and	≥80 and <120
Group III	≥90 and	≤0.03% and	≥120
Group IV	Includes polyalphaolefins (PAO) and GTL products		
Group V	All other base oil stocks not included in Groups I, II, III or IV		

[0034] Natural oils include animal oils, vegetable oils (castor oil and lard oil, for example), and mineral oils. Animal and vegetable oils possessing favorable thermal oxidative stability can be used. Of the natural oils, mineral oils are preferred. Mineral oils vary widely as to their crude source, for example, as to whether they are paraffinic, naphthenic, or mixed paraffinic-naphthenic. Oils derived from coal or shale are also useful. Natural oils vary also as to the method used for their production and purification, for example, their distillation range and whether they are straight run or cracked, hydrorefined, or solvent extracted.

[0035] Group II and/or Group III hydroprocessed or hydrocracked basestocks, including synthetic oils such as polyalphaolefins, alkyl aromatics and synthetic esters are also well known basestock oils.

[0036] Synthetic oils include hydrocarbon oil. Hydrocarbon oils include oils such as polymerized and interpolymers of olefins (polybutylenes, polypropylenes, propylene isobutylene copolymers, ethylene-olefin copolymers, and ethylene-alphaolefin copolymers, for example). Polyalphaolefin (PAO) oil base stocks are commonly used synthetic hydrocarbon oil. By way of example, PAOs derived from C₈, C₁₀, C₁₂, C₁₄ olefins or mixtures thereof may be utilized. See U.S. Patent Nos. 4,956,122; 4,827,064; and 4,827,073.

[0037] The number average molecular weights of the PAOs, which are known materials and generally available on a major commercial scale from suppliers such as ExxonMobil Chemical Company, Chevron Phillips Chemical Company, BP, and others,

typically vary from 250 to 3,000, although PAO's may be made in viscosities up to 100 cSt (100°C). The PAOs are typically comprised of relatively low molecular weight hydrogenated polymers or oligomers of alphaolefins which include, but are not limited to, C₂ to C₃₂ alphaolefins with the C₈ to C₁₆ alphaolefins, such as 1-octene, 1-decene, 1-dodecene and the like, being preferred. The preferred polyalphaolefins are poly-1-octene, poly-1-decene and poly-1-dodecene and mixtures thereof and mixed olefin-derived polyolefins. However, the dimers of higher olefins in the range of C₁₄ to C₁₈ may be used to provide low viscosity base stocks of acceptably low volatility. Depending on the viscosity grade and the starting oligomer, the PAOs may be predominantly trimers and tetramers of the starting olefins, with minor amounts of the higher oligomers, having a viscosity range of 1.5 to 12 cSt. PAO fluids of particular use may include 3.0 cSt, 3.4 cSt, and/or 3.6 cSt and combinations thereof. Bi-modal mixtures of PAO fluids having a viscosity range of 1.5 to 100 cSt may be used if desired.

[0038] The PAO fluids may be conveniently made by the polymerization of an alphaolefin in the presence of a polymerization catalyst such as the Friedel-Crafts catalysts including, for example, aluminum trichloride, boron trifluoride or complexes of boron trifluoride with water, alcohols such as ethanol, propanol or butanol, carboxylic acids or esters such as ethyl acetate or ethyl propionate. For example the methods disclosed by U.S. Patent Nos. 4,149,178 or 3,382,291 may be conveniently used herein. Other descriptions of PAO synthesis are found in the following U.S. Patent Nos. 3,742,082; 3,769,363; 3,876,720; 4,239,930; 4,367,352; 4,413,156; 4,434,408; 4,910,355; 4,956,122; and 5,068,487. The dimers of the C₁₄ to C₁₈ olefins are described in U.S. Patent No. 4,218,330.

[0039] Other useful lubricant oil base stocks include wax isomerate base stocks and base oils, comprising hydroisomerized waxy stocks (e.g. waxy stocks such as gas oils, slack waxes, fuels hydrocracker bottoms, etc.), hydroisomerized Fischer-Tropsch waxes, Gas-to-Liquids (GTL) base stocks and base oils, and other wax isomerate hydroisomerized base stocks and base oils, or mixtures thereof Fischer-Tropsch waxes, the high boiling point residues of Fischer-Tropsch synthesis, are highly paraffinic hydrocarbons with very low sulfur content. The hydroprocessing used for the production of such base stocks may use an amorphous hydrocracking/hydroisomerization catalyst,

such as one of the specialized lube hydrocracking (LHDC) catalysts or a crystalline hydrocracking/hydroisomerization catalyst, preferably a zeolitic catalyst. For example, one useful catalyst is ZSM-48 as described in U.S. Patent No. 5,075,269, the disclosure of which is incorporated herein by reference in its entirety. Processes for making hydrocracked/hydroisomerized distillates and hydrocracked/hydroisomerized waxes are described, for example, in U.S. Patent Nos. 2,817,693; 4,975,177; 4,921,594 and 4,897,178 as well as in British Patent Nos. 1,429,494; 1,350,257; 1,440,230 and 1,390,359. Each of the aforementioned patents is incorporated herein in their entirety. Particularly favorable processes are described in European Patent Application Nos. 464546 and 464547, also incorporated herein by reference. Processes using Fischer-Tropsch wax feeds are described in U.S. Patent Nos. 4,594,172 and 4,943,672, the disclosures of which are incorporated herein by reference in their entirety.

[0040] Gas-to-Liquids (GTL) base oils, Fischer-Tropsch wax derived base oils, and other wax-derived hydroisomerized (wax isomerate) base oils be advantageously used in the instant disclosure, and may have useful kinematic viscosities at 100°C of 3 cSt to 50 cSt, preferably 3 cSt to 30 cSt, more preferably 3.5 cSt to 25 cSt, as exemplified by GTL 4 with kinematic viscosity of 4.0 cSt at 100°C and a viscosity index of 141. These Gas-to-Liquids (GTL) base oils, Fischer-Tropsch wax derived base oils, and other wax-derived hydroisomerized base oils may have useful pour points of -20°C or lower, and under some conditions may have advantageous pour points of -25°C or lower, with useful pour points of -30°C to -40°C or lower. Useful compositions of Gas-to-Liquids (GTL) base oils, Fischer-Tropsch wax derived base oils, and wax-derived hydroisomerized base oils are recited in U.S. Patent Nos. 6,080,301; 6,090,989, and 6,165,949 for example, and are incorporated herein in their entirety by reference.

[0041] The hydrocarbyl aromatics can be used as base oil or base oil component and can be any hydrocarbyl molecule that contains at least 5% of its weight derived from an aromatic moiety such as a benzenoid moiety or naphthenoid moiety, or their derivatives. These hydrocarbyl aromatics include alkyl benzenes, alkyl naphthalenes, alkyl diphenyl oxides, alkyl naphthols, alkyl diphenyl sulfides, alkylated bis-phenol A, alkylated thiodiphenol, and the like. The aromatic can be mono-alkylated, dialkylated, polyalkylated, and the like. The aromatic can be mono- or poly-functionalized. The

hydrocarbyl groups can also be comprised of mixtures of alkyl groups, alkenyl groups, alkynyl, cycloalkyl groups, cycloalkenyl groups and other related hydrocarbyl groups. The hydrocarbyl groups can range from C₆ up to C₆₀ with a range of C₈ to C₂₀ often being preferred. A mixture of hydrocarbyl groups is often preferred, and up to three such substituents may be present. The hydrocarbyl group can optionally contain sulfur, oxygen, and/or nitrogen containing substituents. The aromatic group can also be derived from natural (petroleum) sources, provided at least 5% of the molecule is comprised of an above-type aromatic moiety. Viscosities at 100°C of approximately 3 cSt to 50 cSt are preferred, with viscosities of approximately 3.4 cSt to 20 cSt often being more preferred for the hydrocarbyl aromatic component. In one embodiment, an alkyl naphthalene where the alkyl group is primarily comprised of 1-hexadecene is used. Other alkylates of aromatics can be advantageously used. Naphthalene or methyl naphthalene, for example, can be alkylated with olefins such as octene, decene, dodecene, tetradecene or higher, mixtures of similar olefins, and the like. Useful concentrations of hydrocarbyl aromatic in a lubricant oil composition can be 2% to 25%, preferably 4% to 20%, and more preferably 4% to 15%, depending on the application.

[0042] Alkylated aromatics such as the hydrocarbyl aromatics of the present disclosure may be produced by well-known Friedel-Crafts alkylation of aromatic compounds. See Friedel-Crafts and Related Reactions, Olah, G. A. (ed.), Inter-science Publishers, New York, 1963. For example, an aromatic compound, such as benzene or naphthalene, is alkylated by an olefin, alkyl halide or alcohol in the presence of a Friedel-Crafts catalyst. See Friedel-Crafts and Related Reactions, Vol. 2, part 1, chapters 14, 17, and 18, See Olah, G. A. (ed.), Inter-science Publishers, New York, 1964. Many homogeneous or heterogeneous, solid catalysts are known to one skilled in the art. The choice of catalyst depends on the reactivity of the starting materials and product quality requirements. For example, strong acids such as AlCl₃, BF₃, or HF may be used. In some cases, milder catalysts such as FeCl₃ or SnCl₄ are preferred. Newer alkylation technology uses zeolites or solid super acids.

[0043] Esters comprise a useful base stock. Additive solvency and seal compatibility characteristics may be secured by the use of esters such as the esters of dibasic acids with monoalkanols and the polyol esters of monocarboxylic acids. Esters of the former type

include, for example, the esters of dicarboxylic acids such as phthalic acid, succinic acid, alkyl succinic acid, alkenyl succinic acid, maleic acid, azelaic acid, suberic acid, sebacic acid, fumaric acid, adipic acid, linoleic acid dimer, malonic acid, alkyl malonic acid, alkenyl malonic acid, etc., with a variety of alcohols such as butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, etc. Specific examples of these types of esters include dibutyl adipate, di(2-ethylhexyl) sebacate, di-n-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, etc.

[0044] Particularly useful synthetic esters are those which are obtained by reacting one or more polyhydric alcohols, preferably the hindered polyols (such as the neopentyl polyols, e.g., neopentyl glycol, trimethylol ethane, 2-methyl-2-propyl-1,3-propanediol, trimethylol propane, pentaerythritol and dipentaerythritol) with alkanoic acids containing at least 4 carbon atoms, preferably C₅ to C₃₀ acids such as saturated straight chain fatty acids including caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, arachic acid, and behenic acid, or the corresponding branched chain fatty acids or unsaturated fatty acids such as oleic acid, or mixtures of any of these materials.

[0045] Suitable synthetic ester components include the esters of trimethylol propane, trimethylol butane, trimethylol ethane, pentaerythritol and/or dipentaerythritol with one or more monocarboxylic acids containing from 5 to 10 carbon atoms. These esters are widely available commercially, for example, the Mobil P-41 and P-51 esters of ExxonMobil Chemical Company.

[0046] Also useful are esters derived from renewable material such as coconut, palm, rapeseed, soy, sunflower and the like. These esters may be monoesters, di-esters, polyol esters, complex esters, or mixtures thereof. These esters are widely available commercially, for example, the Mobil P-51 ester of ExxonMobil Chemical Company.

[0047] Engine oil formulations containing renewable esters are included in this disclosure. For such formulations, the renewable content of the ester is typically greater than 70 weight percent, preferably more than 80 weight percent and most preferably

more than 90 weight percent. Renewable esters can be preferred in combination with alkoxyated alcohols.

[0048] Other useful fluids of lubricating viscosity include non-conventional or unconventional base stocks that have been processed, preferably catalytically, or synthesized to provide high performance lubrication characteristics.

[0049] Non-conventional or unconventional base stocks/base oils include one or more of a mixture of base stock(s) derived from one or more Gas-to-Liquids (GTL) materials, as well as isomerate/isodewaxate base stock(s) derived from natural wax or waxy feeds, mineral and or non-mineral oil waxy feed stocks such as slack waxes, natural waxes, and waxy stocks such as gas oils, waxy fuels hydrocracker bottoms, waxy raffinate, hydrocrackate, thermal crackates, or other mineral, mineral oil, or even non-petroleum oil derived waxy materials such as waxy materials received from coal liquefaction or shale oil, and mixtures of such base stocks.

[0050] GTL materials are materials that are derived via one or more synthesis, combination, transformation, rearrangement, and/or degradation/deconstructive processes from gaseous carbon-containing compounds, hydrogen-containing compounds and/or elements as feed stocks such as hydrogen, carbon dioxide, carbon monoxide, water, methane, ethane, ethylene, acetylene, propane, propylene, propyne, butane, butylenes, and butynes. GTL base stocks and/or base oils are GTL materials of lubricating viscosity that are generally derived from hydrocarbons; for example, waxy synthesized hydrocarbons, that are themselves derived from simpler gaseous carbon-containing compounds, hydrogen-containing compounds and/or elements as feed stocks. GTL base stock(s) and/or base oil(s) include oils boiling in the lube oil boiling range (1) separated/fractionated from synthesized GTL materials such as, for example, by distillation and subsequently subjected to a final wax processing step which involves either or both of a catalytic dewaxing process, or a solvent dewaxing process, to produce lube oils of reduced/low pour point; (2) synthesized wax isomerates, comprising, for example, hydrodewaxed or hydroisomerized cat and/or solvent dewaxed synthesized wax or waxy hydrocarbons; (3) hydrodewaxed or hydroisomerized cat and/or solvent dewaxed Fischer-Tropsch (F-T) material (i.e., hydrocarbons, waxy hydrocarbons, waxes

and possible analogous oxygenates); preferably hydrodewaxed or hydroisomerized/followed by cat and/or solvent dewaxing dewaxed F-T waxy hydrocarbons, or hydrodewaxed or hydroisomerized/followed by cat (or solvent) dewaxing dewaxed, F-T waxes, or mixtures thereof.

[0051] GTL base stock(s) and/or base oil(s) derived from GTL materials, especially, hydrodewaxed or hydroisomerized/followed by cat and/or solvent dewaxed wax or waxy feed, preferably F-T material derived base stock(s) and/or base oil(s), are characterized typically as having kinematic viscosities at 100°C of from 2 mm²/s to 50 mm²/s (ASTM D445). They are further characterized typically as having pour points of -5°C to -40°C or lower (ASTM D97). They are also characterized typically as having viscosity indices of 80 to 140 or greater (ASTM D2270).

[0052] In addition, the GTL base stock(s) and/or base oil(s) are typically highly paraffinic (>90% saturates), and may contain mixtures of monocycloparaffins and multicycloparaffins in combination with non-cyclic isoparaffins. The ratio of the naphthenic (i.e., cycloparaffin) content in such combinations varies with the catalyst and temperature used. Further, GTL base stock(s) and/or base oil(s) typically have very low sulfur and nitrogen content, generally containing less than 10 ppm, and more typically less than 5 ppm of each of these elements. The sulfur and nitrogen content of GTL base stock(s) and/or base oil(s) obtained from F-T material, especially F-T wax, is essentially nil. In addition, the absence of phosphorous and aromatics make this materially especially suitable for the formulation of low SAP products.

[0053] The term GTL base stock and/or base oil and/or wax isomerate base stock and/or base oil is to be understood as embracing individual fractions of such materials of wide viscosity range as recovered in the production process, mixtures of two or more of such fractions, as well as mixtures of one or two or more low viscosity fractions with one, two or more higher viscosity fractions to produce a blend wherein the blend exhibits a target kinematic viscosity.

[0054] The GTL material, from which the GTL base stock(s) and/or base oil(s) is/are derived is preferably an F-T material (i.e., hydrocarbons, waxy hydrocarbons, wax).

[0055] In addition, the GTL base stock(s) and/or base oil(s) are typically highly paraffinic (>90% saturates), and may contain mixtures of monocycloparaffins and multicycloparaffins in combination with non-cyclic isoparaffins. The ratio of the naphthenic (i.e., cycloparaffin) content in such combinations varies with the catalyst and temperature used. Further, GTL base stock(s) and/or base oil(s) and hydrodewaxed, or hydroisomerized/cat (and/or solvent) dewaxed base stock(s) and/or base oil(s) typically have very low sulfur and nitrogen content, generally containing less than 10 ppm, and more typically less than 5 ppm of each of these elements. The sulfur and nitrogen content of GTL base stock(s) and/or base oil(s) obtained from F-T material, especially F-T wax, is essentially nil. In addition, the absence of phosphorous and aromatics make this material especially suitable for the formulation of low sulfur, sulfated ash, and phosphorus (low SAP) products.

[0056] Base oils for use in the formulated lubricating oils useful in the present disclosure are any of the variety of oils corresponding to API Group I, Group II, Group III, Group IV, and Group V oils and mixtures thereof, preferably API Group II, Group III, Group IV, and Group V oils and mixtures thereof, more preferably the Group III to Group V base oils due to their exceptional volatility, stability, viscometric and cleanliness features. Minor quantities of Group I stock, such as the amount used to dilute additives for blending into formulated lube oil products, can be tolerated but should be kept to a minimum, i.e. amounts only associated with their use as diluent/carrier oil for additives used on an "as-received" basis. Even in regard to the Group II stocks, it is preferred that the Group II stock be in the higher quality range associated with that stock, i.e. a Group II stock having a viscosity index in the range $100 < VI < 120$.

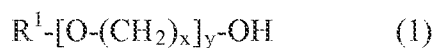
[0057] The base oil constitutes the major component of the engine oil lubricant composition of the present disclosure and typically is present in an amount ranging from 50 to 99 weight percent, preferably from 70 to 95 weight percent, and more preferably from 85 to 95 weight percent, based on the total weight of the composition. The base oil may be selected from any of the synthetic or natural oils typically used as crankcase lubricating oils for spark-ignited and compression-ignited engines. The base oil conveniently has a kinematic viscosity, according to ASTM standards, of 2.5 cSt to 12 cSt (or mm^2/s) at 100°C and preferably of 2.5 cSt to 9 cSt (or mm^2/s) at 100°C.

Mixtures of synthetic and natural base oils may be used if desired. Bi-modal mixtures of Group I, II, III, IV, and/or V base stocks may be used if desired.

Alkoxyated Alcohols

[0058] The alkoxyated alcohol additive useful in the lubricating oils of this disclosure is important for improving fuel efficiency, while maintaining or improving high temperature wear, deposit and varnish control, in an engine lubricated with the lubricating oil.

[0059] In an embodiment, an alkoxyated alcohol useful in this disclosure can be represented by the formula



wherein R^1 is a hydrocarbon group having from 1 to 50 carbon atoms, x is an integer from 1 to 10, and y is an integer from 1 to 10. In formula (1) above, it is understood that the R^1 group can be a mixture of hydrocarbon groups, for example, some portion alkyl and some portion aryl.

[0060] R^1 in formula (1) is a hydrocarbyl group, preferably a straight chain or branched chain alkyl, alkenyl, or alkylaryl group, and more preferably a linear group. In particular, an alkyl or alkenyl group having 1 to 20 carbon atoms is preferable, an alkyl or alkenyl group having 12 to 20 carbon atoms is more preferable, and a lauryl or oleyl group is the most preferable. Stearyl or similar groups can also be preferable. These hydrocarbon groups can be pure or mixtures. Commercially, lauryl and oleyl groups are mixtures (i.e., mixtures of different isomers or slightly different chain lengths).

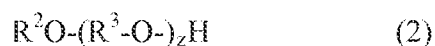
[0061] The integer x ranges from 1 to 10, in other words, an alkylene group, preferably an alkylene group having 2 to 4 carbon atoms, e.g., an ethylene, propylene, or butylene group or mixtures. An addition reaction of alkylene oxide may be homopolymerization, or random or block copolymerization. As a the compound having

a larger $\underline{x}$ decreases the solubility to oil and thermal stability, $\underline{x}$ is preferably 1 to 5, and more preferably 2 to 4.

[0062] The integer $\underline{y}$ ranges from 1 to 10, in other words, the compound may be a monoalkoxylated alcohol or polyalkoxylated alcohol. As the compound having a larger $\underline{y}$ decreases the solubility to oil and thermal stability, $\underline{y}$ is preferably 1 to 5, and more preferably 2 to 4.

[0063] Illustrative alkoxylated alcohols of formula (1) useful in this disclosure include, for example, stearyl alcohol ethoxylate, lauryl alcohol ethoxylate, oleyl alcohol ethoxylate, stearyl alcohol propoxylate, lauryl alcohol propoxylate, oleyl alcohol propoxylate, stearyl alcohol butoxylate, octyl alcohol butoxylate, myristyl alcohol ethoxypropoxylate, stearyl alcohol ethoxypropoxylate, lauryl alcohol ethoxypropoxylate, or mixtures of the above, and the like.

[0064] In another embodiment, an alkoxylated alcohol useful in this disclosure can be represented by the formula



wherein R^2 is a hydrocarbon group having from 12 to 20 carbon atoms, R^3 is an alkylene group having from 2 to 4 carbon atoms, and $\underline{z}$ is an integer from 1 to 10.

[0065] The alkoxylated alcohols represented by formula (2) are (poly)oxyalkyleneglycol ethers. R^2 in formula (2) is a hydrocarbyl group, preferably a straight chain or branched chain alkyl, alkenyl, or alkylaryl group, and more preferably a linear group. In particular, an alkyl or alkenyl group having 1 to 20 carbon atoms is preferable, an alkyl or alkenyl group having 12 to 20 carbon atoms is more preferable, and a lauryl or oleyl group is the most preferable.

[0066] R^3 is an alkylene group, preferably an alkylene group having 2 to 4 carbon atoms, e.g., an ethylene, propylene, or butylene group. The $(R^3-O)_z$ portion is obtained by adding ethylene oxide, propylene oxide, butylene oxide or the like. An addition

reaction of alkylene oxide may be homopolymerization, or random or block copolymerization.

[0067] Further, z ranges from 1 to 10, in other words, the compound may be a monooxyalkyleneglycol ether or polyoxyalkyleneglycol ether. As the compound having a larger z decreases the solubility to oil and thermal stability, z is preferably 1 to 5, and more preferably 2 to 4.

[0068] Illustrative alkyl groups include, for example, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, tert-butyl, pentyl, isopentyl, neopentyl, tert-pentyl, hexyl, heptyl, octyl, 2-ethylhexyl, nonyl, decyl, undecyl, dodecyl, tridecyl, isotridecyl, myristyl, palmityl, stearyl, eicosyl, docosyl, tetracosyl, triacontyl, 2-octyldodecyl, 2-dodecylhexadecyl, 2-tetradecyloctadecyl, monomethyl- branched isostearyl groups, and the like.

[0069] Illustrative alkenyl groups include, for example, vinyl, allyl, propenyl, isopropenyl, butenyl, isobutenyl, pentenyl, isopentenyl, hexenyl, heptenyl, octenyl, nonenyl, decenyl, undecenyl, dodecenyl, tetradecenyl, oleyl groups, and the like.

[0070] Illustrative alkylaryl groups include, for example, phenyl, tolyl, xylyl, cumenyl, mesityl, benzyl, phenethyl, styryl, cinnamyl, benzhydryl, trityl, ethylphenyl, propylphenyl, butylphenyl, pentylphenyl, hexylphenyl, heptylphenyl, octylphenyl, nonylphenyl, α -naphthyl, β -naphthyl groups, and the like.

[0071] Illustrative cycloalkyl and cycloalkenyl groups include, for example, cyclopentyl, cyclohexyl, cyclobutyl, methylcyclopentyl, methylcyclohexyl, methylcycloheptyl, cyclopentenyl, cyclohexenyl, cycloheptenyl, methylcyclopentenyl, methylcyclohexenyl, methylcycloheptenyl, and the like.

[0072] Illustrative alkoxylated alcohols of formula (2) useful in this disclosure include, for example, polyoxyethylene stearyl ether, polyoxyethylene lauryl ether, polyoxyethylene oleyl ether, polyoxypropylene stearyl ether, polyoxypropylene lauryl ether, polyoxypropylene oleyl ether, polyoxybutylene stearyl ether, polyoxybutylene

octyl ether, poly(oxyethylene)(oxypropylene) myristyl ether, poly(oxyethylene)(oxypropylene) stearyl ether, poly(oxyethylene)(oxypropylene) lauryl ether, and the like.

[0073] When a base oil for lubricating oil is used in the lubricating composition according to the present disclosure, the alkoxyated alcohol may be used alone or as a mixture of alkoxyated alcohols. Although the content of the alkoxyated alcohol is not limited, it is preferably 0.01 to 5 wt %, and more preferably 0.1 to 1 wt % of the base oil for lubricating oil.

Other Additives

[0074] The formulated lubricating oil useful in the present disclosure may additionally contain one or more of the other commonly used lubricating oil performance additives including but not limited to antiwear agents, dispersants, other detergents, corrosion inhibitors, rust inhibitors, metal deactivators, extreme pressure additives, anti-seizure agents, wax modifiers, viscosity index improvers, viscosity modifiers, fluid-loss additives, seal compatibility agents, friction modifiers, lubricity agents, anti-staining agents, chromophoric agents, defoamants, demulsifiers, emulsifiers, densifiers, wetting agents, gelling agents, tackiness agents, colorants, and others. For a review of many commonly used additives, see Klamann in Lubricants and Related Products, Verlag Chemie, Deerfield Beach, FL; ISBN 0-89573-177-0. Reference is also made to "Lubricant Additives" by M. W. Ranney, published by Noyes Data Corporation of Parkridge, NJ (1973); see also U.S. Patent No. 7,704,930, the disclosure of which is incorporated herein in its entirety.

[0075] The types and quantities of performance additives used in combination with the instant disclosure in lubricant compositions are not limited by the examples shown herein as illustrations.

Antiwear Additive

[0076] A metal alkylthiophosphate and more particularly a metal dialkyl dithio phosphate in which the metal constituent is zinc, or zinc dialkyl dithio phosphate (ZDDP) is a useful component of the lubricating oils of this disclosure. ZDDP can be derived from primary alcohols, secondary alcohols or mixtures thereof. ZDDP compounds generally are of the formula $\text{Zn}[\text{SP}(\text{S})(\text{OR}^1)(\text{OR}^2)]_2$ where R^1 and R^2 are C_1 - C_{18} alkyl groups, preferably C_2 - C_{12} alkyl groups. These alkyl groups may be straight chain or branched. Alkyl aryl groups may also be used.

[0077] Preferable zinc dithiophosphates which are commercially available include secondary zinc dithiophosphates such as those available from for example, The Lubrizol Corporation under the trade designations "LZ 677A", "LZ 1095" and "LZ 1371", from for example Chevron Oronite under the trade designation "OLOA 262" and from for example Afton Chemical under the trade designation "HITEC 7169".

[0078] The ZDDP is typically used in amounts of from 0.4 weight percent to 1.2 weight percent, preferably from 0.5 weight percent to 1.0 weight percent, and more preferably from 0.6 weight percent to 0.8 weight percent, based on the total weight of the lubricating oil, although more or less can often be used advantageously. Preferably, the ZDDP is a secondary ZDDP and present in an amount of from 0.6 to 1.0 weight percent of the total weight of the lubricating oil.

[0079] Low phosphorus engine oil formulations are included in this disclosure. For such formulations, the phosphorus content is typically less than 0.12 weight percent preferably less than 0.10 weight percent and most preferably less than 0.085 weight percent. Low phosphorus can be preferred in combination with alkoxylated alcohols.

Viscosity Index Improvers

[0080] Viscosity index improvers (also known as VI improvers, viscosity modifiers, and viscosity improvers) can be included in the lubricant compositions of this disclosure.

[0081] Viscosity index improvers provide lubricants with high and low temperature operability. These additives impart shear stability at elevated temperatures and acceptable viscosity at low temperatures.

[0082] Suitable viscosity index improvers include high molecular weight hydrocarbons, polyesters and viscosity index improver dispersants that function as both a viscosity index improver and a dispersant. Typical molecular weights of these polymers are between 10,000 to 1,500,000, more typically 20,000 to 1,200,000, and even more typically between 50,000 and 1,000,000.

[0083] Examples of suitable viscosity index improvers are linear or star-shaped polymers and copolymers of methacrylate, butadiene, olefins, or alkylated styrenes. Polyisobutylene is a commonly used viscosity index improver. Another suitable viscosity index improver is polymethacrylate (copolymers of various chain length alkyl methacrylates, for example), some formulations of which also serve as pour point depressants. Other suitable viscosity index improvers include copolymers of ethylene and propylene, hydrogenated block copolymers of styrene and isoprene, and polyacrylates (copolymers of various chain length acrylates, for example). Specific examples include styrene-isoprene or styrene-butadiene based polymers of 50,000 to 200,000 molecular weight.

[0084] Olefin copolymers, are commercially available from Chevron Oronite Company LLC under the trade designation "PARATONE®" (such as "PARATONE® 8921" and "PARATONE® 8941"); from Afton Chemical Corporation under the trade designation "HiTEC®" (such as "HiTEC® 5850B"; and from The Lubrizol Corporation under the trade designation "Lubrizol® 7067C". Polyisoprene polymers are commercially available from Infineum International Limited, e.g. under the trade designation "SV200"; diene-styrene copolymers are commercially available from Infineum International Limited, e.g. under the trade designation "SV 260".

[0085] In an embodiment of this disclosure, the viscosity index improvers may be used in an amount of less than 2.0 weight percent, preferably less than 1.0 weight

percent, and more preferably less than 0.5 weight percent, based on the total weight of the formulated oil or lubricating engine oil.

[0086] In another embodiment of this disclosure, the viscosity index improvers may be used in an amount of from 0.25 to 2.0 weight percent, preferably 0.15 to 1.0 weight percent, and more preferably 0.05 to 0.5 weight percent, based on the total weight of the formulated oil or lubricating engine oil.

Detergents

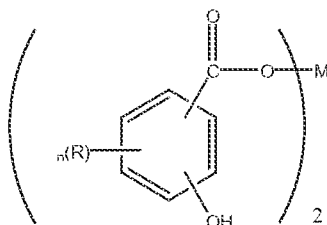
[0087] Illustrative detergents useful in this disclosure include, for example, alkali metal detergents, alkaline earth metal detergents, or mixtures of one or more alkali metal detergents and one or more alkaline earth metal detergents. A typical detergent is an anionic material that contains a long chain hydrophobic portion of the molecule and a smaller anionic or oleophobic hydrophilic portion of the molecule. The anionic portion of the detergent is typically derived from an organic acid such as a sulfur acid, carboxylic acid, phosphorous acid, phenol, or mixtures thereof. The counterion is typically an alkaline earth or alkali metal.

[0088] Salts that contain a substantially stoichiometric amount of the metal are described as neutral salts and have a total base number (TBN, as measured by ASTM D2896) of from 0 to 80. Many compositions are overbased, containing large amounts of a metal base that is achieved by reacting an excess of a metal compound (a metal hydroxide or oxide, for example) with an acidic gas (such as carbon dioxide). Useful detergents can be neutral, mildly overbased, or highly overbased.

[0089] Alkaline earth phenates are another useful class of detergent. These detergents can be made by reacting alkaline earth metal hydroxide or oxide (CaO, Ca(OH)₂, BaO, Ba(OH)₂, MgO, Mg(OH)₂, for example) with an alkyl phenol or sulfurized alkylphenol. Useful alkyl groups include straight chain or branched C₁-C₃₀ alkyl groups, preferably, C₄-C₂₀ or mixtures thereof. Examples of suitable phenols include isobutylphenol, 2-ethylhexylphenol, nonylphenol, dodecyl phenol, and the like. It should be noted that starting alkylphenols may contain more than one alkyl substituent

that are each independently straight chain or branched and can be used from 0.5 to 6 weight percent. When a non-sulfurized alkylphenol is used, the sulfurized product may be obtained by methods well known in the art. These methods include heating a mixture of alkylphenol and sulfurizing agent (including elemental sulfur, sulfur halides such as sulfur dichloride, and the like) and then reacting the sulfurized phenol with an alkaline earth metal base.

[0090] Metal salts of carboxylic acids are also useful as detergents. These carboxylic acid detergents may be prepared by reacting a basic metal compound with at least one carboxylic acid and removing free water from the reaction product. These compounds may be overbased to produce the desired TBN level. Detergents made from salicylic acid are one preferred class of detergents derived from carboxylic acids. Useful salicylates include long chain alkyl salicylates. One useful family of compositions is of the formula



where R is an alkyl group having 1 to 30 carbon atoms, n is an integer from 1 to 4, and M is an alkaline earth metal. Preferred R groups are alkyl chains of at least C₁₁, preferably C₁₃ or greater. R may be optionally substituted with substituents that do not interfere with the detergent's function. M is preferably, calcium, magnesium, or barium. More preferably, M is calcium.

[0091] Hydrocarbyl-substituted salicylic acids may be prepared from phenols by the Kolbe reaction (see U.S. Patent No. 3,595,791). The metal salts of the hydrocarbyl-substituted salicylic acids may be prepared by double decomposition of a metal salt in a polar solvent such as water or alcohol.

[0092] Alkaline earth metal phosphates are also used as detergents and are known in the art.

[0093] Detergents may be simple detergents or what is known as hybrid or complex detergents. The latter detergents can provide the properties of two detergents without the need to blend separate materials. See U.S. Patent No. 6,034,039.

[0094] Preferred detergents include calcium phenates, calcium sulfonates, calcium salicylates, magnesium phenates, magnesium sulfonates, magnesium salicylates and other related components (including borated detergents), and mixtures thereof. Preferred detergents include magnesium sulfonate and calcium salicylate.

[0095] The detergent concentration in the lubricating oils of this disclosure can range from 1.0 to 6.0 weight percent, preferably 2.0 to 5.0 weight percent, and more preferably from 2.0 weight percent to 4.0 weight percent, based on the total weight of the lubricating oil.

[0096] As used herein, the detergent concentrations are given on an “as delivered” basis. Typically, the active detergent is delivered with a process oil. The “as delivered” detergent typically contains from 20 weight percent to 80 weight percent, or from 40 weight percent to 60 weight percent, of active detergent in the “as delivered” detergent product.

Dispersants

[0097] During engine operation, oil-insoluble oxidation byproducts are produced. Dispersants help keep these byproducts in solution, thus diminishing their deposition on metal surfaces. Dispersants used in the formulation of the lubricating oil may be ashless or ash-forming in nature. Preferably, the dispersant is ashless. So called ashless dispersants are organic materials that form substantially no ash upon combustion. For example, non-metal-containing or borated metal-free dispersants are considered ashless. In contrast, metal-containing detergents discussed above form ash upon combustion.

[0098] Suitable dispersants typically contain a polar group attached to a relatively high molecular weight hydrocarbon chain. The polar group typically contains at least

one element of nitrogen, oxygen, or phosphorus. Typical hydrocarbon chains contain 50 to 400 carbon atoms.

[0099] Chemically, many dispersants may be characterized as phenates, sulfonates, sulfurized phenates, salicylates, naphthenates, stearates, carbamates, thiocarbamates, phosphorus derivatives. A particularly useful class of dispersants are the alkenylsuccinic derivatives, typically produced by the reaction of a long chain hydrocarbyl substituted succinic compound, usually a hydrocarbyl substituted succinic anhydride, with a polyhydroxy or polyamino compound. The long chain hydrocarbyl group constituting the oleophilic portion of the molecule which confers solubility in the oil, is normally a polyisobutylene group. Many examples of this type of dispersant are well known commercially and in the literature. Exemplary U.S. patents describing such dispersants are U.S. Patent Nos. 3,172,892; 3,215,707; 3,219,666; 3,316,177; 3,341,542; 3,444,170; 3,454,607; 3,541,012; 3,630,904; 3,632,511; 3,787,374 and 4,234,435. Other types of dispersant are described in U.S. Patent Nos. 3,036,003; 3,200,107; 3,254,025; 3,275,554; 3,438,757; 3,454,555; 3,565,804; 3,413,347; 3,697,574; 3,725,277; 3,725,480; 3,726,882; 4,454,059; 3,329,658; 3,449,250; 3,519,565; 3,666,730; 3,687,849; 3,702,300; 4,100,082; 5,705,458. A further description of dispersants may be found, for example, in European Patent Application No. 471 071, to which reference is made for this purpose.

[00100] Hydrocarbyl-substituted succinic acid and hydrocarbyl-substituted succinic anhydride derivatives are useful dispersants. In particular, succinimide, succinate esters, or succinate ester amides prepared by the reaction of a hydrocarbon-substituted succinic acid compound preferably having at least 50 carbon atoms in the hydrocarbon substituent, with at least one equivalent of an alkylene amine are particularly useful.

[00101] Succinimides are formed by the condensation reaction between hydrocarbyl substituted succinic anhydrides and amines. Molar ratios can vary depending on the polyamine. For example, the molar ratio of hydrocarbyl substituted succinic anhydride to TEPA can vary from 1:1 to 5:1. Representative examples are shown in U.S. Patent Nos. 3,087,936; 3,172,892; 3,219,666; 3,272,746; 3,322,670; and 3,652,616, 3,948,800; and Canada Patent No. 1,094,044.

[00102] Succinate esters are formed by the condensation reaction between hydrocarbyl substituted succinic anhydrides and alcohols or polyols. Molar ratios can vary depending on the alcohol or polyol used. For example, the condensation product of a hydrocarbyl substituted succinic anhydride and pentaerythritol is a useful dispersant.

[00103] Succinate ester amides are formed by condensation reaction between hydrocarbyl substituted succinic anhydrides and alkanol amines. For example, suitable alkanol amines include ethoxylated polyalkylpolyamines, propoxylated polyalkylpolyamines and polyalkenylpolyamines such as polyethylene polyamines. One example is propoxylated hexamethylenediamine. Representative examples are shown in U.S. Patent No. 4,426,305.

[00104] The molecular weight of the hydrocarbyl substituted succinic anhydrides used in the preceding paragraphs will typically range between 800 and 2,500 or more. The above products can be post-reacted with various reagents such as sulfur, oxygen, formaldehyde, carboxylic acids such as oleic acid. The above products can also be post reacted with boron compounds such as boric acid, borate esters or highly borated dispersants, to form borated dispersants generally having from 0.1 to 5 moles of boron per mole of dispersant reaction product.

[00105] Mannich base dispersants are made from the reaction of alkylphenols, formaldehyde, and amines. See U.S. Patent No. 4,767,551, which is incorporated herein by reference. Process aids and catalysts, such as oleic acid and sulfonic acids, can also be part of the reaction mixture. Molecular weights of the alkylphenols range from 800 to 2,500. Representative examples are shown in U.S. Patent Nos. 3,697,574; 3,703,536; 3,704,308; 3,751,365; 3,756,953; 3,798,165; and 3,803,039.

[00106] Typical high molecular weight aliphatic acid modified Mannich condensation products useful in this disclosure can be prepared from high molecular weight alkyl-substituted hydroxyaromatics or HN₂ group-containing reactants.

[00107] Hydrocarbyl substituted amine ashless dispersant additives are well known to one skilled in the art; see, for example, U.S. Patent Nos. 3,275,554; 3,438,757; 3,565,804; 3,755,433, 3,822,209, and 5,084,197.

[00108] Preferred dispersants include borated and non-borated succinimides, including those derivatives from mono-succinimides, bis-succinimides, and/or mixtures of mono- and bis-succinimides, wherein the hydrocarbyl succinimide is derived from a hydrocarbylene group such as polyisobutylene having a Mn of from 500 to 5000 or a mixture of such hydrocarbylene groups, often with high terminal vinylic groups. Other preferred dispersants include succinic acid-esters and amides, alkylphenol-polyamine-coupled Mannich adducts, their capped derivatives, and other related components. Such additives may be used in an amount of 0.1 to 20 weight percent, preferably 0.5 to 8 weight percent.

[00109] As used herein, the dispersant concentrations are given on an "as delivered" basis. Typically, the active dispersant is delivered with a process oil. The "as delivered" dispersant typically contains from 20 weight percent to 80 weight percent, or from 40 weight percent to 60 weight percent, of active dispersant in the "as delivered" dispersant product.

Antioxidants

[00110] Antioxidants retard the oxidative degradation of base oils during service. Such degradation may result in deposits on metal surfaces, the presence of sludge, or a viscosity increase in the lubricant. One skilled in the art knows a wide variety of oxidation inhibitors that are useful in lubricating oil compositions. See, Klamann in Lubricants and Related Products, op cite, and U.S. Patent Nos. 4,798,684 and 5,084,197, for example.

[00111] Useful antioxidants include hindered phenols. These phenolic antioxidants may be ashless (metal-free) phenolic compounds or neutral or basic metal salts of certain phenolic compounds. Typical phenolic antioxidant compounds are the hindered phenolics which are the ones which contain a sterically hindered hydroxyl group, and

these include those derivatives of dihydroxy aryl compounds in which the hydroxyl groups are in the o- or p-position to each other. Typical phenolic antioxidants include the hindered phenols substituted with C₆+ alkyl groups and the alkylene coupled derivatives of these hindered phenols. Examples of phenolic materials of this type 2-t-butyl-4-heptyl phenol; 2-t-butyl-4-octyl phenol; 2-t-butyl-4-dodecyl phenol; 2,6-di-t-butyl-4-heptyl phenol; 2,6-di-t-butyl-4-dodecyl phenol; 2-methyl-6-t-butyl-4-heptyl phenol; and 2-methyl-6-t-butyl-4-dodecyl phenol. Other useful hindered mono-phenolic antioxidants may include for example hindered 2,6-di-alkyl-phenolic propionic ester derivatives. Bis-phenolic antioxidants may also be advantageously used in combination with the instant disclosure. Examples of ortho-coupled phenols include: 2,2'-bis(4-heptyl-6-t-butyl-phenol); 2,2'-bis(4-octyl-6-t-butyl-phenol); and 2,2'-bis(4-dodecyl-6-t-butyl-phenol). Para-coupled bisphenols include for example 4,4'-bis(2,6-di-t-butyl phenol) and 4,4'-methylene-bis(2,6-di-t-butyl phenol).

[00112] Non-phenolic oxidation inhibitors which may be used include aromatic amine antioxidants and these may be used either as such or in combination with phenolics. Typical examples of non-phenolic antioxidants include: alkylated and non-alkylated aromatic amines such as aromatic monoamines of the formula R⁸R⁹R¹⁰N where R⁸ is an aliphatic, aromatic or substituted aromatic group, R⁹ is an aromatic or a substituted aromatic group, and R¹⁰ is H, alkyl, aryl or R¹¹S(O)_xR¹² where R¹¹ is an alkylene, alkenylene, or aralkylene group, R¹² is a higher alkyl group, or an alkenyl, aryl, or alkaryl group, and x is 0, 1 or 2. The aliphatic group R⁸ may contain from 1 to 20 carbon atoms, and preferably contains from 6 to 12 carbon atoms. The aliphatic group is a saturated aliphatic group. Preferably, both R⁸ and R⁹ are aromatic or substituted aromatic groups, and the aromatic group may be a fused ring aromatic group such as naphthyl. Aromatic groups R⁸ and R⁹ may be joined together with other groups such as S.

[00113] Typical aromatic amines antioxidants have alkyl substituent groups of at least 6 carbon atoms. Examples of aliphatic groups include hexyl, heptyl, octyl, nonyl, and decyl. Generally, the aliphatic groups will not contain more than 14 carbon atoms. The general types of amine antioxidants useful in the present compositions include diphenylamines, phenyl naphthylamines, phenothiazines, imidodibenzyls and diphenyl

phenylene diamines. Mixtures of two or more aromatic amines are also useful. Polymeric amine antioxidants can also be used. Particular examples of aromatic amine antioxidants useful in the present disclosure include: p,p'-dioctyldiphenylamine; t-octylphenyl-alpha-naphthylamine; phenyl-alphanaphthylamine; and p-octylphenyl-alpha-naphthylamine.

[00114] Sulfurized alkyl phenols and alkali or alkaline earth metal salts thereof also are useful antioxidants.

[00115] Preferred antioxidants include hindered phenols, arylamines. These antioxidants may be used individually by type or in combination with one another. Such additives may be used in an amount of 0.01 to 5 weight percent, preferably 0.01 to 1.5 weight percent, more preferably zero to less than 1.5 weight percent, most preferably zero.

Pour Point Depressants (PPDs)

[00116] Conventional pour point depressants (also known as lube oil flow improvers) may be added to the compositions of the present disclosure if desired. These pour point depressant may be added to lubricating compositions of the present disclosure to lower the minimum temperature at which the fluid will flow or can be poured. Examples of suitable pour point depressants include polymethacrylates, polyacrylates, polyarylamides, condensation products of haloparaffin waxes and aromatic compounds, vinyl carboxylate polymers, and terpolymers of dialkylfumarates, vinyl esters of fatty acids and allyl vinyl ethers. U.S. Patent Nos. 1,815,022; 2,015,748; 2,191,498; 2,387,501; 2,655, 479; 2,666,746; 2,721,877; 2,721,878; and 3,250,715 describe useful pour point depressants and/or the preparation thereof. Such additives may be used in an amount of 0.01 to 5 weight percent, preferably 0.01 to 1.5 weight percent.

Seal Compatibility Agents

[00117] Seal compatibility agents help to swell elastomeric seals by causing a chemical reaction in the fluid or physical change in the elastomer. Suitable seal

compatibility agents for lubricating oils include organic phosphates, aromatic esters, aromatic hydrocarbons, esters (butylbenzyl phthalate, for example), and polybutenyl succinic anhydride. Such additives may be used in an amount of 0.01 to 3 weight percent, preferably 0.01 to 2 weight percent.

Antifoam Agents

[00118] Anti-foam agents may advantageously be added to lubricant compositions. These agents retard the formation of stable foams. Silicones and organic polymers are typical anti-foam agents. For example, polysiloxanes, such as silicon oil or polydimethyl siloxane, provide antifoam properties. Anti-foam agents are commercially available and may be used in conventional minor amounts along with other additives such as demulsifiers; usually the amount of these additives combined is less than 1 weight percent and often less than 0.1 weight percent.

Friction Modifiers

[00119] A friction modifier is any material or materials that can alter the coefficient of friction of a surface lubricated by any lubricant or fluid containing such material(s). Friction modifiers, also known as friction reducers, or lubricity agents or oiliness agents, and other such agents that change the ability of base oils, formulated lubricant compositions, or functional fluids, to modify the coefficient of friction of a lubricated surface may be effectively used in combination with the base oils or lubricant compositions of the present disclosure if desired. Friction modifiers that lower the coefficient of friction are particularly advantageous in combination with the base oils and lube compositions of this disclosure. Friction modifiers may include metal-containing compounds or materials as well as ashless compounds or materials, or mixtures thereof. Metal-containing friction modifiers may include metal salts or metalligand complexes where the metals may include alkali, alkaline earth, or transition group metals. Such metal-containing friction modifiers may also have low-ash characteristics. Transition metals may include Mo, Sb, Sn, Fe, Cu, Zn, and others. Ligands may include hydrocarbyl derivative of alcohols, polyols, glycerols, partial ester glycerols, thiols, carboxylates, carbamates, thiocarbamates, dithiocarbamates, phosphates, thiophosphates,

dithiophosphates, amides, imides, amines, thiazoles, thiadiazoles, dithiazoles, diazoles, triazoles, and other polar molecular functional groups containing effective amounts of O, N, S, or P, individually or in combination. In particular, Mo-containing compounds can be particularly effective such as for example Mo-dithiocarbamates, Mo(DTC), Mo-dithiophosphates, Mo(DTP), Mo-amines, Mo (Am), Mo-alcoholates, Mo-alcohol-amides, etc. See U.S. Patent Nos. 5,824,627, 6,232,276, 6,153,564, 6,143,701, 6,110,878, 5,837,657, 6,010,987, 5,906,968, 6,734,150, 6,730,638, 6,689,725, 6,569,820; WO 99/66013; WO 99/47629; and WO 98/26030.

[00120] Ashless friction modifiers may also include lubricant materials that contain effective amounts of polar groups, for example, hydroxyl-containing hydrocarbyl base oils, glycerides, partial glycerides, glyceride derivatives, and the like. Polar groups in friction modifiers may include hydrocarbyl groups containing effective amounts of O, N, S, or P, individually or in combination. Other friction modifiers that may be particularly effective include, for example, salts (both ash-containing and ashless derivatives) of fatty acids, fatty alcohols, fatty amides, fatty esters, hydroxyl-containing carboxylates, and comparable synthetic long-chain hydrocarbyl acids, alcohols, amides, esters, carboxylates, and the like. In some instances fatty organic acids, fatty amines, and sulfurized fatty acids may be used as suitable friction modifiers.

[00121] Useful concentrations of friction modifiers may range from 0.01 weight percent to 10-15 weight percent or more, often with a preferred range of 0.1 weight percent to 5 weight percent. Concentrations of molybdenum-containing materials are often described in terms of Mo metal concentration. Advantageous concentrations of Mo may range from 10 ppm to 3000 ppm or more, and often with a preferred range of 20-2000 ppm, and in some instances a more preferred range of 30-1000 ppm. Friction modifiers of all types may be used alone or in mixtures with the materials of this disclosure. Often mixtures of two or more friction modifiers, or mixtures of friction modifier(s) with alternate surface active material(s), are also desirable.

Inhibitors and Antirust Additives

[00122] Antirust additives (or corrosion inhibitors) are additives that protect lubricated metal surfaces against chemical attack by water or other contaminants. A wide variety of these are commercially available.

[00123] One type of antirust additive is a polar compound that wets the metal surface preferentially, protecting it with a film of oil. Another type of antirust additive absorbs water by incorporating it in a water-in-oil emulsion so that only the oil touches the metal surface. Yet another type of antirust additive chemically adheres to the metal to produce a non-reactive surface. Examples of suitable additives include zinc dithiophosphates, metal phenolates, basic metal sulfonates, fatty acids and amines. Such additives may be used in an amount of 0.01 to 5 weight percent, preferably 0.01 to 1.5 weight percent.

[00124] When lubricating oil compositions contain one or more of the additives discussed above, the additive(s) are blended into the composition in an amount sufficient for it to perform its intended function. Typical amounts of such additives useful in the present disclosure are shown in Table 1 below.

[00125] It is noted that many of the additives are shipped from the additive manufacturer as a concentrate, containing one or more additives together, with a certain amount of base oil diluents. Accordingly, the weight amounts in the table below, as well as other amounts mentioned herein, are directed to the amount of active ingredient (that is the non-diluent portion of the ingredient). The weight percent (wt%) indicated below is based on the total weight of the lubricating oil composition.

TABLE 1
Typical Amounts of Other Lubricating Oil Components

Compound	Approximate wt% (Useful)	Approximate wt% (Preferred)
Dispersant	0.1-20	0.1-8
Detergent	0.1-20	0.1-8
Friction Modifier	0.01-5	0.01-1.5
Antioxidant	0.1-5	0.1-1.5
Pour Point Depressant (PPD)	0.0-5	0.01-1.5
Anti-foam Agent	0.001-3	0.001-0.15
Viscosity Index Improver (solid polymer basis)	0.1-2	0.1-1
Anti-wear	0.4-1.2	0.5-1
Inhibitor and Antirust	0.01-5	0.01-1.5

[00126] The foregoing additives are all commercially available materials. These additives may be added independently but are usually precombined in packages which can be obtained from suppliers of lubricant oil additives. Additive packages with a variety of ingredients, proportions and characteristics are available and selection of the appropriate package will take the requisite use of the ultimate composition into account.

[00127] The following non-limiting examples are provided to illustrate the disclosure.

EXAMPLES

[00128] PCMO (passenger car motor oil) formulations were prepared. Fig. 1 provides formulation details in weight percent based on the total weight percent of the formulation. The alkoxyated alcohol used in each of the formulations in Fig. 1 was a polyoxyalkylene alkyl ether. The Group III base stock used in each of the formulations in Fig. 1 was Yubase™ 4 Plus. The Group IV base stock used in each of the formulations in Fig. 1 was a mixture of PAO 4 and PAO 6. The Group V base stock

used in each of the formulations in Fig. 1 was ExxonMobil Chemical MCP 2481. The viscosity modifier used in each of the formulations in Fig. 1 was Lubrizol VL1151J. The additive package used in each of the formulations in Fig. 1 included the following: detergents, dispersants, antioxidants, antiwear additives, defoamant, ashless friction modifier, MoDTC, and a pour point depressant. All of the ingredients are commercially available.

[00129] Bench and engine testing was conducted for each of the formulations listed in Fig. 1. The testing results are set forth in Fig. 2. The bench testing in Fig. 2 included the following: kinematic viscosity (KV) at 100°C measured by ASTM D445; high temperature high shear (HTHS) viscosity at 150°C measured by ASTM D4683; and cold cranking simulator (CCS) at -35°C measured by ASTM D5273. The engine testing in Fig. 2 included the following: Sequence IIIG (kinematic viscosity increase at 40°C, %) measured by ASTM D7320; Sequence IIIG (average weighted piston deposits, merits) measured by ASTM D7320; Sequence IIIG (average cam and lifter wear, μm) measured by ASTM D7320; oil consumption (L) measured by ASTM D7320; Sequence VID FEI 1 (Fuel Economy Improvement 1) measured by ASTM D7589; Sequence VID FEI 2 (Fuel Economy Improvement 2) measured by ASTM D7589; and Sequence VID FEI SUM (Fuel Economy Improvement SUM) measured by ASTM D7589.

[00130] In Fig. 2, a comparison of the Reference 1 formulation and Example 3 formulation shows that addition of alkoxylated alcohol delivers improved high temperature deposit control while maintaining good wear protection as measured by the Sequence IIIG test. Moreover, using the Sequence VID test as a measure of fuel economy, a comparison of the Reference 2 formulation and Example 3 formulation shows that addition of alkoxylated alcohol also significantly improves fuel economy. The fuel economy benefit was observed with the Example 3 formulation having the alkoxylated alcohol even though this formulation was a heavier viscosity grade (5W-20) than the Reference 2 formulation (0W-20).

[00131] MTM (mini-traction machine) data for the formulation of Example 3 as shown in Fig. 3 indicates a high level of alkoxylated alcohol activity at low temperature ($< 100^\circ\text{C}$) as compared to the formulation of Reference 1. At a temperature of 50°C , the

presence of the alkoxylated alcohol maintains a low coefficient of friction over many test cycles. In contrast, the formulation without the alkoxylated alcohol (Reference 1) exhibits an increase in friction as the number of test cycles increases. Additionally, Fig. 4 indicates alkoxylated alcohol activity even at higher temperature suggesting preferential adsorption of the alkoxylated alcohol onto the steel surface. At 100°C, the presence of the alkoxylated alcohol significantly reduced friction over a broad range of sliding speed (1000 mm/s to 10 mm/s).

[00132] PCMO (passenger car motor oil) formulations were prepared. Fig. 5 provides formulation details in weight percent based on the total weight percent of the formulation. The alkoxylated alcohol used in formulation 6 in Fig. 5 was a polyoxyalkylene alkyl ether. The styrene-isoprene block copolymers used in each of the formulations in Fig. 5 was Infineum™ SV140. The Group II base stock used in each of the formulations in Fig. 5 was Exxon Mobil EHC 45. The Group IV base stock used in each of the formulations in Fig. 5 was a mixture of PAO 4 and PAO 6. The C₈/C₁₀ trimethylolpropane (TMP) used in each of the formulations in Fig. 5 was ExxonMobil Chemical MCP 166. The additive package used in each of the formulations in Fig. 5 included the following: detergents, dispersants, antioxidants, antiwear additives, defoamant, ashless friction modifier, MoDTC, and a pour point depressant. All of the ingredients are commercially available.

[00133] The engine testing in Fig. 5 included the following: Sequence IIIG (kinematic viscosity increase at 40°C, %) measured by ASTM D7320; Sequence IIIG (average weighted piston deposits, merits) measured by ASTM D7320; Sequence IIIG (hot stuck rings) measured by ASTM D7320; Sequence IIIG (average cam and lifter wear, µm) measured by ASTM D7320; Sequence IIIG (oil ring land deposit, merits) measured by ASTM D7320; Sequence IIIG (undercrown, merits) measured by ASTM D7320; Sequence IIIG (Groove 1) measured by ASTM D7320; Sequence IIIG (Groove 2) measured by ASTM D7320; Sequence IIIG (Groove 3) measured by ASTM D7320; Sequence IIIG (Land 2) measured by ASTM D7320; Sequence IIIG (oil consumption, L) measured by ASTM D7320; and Sequence IIIG (phosphorus retention, %) as measured by ASTM D7320.

[00134] As shown in Fig. 5, the addition of 5% of the alkoxyated alcohol provided benefits in overall piston cleanliness (weighted piston deposits) with clear benefits observed in the following regions of the piston: oil ring land (ORLD), groove 2, and land 2. In addition, the alkoxyated alcohol surprisingly reduced wear by 45% which is expected to significantly improve vehicle durability. Also, the addition of the alkoxyated alcohol unexpectedly improved phosphorus retention which is expected to result in less phosphorus poisoning catalytic converters and result in improved emissions control.

[00135] Additional PCMO (passenger car motor oil) formulations were prepared. Fig. 6 provides formulation details in weight percent based on the total weight percent of the formulation. The Group V base stock used in each of the formulations in Fig. 6 was ExxonMobil Chemical MCP 2481. The Group IIIA base stock used in reference formulation 5 and formulations 7 and 8 in Fig. 6 was Visom 4. The Group IIIB base stock used in reference formulations 1 and 4 in Fig. 6 was Yubase™ 4 Plus. The Group IV base stock used in each of the formulations in Fig. 6 was a mixture of PAO 4 and PAO 6. The Detergent 5 used in each of the formulations in Fig. 6 was Infineum P5090. The Detergent 6 used in reference formulations 1 and 4 in Fig. 6 was Parabar 9340. The Detergent 3 used in formulations 7 and 8 in Fig. 6 was Infineum M7102. The Alkoxyated Alcohol FM1 used in formulations 7 and 8 in Fig. 6 was a polyoxyalkylene alkyl ether. The Organic FM2 used in each of the formulations in Fig. 6 was Perfad FM 3336. The Organometallic FM3 used in each of the formulations in Fig. 6 was MolyVan 855. The Organometallic FM4 used in each of the formulations in Fig. 6 was Infineum C9455. The additive package used in each of the formulations in Fig. 6 included the following: detergents, dispersants, antioxidants, antiwear additives, defoamant, ashless friction modifier, MoDTC, and a pour point depressant. Dispersants can include borated and non-borated molecules derived from high terminal vinylic polyisobutylene of molecular weight greater than 2500 which are reacted with maleic anhydride and the like, such as Infineum C9280. All of the ingredients are commercially available.

[00136] Bench and engine testing was conducted for each of the formulations listed in Fig. 6. The testing results are set forth in Fig. 6. The engine testing in Fig. 6 included the following: Sequence IIIG (WPD) measured by ASTM D7320; Sequence IIIG

(viscosity increase, %) measured by ASTM D7320; Sequence IIIG (wear, microns) measured by ASTM D7320; Sequence IIIG (oil consumption, L) measured by ASTM D7320; Sequence VID (FEI 1) measured by ASTM D7589; Sequence VID (FEI 2) measured by ASTM D7589; and Sequence VID (FEI SUM) measured by ASTM D7589. The bench testing in Fig. 6 included the following: kinematic viscosity (KV) at 100°C measured by ASTM D445; high temperature high shear (HTHS) viscosity at 150°C measured by ASTM D4683; and MTM friction average measured by WI307SF-9.

[00137] As shown in Fig. 6, the addition of the alkoxyated alcohol provided good wear protection as measured by the Sequence IIIG test. Moreover, using the Sequence VID test as a measure of fuel economy, the addition of the alkoxyated alcohol shows significantly improved fuel economy. The data in Fig. 6 shows both improved fuel economy and piston cleanliness for Example 7 and 8 formulations in comparison to the Reference 1, 4 and 5 formulations. As shown in Fig. 6, the addition of 0.3 to 1.0 % of the alkoxyated alcohol provided benefits in overall piston cleanliness (weighted piston deposits) with clear benefits observed in the following regions of the piston: oil ring land (ORLD), groove 2, and land 2. In addition of the alkoxyated alcohol unexpectedly improved phosphorus retention which is expected to result in less phosphorus poisoning catalytic converters and result in improved emissions control.

[00138] Additional PCMO (passenger car motor oil) formulations were prepared. Fig. 7 provides formulation details in weight percent based on the total weight percent of the formulation. The Group V base stock used in each of the formulations in Fig. 7 was ExxonMobil Chemical MCP 2481. The Group III base stock used in each of the formulations in Fig. 7 was Yubase™ 4 Plus. The Group IV base stock used in each of the formulations in Fig. 7 was a mixture of PAO 4 and PAO 6. The alkoxyated alcohol used in each of the formulations in Fig. 7 was a polyoxyalkylene alkyl ether. The viscosity modifier used in each of the formulations in Fig. 7 was Lubrizol VL1151J. The additive package used in each of the formulations in Fig. 7 included the following: detergents, dispersants, antioxidants, antiwear additives, defoamant, ashless friction modifier, MoDTC, and a pour point depressant. All of the ingredients are commercially available.

[00139] Bench and engine testing was conducted for each of the formulations listed in Fig. 7. The testing results are set forth in Fig. 7. The bench testing in Fig. 7 included the following: sulfated ash as measured by ASTM D874; total base number (TBN) as measured by ASTM D2896; kinematic viscosity (KV) at 100°C measured by ASTM D445; high temperature high shear (HTHS) viscosity at 150°C measured by ASTM D4683; and cold cranking simulator (CCS) at -35°C measured by ASTM D5273.

[00140] As shown in Fig. 7, Example 9 contains a sulfated ash level of 1.8 weight percent and a total base number of 15. Example 10 contains a sulfated ash level of 0.3 weight percent and a total base number of 4. Low total base number can be preferred in combination with alkoxyated alcohols. Low sulfated ash can be preferred in combination with alkoxyated alcohols.

[00141] The lubricating engine oil formulations in Fig. 8 are combinations of additives and base stocks and are anticipated to have a kinematic viscosity at 100°C around 7 cSt and high temperature high shear (10^{-6} s^{-1}) viscosity at 150°C around 2.3 cP. The lubricating engine oil formulations of Examples 11, 12, 15, 16, 19, and 20 are anticipated to have a phosphorus level around 300 ppm. The lubricating engine oil formulations of Examples 13, 14, 17, 18, 21, 22 are anticipated to have a phosphorus level around 700 ppm. The lubricating engine oil formulations of Examples 20 and 22 are anticipated to have a sulfated ash level around 0.3 weight percent and a total base number around 4. The lubricating engine oil formulations of Examples 11-19 and 21 are anticipated to have sulfated ash levels greater than or equal to 1.0 weight percent and total base number greater than or equal to 9. The lubricating engine oil formulations of Examples 15 and 17 do not contain molybdenum. The lubricating engine oil formulations of Examples 16 and 18 are anticipated to have a molybdenum level of around 250 ppm. The lubricating engine oil formulations of Examples 11-15 and 19-22 are anticipated to have molybdenum levels of around 90 ppm. All lubricating engine oil formulations in Fig. 8 that include at least one alkoxyated alcohol are anticipated to provide improvements in fuel economy without sacrificing engine durability (e.g., while maintaining or improving high temperature wear, deposit and varnish control) in an engine lubricated with the lubricating oil formulation.

[00142] The lubricating engine oil formulations in Fig. 9 are combinations of additives and base stocks and are anticipated to have a kinematic viscosity at 100°C around 6 cSt and high temperature high shear (10^{-6} s^{-1}) viscosity at 150°C around 2.0 cP. The lubricating engine oil formulations of Examples 23, 24, 27, 28, 31, and 32 are anticipated to have a phosphorus level around 300 ppm. The lubricating engine oil formulations of Examples 25, 26, 29, 30, 33, and 34 are anticipated to have a phosphorus level around 700 ppm. The lubricating engine oil formulations of Examples 32 and 34 are anticipated to have a sulfated ash level around 0.3 weight percent and a total base number around 4. The lubricating engine oil formulations of Examples 23-31 and 33 are anticipated to have sulfated ash levels greater than or equal to 1.0 weight percent and total base number greater than or equal to 9. The lubricating engine oil formulations of Examples 27 and 29 do not contain molybdenum. The lubricating engine oil formulations of Examples 28 and 30 are anticipated to have a molybdenum level of around 250 ppm. The lubricating engine oil formulations of Examples 23-27 and 31-34 are anticipated to have molybdenum levels of around 90 ppm. All lubricating engine oil formulations in Fig. 9 that include at least one alkoxylated alcohol are anticipated to provide improvements in fuel economy without sacrificing engine durability (e.g., while maintaining or improving high temperature wear, deposit and varnish control) in an engine lubricated with the lubricating oil formulation.

[00143] The lubricating engine oil formulations in Fig. 10 are combinations of additives and base stocks and are anticipated to have a kinematic viscosity at 100°C around 8 cSt and high temperature high shear (10^{-6} s^{-1}) viscosity at 150°C around 2.7 cP. The lubricating engine oil formulations of Examples 35, 36, 39, 40, 43, and 44 are anticipated to have a phosphorus level around 300 ppm. The lubricating engine oil formulations of Examples 37, 38, 41, 42, 45, and 46 are anticipated to have a phosphorus level around 700 ppm. The lubricating engine oil formulations of Examples 44 and 46 are anticipated to have a sulfated ash level around 0.3 weight percent and a total base number around 4. The lubricating engine oil formulations of Examples 35-43 and 45 are anticipated to have sulfated ash levels greater than or equal to 1.0 weight percent and total base number greater than or equal to 9. The lubricating engine oil formulations of Examples 39 and 41 do not contain molybdenum. The lubricating engine oil formulations of Examples 40 and 42 are anticipated to have a molybdenum level of

around 250 ppm. The lubricating engine oil formulations of Examples 35-39 and 43-46 are anticipated to have molybdenum levels of around 90 ppm. All lubricating engine oil formulations in Fig. 10 that include at least one alkoxyated alcohol are anticipated to provide improvements in fuel economy without sacrificing engine durability (e.g., while maintaining or improving high temperature wear, deposit and varnish control) in an engine lubricated with the lubricating oil formulation.

[00144] The lubricating engine oil formulations in Fig. 11 are combinations of additives and base stocks and are anticipated to have a kinematic viscosity at 100°C around 10 cSt and high temperature high shear (10^{-6} s^{-1}) viscosity at 150°C around 3.0 cP. The lubricating engine oil formulations of Examples 47, 48, 51, 52, 55, and 56 are anticipated to have a phosphorus level around 300 ppm. The lubricating engine oil formulations of Examples 49, 50, 53, 54, 57, and 58 are anticipated to have a phosphorus level around 700 ppm. The lubricating engine oil formulations of Examples 56 and 58 are anticipated to have a sulfated ash level around 0.3 weight percent and a total base number around 4. The lubricating engine oil formulations of Examples 47-55 and 57 are anticipated to have sulfated ash levels greater than or equal to 1.0 weight percent and total base number greater than or equal to 9. The lubricating engine oil formulations of Examples 51 and 53 do not contain molybdenum. The lubricating engine oil formulations of Examples 52 and 54 are anticipated to have a molybdenum level of around 250 ppm. The lubricating engine oil formulations of Examples 47-51 and 55-58 are anticipated to have molybdenum levels of around 90 ppm. All lubricating engine oil formulations in Fig. 11 that include at least one alkoxyated alcohol are anticipated to provide improvements in fuel economy without sacrificing engine durability (e.g., while maintaining or improving high temperature wear, deposit and varnish control) in an engine lubricated with the lubricating oil formulation.

[00145] All patents and patent applications, test procedures (such as ASTM methods, UL methods, and the like), and other documents cited herein are fully incorporated by reference to the extent such disclosure is not inconsistent with this disclosure and for all jurisdictions in which such incorporation is permitted.

[00146] When numerical lower limits and numerical upper limits are listed herein, ranges from any lower limit to any upper limit are contemplated. While the illustrative embodiments of the disclosure have been described with particularity, it will be understood that various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the spirit and scope of the disclosure. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the examples and descriptions set forth herein but rather that the claims be construed as encompassing all the features of patentable novelty which reside in the present disclosure, including all features which would be treated as equivalents thereof by those skilled in the art to which the disclosure pertains.

[00147] The present disclosure has been described above with reference to numerous embodiments and specific examples. Many variations will suggest themselves to those skilled in this art in light of the above detailed description. All such obvious variations are within the full intended scope of the appended claims.

CLAIMS:

1. A method for improving fuel efficiency, while maintaining or improving high temperature wear, deposit and varnish control, in an engine lubricated with a lubricating oil by using as the lubricating oil a formulated oil, said formulated oil having a composition comprising a lubricating oil base stock as a major component; and at least one alkoxyated alcohol, as a minor component; wherein fuel efficiency is improved and high temperature wear, deposit and varnish control are maintained or improved as compared to high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol.

2. The method of claim 1 wherein the lubricating oil base stock comprises a Group I, Group II, Group III, Group IV or Group V base oil.

3. The method of claims 1 and 2 wherein, in comparison with fuel efficiency achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oil containing at least one alkoxyated alcohol exhibits a fuel efficiency, FEI sum, greater than 1.2X, as determined by a Sequence VID Fuel Economy (ASTM D7589) engine test; and wherein, in comparison with high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oil containing at least one alkoxyated alcohol exhibits high temperature wear, deposit and varnish control greater than 1.1X, as determined by a Sequence IIIG/IIIGA (ASTM D7320) engine test.

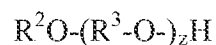
4. The method of claims 1-3 wherein the alkoxyated alcohol is represented by the formula



wherein R^1 is a hydrocarbon group having from 1 to 50 carbon atoms, x is an integer from 1 to 10, and y is an integer from 1 to 10.

5. The method of claims 1-4 wherein the alkoxyated alcohol is selected from stearyl alcohol ethoxylate, lauryl alcohol ethoxylate, oleyl alcohol ethoxylate, stearyl alcohol propoxylate, lauryl alcohol propoxylate, oleyl alcohol propoxylate, stearyl alcohol butoxylate, octyl alcohol butoxylate, myristyl alcohol ethoxypropoxylate, stearyl alcohol ethoxypropoxylate, lauryl alcohol ethoxypropoxylate, and mixtures thereof.

6. The method of claims 1-5 wherein the alkoxyated alcohol is represented by the formula



wherein R^2 is a branched or linear hydrocarbon group having from 12 to 20 carbon atoms, R^3 is an alkylene group having from 2 to 4 carbon atoms, and z is an integer from 1 to 10.

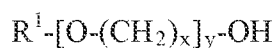
7. The method of claims 1-6 wherein the alkoxyated alcohol is selected from polyoxyethylene stearyl ether, polyoxyethylene lauryl ether, polyoxyethylene oleyl ether, polyoxypropylene stearyl ether, polyoxypropylene lauryl ether, polyoxypropylene oleyl ether, polyoxybutylene stearyl ether, polyoxybutylene octyl ether, poly(oxyethylene)(oxypropylene) myristyl ether, poly(oxyethylene)(oxypropylene) stearyl ether, poly(oxyethylene)(oxypropylene) lauryl ether, and mixtures thereof.

8. A lubricating engine oil having a composition comprising a lubricating oil base stock as a major component; and at least one alkoxyated alcohol, as a minor component; wherein fuel efficiency is improved and high temperature wear, deposit and varnish control are maintained or improved as compared to high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol.

9. The lubricating engine oil of claim 8 wherein the lubricating oil base stock comprises a Group I, Group II, Group III, Group IV or Group V base oil.

10. The lubricating engine oil of claims 8 and 9 wherein, in comparison with fuel efficiency achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oil containing at least one alkoxyated alcohol exhibits a fuel efficiency, FEI sum, greater than 1.2X, as determined by a Sequence VID Fuel Economy (ASTM D7589) engine test; and wherein, in comparison with high temperature wear, deposit and varnish control achieved using a lubricating engine oil containing a minor component other than the at least one alkoxyated alcohol, the lubricating engine oil containing at least one alkoxyated alcohol exhibits high temperature wear, deposit and varnish control greater than 1.1X, as determined by a Sequence IIIG/IIIGA (ASTM D7320) engine test.

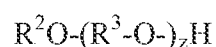
11. The lubricating engine oil of claims 8-10 wherein the alkoxyated alcohol is represented by the formula



wherein R^1 is a hydrocarbon group having from 1 to 50 carbon atoms, x is an integer from 1 to 10, and y is an integer from 1 to 10.

12. The lubricating engine oil of claims 8-11 wherein the alkoxyated alcohol is selected from stearyl alcohol ethoxylate, lauryl alcohol ethoxylate, oleyl alcohol ethoxylate, stearyl alcohol propoxylate, lauryl alcohol propoxylate, oleyl alcohol propoxylate, stearyl alcohol butoxylate, octyl alcohol butoxylate, myristyl alcohol ethoxypropoxylate, stearyl alcohol ethoxypropoxylate, and lauryl alcohol ethoxypropoxylate.

13. The lubricating engine oil of claims 8-12 wherein the alkoxyated alcohol is represented by the formula



wherein R^2 is a hydrocarbon group having from 12 to 20 carbon atoms, R^3 is an alkylene group having from 2 to 4 carbon atoms, and z is an integer from 1 to 10.

14. The lubricating engine oil of claims 8-13 wherein the alkoxylated alcohol is selected from polyoxyethylene stearyl ether, polyoxyethylene lauryl ether, polyoxyethylene oleyl ether, polyoxypropylene stearyl ether, polyoxypropylene lauryl ether, polyoxypropylene oleyl ether, polyoxybutylene stearyl ether, polyoxybutylene octyl ether, poly(oxyethylene)(oxypropylene) myristyl ether, poly(oxyethylene)(oxypropylene) stearyl ether, and poly(oxyethylene)(oxypropylene) lauryl ether.

15. The lubricating engine oil of claims 8-14 or the method of claims 1-7 wherein, in friction measurements of the lubricating oil by mini-traction machine (MTM) in Stribeck mode at 50°C and 100°C, the integrated Stribeck friction coefficient of the lubricating oil in the MTM is reduced as compared to the integrated Stribeck friction coefficient of a lubricating oil containing a minor component other than the at least one alkoxylated alcohol, and/or phosphorus retention is improved as compared to phosphorus retention achieved using a lubricating engine oil containing a minor component other than the at least one alkoxylated alcohol.