

DESCRIPTION**TITLE OF INVENTION****LUBRICATING OIL COMPOSITIONS FOR MOTORCYCLES**

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FIELD OF THE INVENTION

The present invention generally relates to lubricating oil compositions useful for motorcycles.

BACKGROUND OF THE INVENTION

10 Lubricants for motorcycles typically provide lubrication for the engine (a crankcase) and a wet clutch. These two devices, although often lubricated by the same fluid, often have different lubrication requirements. For example, the lubrication of the engine desirably provides low "metal-on-metal" friction interface to promote good fuel economy. Typically, the "metal" referred to is steel. However, the friction coefficient for the "metal-on-composition" interface, which occurs within the wet clutch, is typically desired to be
15 relatively high, to assure good engagement and power transmission. Additionally, motorcycle lubricants also lubricate other devices such as gears or bearings, each having their own lubrication requirement.

Many lubricants have been designed over the years for lubrication of motorcycles (also known as motorbikes or motorscooters). One such lubricant is described in U.S. Patent
20 Publication 2008-0096778, Breon et al., April 24, 2008.

Four-stroke motorcycle engine lubricants may appear to be similar to passenger car engine lubricants. However, there are several key engineering design features of motorcycles, such as integration of clutch and gearbox, high speed of operation, high specific power output, low sump volumes, and lightweight engine construction, all of which require additional
25 consideration when formulating motorcycle oils. Because of the varied and demanding lubrication performance required, motorcycle lubricants are typically designed specifically for use in motorcycles. That is, typical lubricants as used in lubricating passenger car engines are not normally used for motorcycles.

Nevertheless, there are a certain number of motorcycles which do not employ a wet clutch,
30 but, rather, "dry" or non-lubricated clutches or clutch plates. Likewise, there might be motorcycles for which a wet clutch is lubricated by a separate lubricant from that used to lubricate the engine. For those motorcycles, the high metal-on-composition friction is of no

benefit to the engine and is indeed undesirable to the extent that it may interfere with the provision of the lowest possible friction in the metal-on-metal interfaces. While one possible approach to solving this problem would be to remove from the lubricant those components that provide high metal-on-composition friction, this is not necessarily desirable. The additives within such lubricants are usually carefully balanced, so that the removal of one component may affect the performance of the lubricant in unintended ways. Furthermore, it may be undesirable, from a commercial standpoint, to stock multiple complete motorcycle lubricants: some for motorcycles with a wet clutch, and some for motorcycles with a dry clutch.

JASO (Japanese Automobile Standard Organization) MB oils are being widely used in the world for four cycle gasoline engine of motorcycles with a dry clutch, e.g. scooter. The MB oils have been formulated with MoDTC since it is essential to meet OEM's requirement of friction characteristics and fuel economy. One such lubricant is described in JP2004099676.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, there is provided a MoDTC-free lubricating oil composition for motorcycles which comprises an engine and a clutch,

wherein the composition comprises:

- (a) a major amount of an oil of lubricating viscosity,
- (b) a molybdenum compound, and
- (c) a salicylate detergent having a TBN 100-450 on active basis,

wherein the composition lubricates the engine but not the clutch.

In another embodiment, provided is a method for lubricating the engine of a motorcycle which comprises an engine and a clutch, with a MoDTC-free lubricating oil composition,

wherein the composition comprises:

- (a) a major amount of an oil of lubricating viscosity,
- (b) a molybdenum compound, and
- (c) a salicylate detergent having a TBN 100-450 on active basis, and

wherein the composition lubricates the engine but not the clutch.

In a further embodiment, disclosed is the use of a lubricating oil composition to lubricate the engine of a motorcycle which comprises an engine and a clutch, with a MoDTC-free lubricating oil composition,

wherein the composition comprises:

- 5 a. a major amount of an oil of lubricating viscosity,
 b. a molybdenum compound, and
 c. a salicylate detergent having a TBN 100-450 on active basis, and
 wherein the composition lubricates the engine but not the clutch.

10 In another embodiment, disclosed is the use of the lubricating oil compositions above to lubricate four cycle gasoline engines of motorcycles equipped with a dry clutch.

Definitions:

The following terms will be used throughout the specification and will have the following meanings unless otherwise indicated.

15 The term “a major amount” of a base oil refers to where the amount of the base oil is at least 40 wt. % of the lubricating oil composition. In some embodiments, “a major amount” of a base oil refers to an amount of the base oil more than 50 wt.%, more than 60 wt.%, more than 70 wt.%, more than 80 wt.%, or more than 90 wt.% of the lubricating oil composition.

20 In the following description, all numbers disclosed herein are approximate values, regardless whether the word “about” or “approximate” is used in connection therewith. They may vary by 1 percent, 2 percent, 5 percent, or, sometimes, 10 to 20 percent.

25 The term “Total Base Number” or “TBN” refers to the level of alkalinity in an oil sample, which indicates the ability of the composition to continue to neutralize corrosive acids, in accordance with ASTM Standard No. D2896 or equivalent procedure. The test measures the change in electrical conductivity, and the results are expressed as mgKOH/g (the equivalent number of milligrams of KOH needed to neutralize 1 gram of a product). Therefore, a high TBN reflects strongly overbased products and, as a result, a higher base reserve for neutralizing acids.

The term “NAO” refers to Normal Alpha Olefins.

The term "on an actives basis" indicates that only the active component(s) of a particular additive are considered when determining the concentration or amount of that particular additive within the overall motorcycle lubricating oil composition. Diluent oil in the additive is excluded.

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DETAILED DESCRIPTION OF THE INVENTION

Provided herein are lubricating oil compositions suitable for motorcycles that do not have a clutch lubricated by the same lubricant, e.g., with non- lubricated ("dry") clutch plates. The compositions are MoDTC-free, but give low friction properties and show good fuel economy performance.

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Molybdenum Succinimide

The unsulfurized or sulfurized oxymolybdenum-containing compounds employed in the present invention ([component (b)]) may be generally characterized as an oxymolybdenum complex of a basic nitrogen compound. Such molybdenum/sulfur complexes are known in the art and are described, for example, in U.S. Pat. No. 4,263,152 to King et al., the disclosure of which is hereby incorporated by reference.

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The structure of the molybdenum compound employed in this invention are not known with certainty; however, they are believed to be compounds in which molybdenum, whose valences are satisfied with atoms of oxygen or sulfur, is either complexed by, or the salt of, one or more nitrogen atoms of the basic nitrogen containing compound used in the preparation of these compositions.

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The molybdenum compounds used to prepare the oxymolybdenum and oxymolybdenum/sulfur complexes employed in the present invention are acidic molybdenum compounds. By acidic is meant that the molybdenum compounds will react with a basic nitrogen compound as measured by ASTM test D-664 or D-2896 titration procedure.

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Typically, these molybdenum compounds are hexavalent and are represented by the following compounds: molybdic acid, ammonium molybdate, sodium molybdate, potassium molybdate and other alkaline metal molybdates and other molybdenum salts such as hydrogen salts, e.g., hydrogen sodium molybdate, MoOCl_4 , MoO_2Br_2 , $\text{Mo}_2\text{O}_3\text{Cl}_6$, molybdenum trioxide or similar acidic molybdenum compounds. Preferred acidic

molybdenum compounds are molybdic acid, ammonium molybdate, and alkali metal molybdates. Particularly preferred are molybdic acid and ammonium molybdate.

The basic nitrogen compound used to prepare the oxymolybdenum complexes have at least one basic nitrogen and are preferably oil-soluble. Typical examples of such compound are succinimides, carboxylic acid amides, hydrocarbyl monoamines, hydrocarbon polyamines, Mannich bases, phosphoramides, thiophosphoramides, phosphonamides, dispersant viscosity index improvers, and mixtures thereof. Any of the nitrogen-containing compounds may be after-treated with, e.g., boron, using procedures well known in the art so long as the compounds continue to contain basic nitrogen. These after-treatments are particularly applicable to succinimides and Mannich base compositions.

The mono and polysuccinimides that can be used to prepare the molybdenum complexes described herein are disclosed in numerous references and are well known in the art. Certain fundamental types of succinimides and the related materials encompassed by the term of art "succinimide" are taught in U.S. Pat. Nos. 3,219,666; 3,172,892; and 3,272,746, the disclosures of which are hereby incorporated by reference. The term "succinimide" is understood in the art to include many of the amide, imide, and amidine species which may also be formed. The predominant product however is a succinimide and this term has been generally accepted as meaning the product of a reaction of an alkenyl substituted succinic acid or anhydride with a nitrogen-containing compound. Preferred succinimides, because of their commercial availability, are those succinimides prepared from a hydrocarbyl succinic anhydride, wherein the hydrocarbyl group contains from about 24 to about 350 carbon atoms, and an ethylene amine, said ethylene amines being especially characterized by ethylene diamine, diethylene triamine, triethylene tetramine, and tetraethylene pentamine. Particularly preferred are those succinimides prepared from polyisobutenyl succinic anhydride of 70 to 128 carbon atoms and tetraethylene pentamine or triethylene tetramine or mixtures thereof.

Also included within the term "succinimide" are the cooligomers of a hydrocarbyl succinic acid or anhydride and a poly secondary amine containing at least one tertiary amino nitrogen in addition to two or more secondary amino groups. Ordinarily this composition has between 1500 and 50000 average molecular weight. A typical compound would be that prepared by reacting polyisobutenyl succinic anhydride and ethylene dipiperazine.

Carboxylic acid amide compounds are also suitable starting materials for preparing the oxymolybdenum complexes employed in this invention. Typical of such compounds are those disclosed in U.S. Pat. No. 3,405,064, the disclosure of which is hereby incorporated by

reference. These compounds are ordinarily prepared by reacting a carboxylic acid or anhydride or ester thereof, having at least 12 to about 350 aliphatic carbon atoms in the principal aliphatic chain and, if desired, having sufficient pendant aliphatic groups to render the molecule oil soluble with an amine or a hydrocarbyl polyamine, such as an ethylene amine, to give a mono or polycarboxylic acid amide. Preferred are those amides prepared from (1) a carboxylic acid of the formula $R'COOH$, where R' is C_{12-20} alkyl or a mixture of this acid with a polyisobutenyl carboxylic acid in which the polyisobutenyl group contains from about 72 to 128 carbon atoms and (2) an ethylene amine, especially triethylene tetramine or tetraethylene pentamine or mixtures thereof.

Another class of compounds which are useful in this invention are hydrocarbyl monoamines and hydrocarbyl polyamines, preferably of the type disclosed in U.S. Pat. No. 3,574,576, the disclosure of which is hereby incorporated by reference. The hydrocarbyl group, which is preferably alkyl, or olefinic having one or two sites of unsaturation, usually contains from about 9 to 350, preferably from about 20 to 200 carbon atoms. Particularly preferred hydrocarbyl polyamines are those which are derived, e.g., by reacting polyisobutenyl chloride and a polyalkylene polyamine, such as an ethylene amine, e.g., ethylene diamine, diethylene triamine, tetraethylene pentamine, 2-aminoethylpiperazine, 1,3-propylene diamine, 1,2-propylenediamine, and the like.

Another class of compounds useful for supplying basic nitrogen are the Mannich base compounds. These compounds are prepared from a phenol or C_{9-200} alkylphenol, an aldehyde, such as formaldehyde or formaldehyde precursor such as paraformaldehyde, and an amine compound. The amine may be a mono or polyamine and typical compounds are prepared from an alkylamine, such as methylamine or an ethylene amine, such as, diethylene triamine, or tetraethylene pentamine, and the like. The phenolic material may be sulfurized and preferably is dodecylphenol or a C_{80-100} alkylphenol. Typical Mannich bases which can be used in this invention are disclosed in U.S. Pat. Nos. 4,157,309 and 3,649,229; 3,368,972; and 3,539,663, the disclosures of which are hereby incorporated by reference. The last referenced patent discloses Mannich bases prepared by reacting an alkylphenol having at least 50 carbon atoms, preferably 50 to 200 carbon atoms with formaldehyde and an alkylene polyamine $HN(ANH)_nH$ where A is a saturated divalent alkyl hydrocarbon of from about 2 to 6 carbon atoms and n is from about 1-10 and where the condensation product of said alkylene polyamine may be further reacted with urea or thiourea. The utility of these Mannich bases as starting materials for preparing lubricating oil additives can often be significantly improved

by treating the Mannich base using conventional techniques to introduce boron into the composition.

Another class of compounds useful for preparing the oxymolybdenum complexes employed in this invention are the phosphoramides and phosphonamides such as those disclosed in U.S. Pat. Nos. 3,909,430 and 3,968,157, the disclosures of which are hereby incorporated by reference. These compounds may be prepared by forming a phosphorus compound having at least one P—N bond. They can be prepared, for example, by reacting phosphorus oxychloride with a hydrocarbyl diol in the presence of a monoamine or by reacting phosphorus oxychloride with a difunctional secondary amine and a mono-functional amine. Thiophosphoramides can be prepared by reacting an unsaturated hydrocarbon compound containing from about 2 to 450 or more carbon atoms, such as polyethylene, polyisobutylene, polypropylene, ethylene, 1-hexene, 1,3-hexadiene, isobutylene, 4-methyl-1-pentene, and the like, with phosphorus pentasulfide and a nitrogen-containing compound as defined above, particularly an alkylamine, alkyldiamine, alkylpolyamine, or an alkyleneamine, such as ethylene diamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, and the like.

Another class of nitrogen-containing compounds useful in preparing the molybdenum complexes employed in this invention includes the so-called dispersant viscosity index improvers (VI improvers). These VI improvers are commonly prepared by functionalizing a hydrocarbon polymer, especially a polymer derived from ethylene and/or propylene, optionally containing additional units derived from one or more co-monomers such as alicyclic or aliphatic olefins or diolefins. The functionalization may be carried out by a variety of processes which introduce a reactive site or sites which usually has at least one oxygen atom on the polymer. The polymer is then contacted with a nitrogen-containing source to introduce nitrogen-containing functional groups on the polymer backbone. Commonly used nitrogen sources include any basic nitrogen compound especially those nitrogen-containing compounds and compositions described herein. Preferred nitrogen sources are alkylene amines, such as ethylene amines, alkyl amines, and Mannich bases.

Preferred basic nitrogen compounds for use in this invention are succinimides, carboxylic acid amides, and Mannich bases. More preferred are succinimides having an average molecular weight of 1000 or 1300 or 2300 and mixtures thereof. Such succinimides can be post treated with boron or ethylene carbonate as known in the art.

The oxymolybdenum complexes of this invention can also be sulfurized.

Representative sulfur sources for preparing the oxymolybdenum/sulfur complexes used in this invention are sulfur, hydrogen sulfide, sulfur monochloride, sulfur dichloride, phosphorus pentasulfide, R''_2-S_x where R'' is hydrocarbyl, preferably C_{1-40} alkyl, and x is at least 2, inorganic sulfides and polysulfides such as $(NH_4)_2S_y$, where y is at least 1, thioacetamide, thiourea, and mercaptans of the formula $R''SH$ where R'' is as defined above. Also useful as sulfurizing agents are traditional sulfur-containing antioxidants such as wax sulfides and polysulfides, sulfurized olefins, sulfurized carboxylic and esters and sulfurized ester-olefins, and sulfurized alkylphenols and the metal salts thereof.

The sulfurized fatty acid esters are prepared by reacting sulfur, sulfur monochloride, and/or sulfur dichloride with an unsaturated fatty ester under elevated temperatures. Typical esters include C_1-C_{20} alkyl esters of C_8-C_{24} unsaturated fatty acids, such as palmitoleic, oleic, ricinoleic, petroselinic, vaccenic, linoleic, linolenic, oleostearic, licanic, paranaric, tariric, gadoleic, arachidonic, cetoleic, etc. Particularly good results have been obtained with mixed unsaturated fatty acid esters, such as are obtained from animal fats and vegetable oils, such as tall oil, linseed oil, olive oil, castor oil, peanut oil, rape oil, fish oil, sperm oil, and so forth.

Exemplary fatty esters include lauryl tallate, methyl oleate, ethyl oleate, lauryl oleate, cetyl oleate, cetyl linoleate, lauryl ricinoleate, oleyl linoleate, oleyl stearate, and alkyl glycerides.

Cross-sulfurized ester olefins, such as a sulfurized mixture of $C_{10}-C_{25}$ olefins with fatty acid esters of $C_{10}-C_{25}$ fatty acids and $C_{10}-C_{25}$ alkyl or alkenyl alcohols, wherein the fatty acid and/or the alcohol is unsaturated may also be used.

Sulfurized olefins are prepared by the reaction of the C_3-C_6 olefin or a low-molecular-weight polyolefin derived therefrom with a sulfur-containing compound such as sulfur, sulfur monochloride, and/or sulfur dichloride.

Also useful are the aromatic and alkyl sulfides, such as dibenzyl sulfide, dixylyl sulfide, dicetyl sulfide, diparaffin wax sulfide and polysulfide, cracked wax-olefin sulfides and so forth. They can be prepared by treating the starting material, e.g., olefinically unsaturated compounds, with sulfur, sulfur monochloride, and sulfur dichloride. Particularly preferred are the paraffin wax thiomers described in U.S. Pat. No. 2,346,156.

Sulfurized alkyl phenols and the metal salts thereof include compositions such as sulfurized dodecylphenol and the calcium salts thereof. The alkyl group ordinarily contains

from about 9 to 300 carbon atoms. The metal salt may be preferably, a Group I or Group II salt, especially sodium, calcium, magnesium, or barium.

Preferred sulfur sources are sulfur, hydrogen sulfide, phosphorus pentasulfide, R'''_2S_z where R''' is hydrocarbyl, preferably C_1 - C_{10} alkyl, and z is at least 3, mercaptans wherein R''' is C_1 - C_{10} alkyl, inorganic sulfides and polysulfides, thioacetamide, and thiourea. Most preferred sulfur sources are sulfur, hydrogen sulfide, phosphorus pentasulfide, and inorganic sulfides and polysulfides.

The polar promoter used in the preparation of the molybdenum complexes employed in this invention is one which facilitates the interaction between the acidic molybdenum compound and the basic nitrogen compound. A wide variety of such promoters are well known to those skilled in the art. Typical promoters are 1,3-propanediol, 1,4-butanediol, diethylene glycol, butyl cellosolve, propylene glycol, 1,4-butyleneglycol, methyl carbitol, ethanolamine, diethanolamine, N-methyl-diethanol-amine, dimethyl formamide, N-methyl acetamide, dimethyl acetamide, methanol, ethylene glycol, dimethyl sulfoxide, hexamethyl phosphoramide, tetrahydrofuran and water. Preferred are water and ethylene glycol. Particularly preferred is water.

While ordinarily the polar promoter is separately added to the reaction mixture, it may also be present, particularly in the case of water, as a component of non-anhydrous starting materials or as waters of hydration in the acidic molybdenum compound, such as $(NH_4)_6Mo_7O_{24} \cdot H_2O$. Water may also be added as ammonium hydroxide.

A method for preparing the oxymolybdenum complexes used in this invention is to prepare a solution of the acidic molybdenum precursor and a polar promoter with a basic nitrogen-containing compound with or without diluent. The diluent is used, if necessary, to provide a suitable viscosity for easy stirring. Typical diluents are lubricating oils and liquid compounds containing only carbon and hydrogen. If desired, ammonium hydroxide may also be added to the reaction mixture to provide a solution of ammonium molybdate. This reaction is carried out at a variety of temperatures, typically at or below the melting point of the mixture to reflux temperature. It is ordinarily carried out at atmospheric pressure although higher or lower pressures may be used if desired. This reaction mixture may optionally be treated with a sulfur source as defined above at a suitable pressure and temperature for the sulfur source to react with the acidic molybdenum and basic nitrogen compounds. In some cases, removal of water from the reaction mixture may be desirable prior to completion of reaction with the sulfur source.

In a preferred and improved method for preparing the oxymolybdenum complexes, the reactor is agitated and heated at a temperature less than or equal to about 120° C., preferably from about 70° C. to about 90° C. Molybdic oxide or other suitable molybdenum source is then charged to the reactor and the temperature is maintained at a temperature less than or equal to about 120° C., preferably at about 70° C. to about 90° C., until the molybdenum is sufficiently reacted. Excess water is removed from the reaction mixture. Removal methods include but are not limited to vacuum distillation or nitrogen stripping while maintaining the temperature of the reactor at a temperature less than or equal to about 120° C., preferably between about 70° C. to about 90° C. The temperature during the stripping process is held at a temperature less than or equal to about 120° C. to maintain the low color intensity of the molybdenum-containing composition. It is ordinarily carried out at atmospheric pressure although higher or lower pressures may be used. The stripping step is typically carried out for a period of about 0.5 to about 5 hours.

If desired, this product can be sulfurized by treating this reaction mixture with a sulfur source as defined above at a suitable pressure and temperature, not to exceed about 120° C. for the sulfur source to react with the acidic molybdenum and basic nitrogen compounds. The sulfurization step is typically carried out for a period of from about 0.5 to about 5 hours and preferably from about 0.5 to about 2 hours. In some cases, removal of the polar promoter (water) from the reaction mixture may be desirable prior to completion of reaction with the sulfur source.

The oxymolybdenum complex and oxymolybdenum/sulfur complex produced by such method is lighter in color (when compared to complexes prepared at higher temperatures) while maintaining good fuel economy, excellent oxidation inhibition, and anti-wear performance qualities. Color in this instance can be more visibly or more quantifiably using a UV spectrophotometer such as a Perkin-Elmer Lambda 18 UV-Visible Double-Beam Spectrophotometer. As used herein, this test recorded the visible spectra of molybdenum compositions at a constant concentration in an isooctane solvent. The spectra represent the absorbance intensity plotted versus the wavelength in nanometers. The spectra extend from the visible region into the near infrared region of the electromagnetic radiation (350 nanometers to 900 nanometers). In this test, the highly colored samples showed increasingly higher absorbance at increasingly higher wavelengths at a constant molybdenum concentration. The preparation of the sample for color measurement comprises diluting the molybdenum-containing composition with isooctane to achieve a constant molybdenum

concentration of 0.00025 g molybdenum per gram of the molybdenum-containing composition/isooctane mixture. Prior to sample measurement the spectrophotometer is referenced by scanning air versus air. The UV visible spectrum from 350 nanometers to 900 nanometers is obtained using a one centimeter path-length quartz cell versus an air reference.

5 The spectra are offset corrected by setting the 867 nanometer absorbance to zero. Then the absorbance of the sample is determined at 350 nanometers wavelength.

Characteristics of these new oxymolybdenum/sulfur complexes are disclosed in U.S. patent application Ser. No. 10/159,446 filed May 31, 2002, entitled REDUCED COLOR MOLYBDENUM-CONTAINING COMPOSITION AND A METHOD OF MAKING SAME, incorporated herein by reference in its entirety.

10 In the reaction mixture, the ratio of molybdenum compound to basic nitrogen compound is not critical; however, as the amount of molybdenum with respect to basic nitrogen increases, the filtration of the product becomes more difficult. Since the molybdenum component probably oligomerizes, it is advantageous to add as much molybdenum as can easily be maintained in the composition. Usually, the reaction mixture will have charged to it from about 0.01 to 2.00 atoms of molybdenum per basic nitrogen atom. Preferably from about 0.3 to 1.0, and most preferably from about 0.4 to 0.7, atoms of molybdenum per atom of basic nitrogen is added to the reaction mixture.

When optionally sulfurized, the sulfurized oxymolybdenum containing compositions may be generally characterized as a sulfur/molybdenum complex of a basic nitrogen dispersant compound preferably with a sulfur to molybdenum weight ratio of from about (0.01 to 1.0) to 1 and more preferably from about (0.05 to 0.5) to 1 and a nitrogen to molybdenum weight ratio of from about (1 to 10) to 1 and more preferably from about (2 to 5) to 1. For extremely low sulfur incorporation the sulfur to molybdenum weight ratio can be from about (0.01 to 0.08) to 1.

25 The oxymolybdenum-containing complex comprises from about 0.02 to 10 wt % and preferably from about 0.1 to 2.0 wt %, based on the total weight of the lubricating oil composition.

In one embodiment, the molybdenum succinimide present in the lubrication oil is 0.1 - 5 wt%. In another embodiment, the molybdenum succinimide present in the lubrication oil is 0.1 - 2 wt%. In another embodiment, the molybdenum succinimide present in the lubrication oil is 0.1 - 1 wt%. In another embodiment, the molybdenum succinimide present in the lubrication oil is 0.5 - 2 wt%. In another embodiment, the molybdenum succinimide

present in the lubrication oil is 0.1 – 2 wt%. In another embodiment, the molybdenum succinimide present in the lubrication oil is 0.5 – 1 wt%.

Salicylate

5 In one embodiment, the lubricating oil composition disclosed herein comprises a salicylate compound [component (c)]. In one embodiment, the salicylate compound is a calcium alkylsalicylate detergent. The calcium alkylsalicylate detergent necessarily contained in the lubricating oil composition of the invention contains an organic acid calcium salt to give the lubricating oil composition containing the organic acid calcium salt in an amount of
10 0.1 to 10 wt. %, preferably 0.2 to 7 wt. %, more preferably 1.0 to 6 wt. %, and comprises an unsulfurized calcium alkylsalicylate detergent having a TBN of 100-450 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 100-400 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 100-350 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 150-400 on active basis.
15 In one embodiment, the calcium alkylsalicylate detergent has a TBN 150-350 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 200-400 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 200-350 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 250-400 on active basis. In one embodiment, the calcium alkylsalicylate detergent has a TBN 250-350 on active basis.

20 The calcium alkylsalicylate detergent may have an alkyl group having 10-40 carbon atoms, and the alkyl group may be derived from normal- α -olefins (NAO) or isomerized normal- α -olefins (NAO). In one embodiment, the calcium alkylsalicylate detergent may be derived from a C14-18 NAO. In another embodiment, the calcium alkylsalicylate detergent is derived from a C20-28 NAO. In another embodiment, the calcium
25 alkylsalicylate detergent is derived from a C20-24 isomerized NAO.

The unsulfurized calcium alkylsalicylate detergent preferably is a calcium alkylsalicylate prepared from an alkyl phenol (which is prepared from α -olefin having the desired carbon atom number and phenol) by way of Kolbe-Schmitt reaction. Generally, an overbased calcium salicylate which is obtained by way of the carbonation process using
30 slaked lime and carbon dioxide gas for overbasing is used as the calcium salicylate detergent.

Otherwise, the calcium alkylsalicylate can be directly produced by carbonizing an alkylphenol calcium salt obtained by direct neutralization.

In addition to the heretofore described metal-containing detergents, a small amount of sulfonates such as alkali metal salts or alkaline earth metal salts of petroleum sulfonic acid, alkylbenzenesulfonic acid or alkyltoluenesulfonic acid can be employed in combination with the alkylsalicylate detergent.

A sulfurized phenate which has been used for the conventional engine oils is an alkali metal salt or an alkaline earth metal salt of a sulfurized alkylphenol. Typically, calcium salt and magnesium salt are employed. The sulfurized phenate shows high thermal stability but generally has a high sulfur content such as approx. 3 wt. % or more, which is brought about by the sulfurization reaction. In the invention, a small amount of the sulfurized phenate may be employed in combination with the alkylsalicylate detergent.

In one embodiment, the calcium alkylsalicylate is 0.1 – 10wt%. In another embodiment, the calcium alkylsalicylate is 0.5 – 10wt%. In another embodiment, the calcium alkylsalicylate is 1 – 10wt%. In another embodiment, the calcium alkylsalicylate is 2 – 10wt%. In another embodiment, the calcium alkylsalicylate is 2 – 6wt%.

The Oil of Lubricating Viscosity

The lubricating oil compositions disclosed herein generally comprise at least one oil of lubricating viscosity. Any base oil known to a skilled artisan can be used as the oil of lubricating viscosity disclosed herein. Some base oils suitable for preparing the lubricating oil compositions have been described in Mortier et al., “*Chemistry and Technology of Lubricants*,” 2nd Edition, London, Springer, Chapters 1 and 2 (1996); and A. Sequeria, Jr., “*Lubricant Base Oil and Wax Processing*,” New York, Marcel Decker, Chapter 6, (1994); and D. V. Brock, *Lubrication Engineering*, Vol. 43, pages 184-5, (1987), all of which are incorporated herein by reference. Generally, the amount of the base oil in the lubricating oil composition may be from about 70 to about 99.5 wt. %, based on the total weight of the lubricating oil composition. In some embodiments, the amount of the base oil in the lubricating oil composition is from about 75 to about 99 wt. %, from about 80 to about 98.5

wt. %, or from about 80 to about 98 wt. %, based on the total weight of the lubricating oil composition.

In certain embodiments, the base oil is or comprises any natural or synthetic lubricating base oil fraction. Some non-limiting examples of synthetic oils include oils, such as polyalphaolefins or PAOs, prepared from the polymerization of at least one alpha-olefin, such as ethylene, or from hydrocarbon synthesis procedures using carbon monoxide and hydrogen gases, such as the Fisher-Tropsch process. In certain embodiments, the base oil comprises less than about 10 wt. % of one or more heavy fractions, based on the total weight of the base oil. A heavy fraction refers to a lube oil fraction having a viscosity of at least about 20 cSt at 100° C. In certain embodiments, the heavy fraction has a viscosity of at least about 25 cSt or at least about 30 cSt at 100° C. In further embodiments, the amount of the one or more heavy fractions in the base oil is less than about 10 wt. %, less than about 5 wt. %, less than about 2.5 wt. %, less than about 1 wt. %, or less than about 0.1 wt. %, based on the total weight of the base oil. In still further embodiments, the base oil comprises no heavy fraction.

In certain embodiments, the lubricating oil compositions comprise a major amount of a base oil of lubricating viscosity. In some embodiments, the base oil has a kinematic viscosity at 100° C. from about 2.5 centistokes (cSt) to about 20 cSt, from about 4 centistokes (cSt) to about 20 cSt, or from about 5 cSt to about 16 cSt. The kinematic viscosity of the base oils or the lubricating oil compositions disclosed herein can be measured according to ASTM D 445, which is incorporated herein by reference.

In other embodiments, the base oil is or comprises a base stock or blend of base stocks. In further embodiments, the base stocks are manufactured using a variety of different processes including, but not limited to, distillation, solvent refining, hydrogen processing, oligomerization, esterification, and rerefining. In some embodiments, the base stocks comprise a rerefined stock. In further embodiments, the rerefined stock shall be substantially free from materials introduced through manufacturing, contamination, or previous use.

In some embodiments, the base oil comprises one or more of the base stocks in one or more of Groups I-V as specified in the American Petroleum Institute (API) Publication 1509, Fourteen Edition, December 1996 (i.e., API Base Oil Interchangeability Guidelines for Passenger Car Motor Oils and Diesel Engine Oils), which is incorporated herein by reference. The API guideline defines a base stock as a lubricant component that may be manufactured using a variety of different processes. Groups I, II and III base stocks are mineral oils, each

with specific ranges of the amount of saturates, sulfur content and viscosity index. Group IV base stocks are polyalphaolefins (PAO). Group V base stocks include all other base stocks not included in Group I, II, III, or IV.

In some embodiments, the base oil comprises one or more of the base stocks in Group I, II, III, IV, V or a combination thereof. In other embodiments, the base oil comprises one or more of the base stocks in Group II, III, IV or a combination thereof. In further embodiments, the base oil comprises one or more of the base stocks in Group II, III, IV or a combination thereof wherein the base oil has a kinematic viscosity from about 2.5 centistokes (cSt) to about 20 cSt, from about 4 cSt to about 20 cSt, or from about 5 cSt to about 16 cSt at 100° C.

The base oil may be selected from the group consisting of natural oils of lubricating viscosity, synthetic oils of lubricating viscosity and mixtures thereof. In some embodiments, the base oil includes base stocks obtained by isomerization of synthetic wax and slack wax, as well as hydrocrackate base stocks produced by hydrocracking (rather than solvent extracting) the aromatic and polar components of the crude. In other embodiments, the base oil of lubricating viscosity includes natural oils, such as animal oils, vegetable oils, mineral oils (e.g., liquid petroleum oils and solvent treated or acid-treated mineral oils of the paraffinic, naphthenic or mixed paraffinic-naphthenic types), oils derived from coal or shale, and combinations thereof. Some non-limiting examples of animal oils include bone oil, lanolin, fish oil, lard oil, dolphin oil, seal oil, shark oil, tallow oil, and whale oil. Some non-limiting examples of vegetable oils include castor oil, olive oil, peanut oil, rapeseed oil, corn oil, sesame oil, cottonseed oil, soybean oil, sunflower oil, safflower oil, hemp oil, linseed oil, tung oil, oiticica oil, jojoba oil, and meadow foam oil. Such oils may be partially or fully hydrogenated.

In some embodiments, the synthetic oils of lubricating viscosity include hydrocarbon oils and halo-substituted hydrocarbon oils such as polymerized and inter-polymerized olefins, alkylbenzenes, polyphenyls, alkylated diphenyl ethers, alkylated diphenyl sulfides, as well as their derivatives, analogues and homologues thereof, and the like. In other embodiments, the synthetic oils include alkylene oxide polymers, interpolymers, copolymers and derivatives thereof wherein the terminal hydroxyl groups can be modified by esterification, etherification, and the like. In further embodiments, the synthetic oils include the esters of dicarboxylic acids with a variety of alcohols. In certain embodiments, the synthetic oils include esters made from C₅ to C₁₂ monocarboxylic acids and polyols and polyol ethers. In further

embodiments, the synthetic oils include tri-alkyl phosphate ester oils, such as tri-n-butyl phosphate and tri-iso-butyl phosphate.

In some embodiments, the synthetic oils of lubricating viscosity include silicon-based oils (such as the polyakyl-, polyaryl-, polyalkoxy-, polyaryloxy-siloxane oils and silicate oils).

5 In other embodiments, the synthetic oils include liquid esters of phosphorus-containing acids, polymeric tetrahydrofurans, polyalphaolefins, and the like.

Base oil derived from the hydroisomerization of wax may also be used, either alone or in combination with the aforesaid natural and/or synthetic base oil. Such wax isomerase oil is produced by the hydroisomerization of natural or synthetic waxes or mixtures thereof over a
10 hydroisomerization catalyst.

In further embodiments, the base oil comprises a poly-alpha-olefin (PAO). In general, the poly-alpha-olefins may be derived from an alpha-olefin having from about 2 to about 30, from about 4 to about 20, or from about 6 to about 16 carbon atoms. Non-limiting examples of suitable poly-alpha-olefins include those derived from octene, decene, mixtures thereof,
15 and the like. These poly-alpha-olefins may have a viscosity from about 2 to about 15, from about 3 to about 12, or from about 4 to about 8 centistokes at 100° C. In some instances, the poly-alpha-olefins may be used together with other base oils such as mineral oils.

In further embodiments, the base oil comprises a polyalkylene glycol or a polyalkylene glycol derivative, where the terminal hydroxyl groups of the polyalkylene glycol may be modified by esterification, etherification, acetylation and the like. Non-limiting
20 examples of suitable polyalkylene glycols include polyethylene glycol, polypropylene glycol, polyisopropylene glycol, and combinations thereof. Non-limiting examples of suitable polyalkylene glycol derivatives include ethers of polyalkylene glycols (e.g., methyl ether of polyisopropylene glycol, diphenyl ether of polyethylene glycol, diethyl ether of
25 polypropylene glycol, etc.), mono- and polycarboxylic esters of polyalkylene glycols, and combinations thereof. In some instances, the polyalkylene glycol or polyalkylene glycol derivative may be used together with other base oils such as poly-alpha-olefins and mineral oils.

In further embodiments, the base oil comprises any of the esters of dicarboxylic acids
30 (e.g., phthalic acid, succinic acid, alkyl succinic acids, alkenyl succinic acids, maleic acid, azelaic acid, suberic acid, sebacic acid, fumaric acid, adipic acid, linoleic acid dimer, malonic acid, alkyl malonic acids, alkenyl malonic acids, and the like) with a variety of alcohols (e.g., butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, ethylene glycol,

diethylene glycol monoether, propylene glycol, and the like). Non-limiting examples of these esters include dibutyl adipate, di(2-ethylhexyl) sebacate, di-n-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, the 2-ethylhexyl diester of linoleic acid dimer, and the like.

5 In further embodiments, the base oil comprises a hydrocarbon prepared by the Fischer-Tropsch process. The Fischer-Tropsch process prepares hydrocarbons from gases containing hydrogen and carbon monoxide using a Fischer-Tropsch catalyst. These hydrocarbons may require further processing in order to be useful as base oils. For example, the hydrocarbons may be dewaxed, hydroisomerized, and/or hydrocracked using processes
10 known to a person of ordinary skill in the art.

In further embodiments, the base oil comprises an unrefined oil, a refined oil, a rerefined oil, or a mixture thereof. Unrefined oils are those obtained directly from a natural or synthetic source without further purification treatment. Non-limiting examples of unrefined
15 oils include shale oils obtained directly from retorting operations, petroleum oils obtained directly from primary distillation, and ester oils obtained directly from an esterification process and used without further treatment. Refined oils are similar to the unrefined oils except the former have been further treated by one or more purification processes to improve one or more properties. Many such purification processes are known to those skilled in the art such as solvent extraction, secondary distillation, acid or base extraction, filtration,
20 percolation, and the like. Rerefined oils are obtained by applying to refined oils processes similar to those used to obtain refined oils. Such rerefined oils are also known as reclaimed or reprocessed oils and often are additionally treated by processes directed to removal of spent additives and oil breakdown products.

Other additives

25 Optionally, the lubricating oil composition may further comprise at least an additive or a modifier (hereinafter designated as "additive") that can impart or improve any desirable property of the lubricating oil composition. Any additive known to a person of ordinary skill in the art may be used in the lubricating oil compositions disclosed herein. Some suitable additives have been described in Mortier et al., "*Chemistry and Technology of Lubricants*,"
30 2nd Edition, London, Springer, (1996); and Leslie R. Rudnick, "*Lubricant Additives: Chemistry and Applications*," New York, Marcel Dekker (2003), both of which are

incorporated herein by reference. In some embodiments, the additive can be selected from the group consisting of antioxidants, antiwear agents, detergents, rust inhibitors, demulsifiers, friction modifiers, multi-functional additives, viscosity index improvers, pour point depressants, foam inhibitors, metal deactivators, dispersants, corrosion inhibitors, lubricity improvers, thermal stability improvers, anti-haze additives, icing inhibitors, dyes, markers, static dissipaters, biocides and combinations thereof. In general, the concentration of each of the additives in the lubricating oil composition, when used, may range from about 0.001 wt. % to about 10 wt. %, from about 0.01 wt. % to about 5 wt. %, or from about 0.1 wt. % to about 2.5 wt. %, based on the total weight of the lubricating oil composition. Further, the total amount of the additives in the lubricating oil composition may range from about 0.001 wt. % to about 20 wt. %, from about 0.01 wt. % to about 10 wt. %, or from about 0.1 wt. % to about 5 wt. %, based on the total weight of the lubricating oil composition.

Dispersants

In one embodiment, the lubricating oil composition disclosed herein comprises an ashless dispersant which can be an alkenyl succinimide, an alkyl succinimide, or a derivative thereof, in which the alkenyl group and alkyl group can be derived from polyolefin. The ashless dispersant is incorporated into the lubricating oil composition in an amount of 0.01 to 0.3 wt. % in terms of the nitrogen content. The percent is given per the amount of the lubricating oil composition. A representative succinimide can be obtained by the reaction between succinic anhydride having a substituent group of a high molecular weight alkenyl or alkyl with a polyalkylene polyamine having a mean nitrogen atom number of 4 to 10, preferably 5 to 7. The high molecular weight alkenyl or alkyl is preferably derived from polybutene having a number average molecular weight of approximately 900 to 3,000, 900 to 2300, 900 to 1100, or 1100 to 2300.

In the process for producing a polybutenyl succinic anhydride by the reaction of polybutene and maleic anhydride, a chlorination procedure is generally employed. However, the chlorination procedure gives remaining chlorine in the product, and hence the finally produced succinimide inevitably contains a large amount (such as approximately 2,000 to 3,000 ppm) of the emigrated chlorine. In contrast, the thermal reaction using no chlorine gives a final product having an extremely small chlorine content (such as 0 to 30 ppm).

Therefore, the succinimide derived from a polyisobutenyl succinimide obtained by the thermal reaction can be favorably employed for formulating a lubricating oil composition having low chlorine content such as 0 to 30 wt. ppm. The succinimide can be post-treated with boric acid, a boron-containing compound, alcohol, aldehyde, ketone, alkylphenol, cyclic carbonate or an organic acid. Preferred is a borated alkenyl- (or alkyl-) succinimide which is obtained by post-treatment with boric acid or a boron-containing compound, and which shows high thermal stability and high oxidation stability.

In one embodiment, the lubricating oil composition comprises a succinimide. In another embodiment, the lubricating oil composition comprises a bissuccinimide. In another embodiment, the lubricating oil composition comprises a borated bissuccinimide. In another embodiment, the lubricating oil composition comprises a mixture of borated and non-borated bissuccinimide.

Antioxidants

The lubricating oil composition of the present invention can contain one or more antioxidants that can reduce or prevent the oxidation of the base oil. Any antioxidant known by a person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable antioxidants include amine-based antioxidants (e.g., alkyl diphenylamines such as bis-nonylated diphenylamine, bis-octylated diphenylamine, and octylated/butylated diphenylamine, phenyl- α -naphthylamine, alkyl or arylalkyl substituted phenyl- α -naphthylamine, alkylated p-phenylene diamines, tetramethyldiaminodiphenylamine and the like), phenolic antioxidants (e.g., 2-tert-butylphenol, 4-methyl-2,6-di-tert-butylphenol, 2,4,6-tri-tert-butylphenol, 2,6-di-tert-butyl-p-cresol, 2,6-di-tert-butylphenol, 4,4'-methylenebis(2,6-di-tert-butylphenol), 4,4'-thiobis(6-di-tert-butyl-o-cresol) and the like), sulfur-based antioxidants (e.g., dilauryl-3,3'-thiodipropionate, sulfurized phenolic antioxidants and the like), phosphorous-based antioxidants (e.g., phosphites and the like), zinc dithiophosphate, oil-soluble copper compounds and combinations thereof. The amount of the antioxidant may vary from about 0.01 wt. % to about 10 wt. %, from about 0.05 wt. % to about 5 wt. %, or from about 0.1 wt. % to about 3 wt. %, based on the total weight of the lubricating oil composition.

Wear Inhibitors

The lubricating oil composition of the present invention can contain one or more anti-wear agents that can reduce friction and excessive wear. Any anti-wear agent

known by a person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable anti-wear agents include zinc dithiophosphate, metal (e.g., Pb, Sb, Mo and the like) salts of dithiophosphates, metal (e.g., Zn, Pb, Sb, Mo and the like) salts of dithiocarbamates, metal (e.g., Zn, Pb, Sb and the like) salts of fatty acids, boron compounds, phosphate esters, phosphite esters, amine salts of phosphoric acid esters or thiophosphoric acid esters, reaction products of dicyclopentadiene and thiophosphoric acids and combinations thereof. The amount of the anti-wear agent may vary from about 0.01 wt. % to about 5 wt. %, from about 0.05 wt. % to about 3 wt. %, or from about 0.1 wt. % to about 1 wt. %, based on the total weight of the lubricating oil composition.

In certain embodiments, the anti-wear agent is or comprises a dihydrocarbyl dithiophosphate metal salt, such as zinc dialkyl dithiophosphate compounds. The metal of the dihydrocarbyl dithiophosphate metal salt may be an alkali or alkaline earth metal, or aluminum, lead, tin, molybdenum, manganese, nickel or copper. In some embodiments, the metal is zinc. In other embodiments, the alkyl group of the dihydrocarbyl dithiophosphate metal salt has from about 3 to about 22 carbon atoms, from about 3 to about 18 carbon atoms, from about 3 to about 12 carbon atoms, or from about 3 to about 8 carbon atoms. In further embodiments, the alkyl group is linear or branched.

The amount of the dihydrocarbyl dithiophosphate metal salt including the zinc dialkyl dithiophosphate salts in the lubricating oil composition disclosed herein is measured by its phosphorus content. In some embodiments, the phosphorus content of the lubricating oil composition disclosed herein is from about 0.01 wt. % to about 0.14 wt., based on the total weight of the lubricating oil composition.

Foam Inhibitors

The lubricating oil composition of the present invention can contain one or more foam inhibitors or anti-foam inhibitors that can break up foams in oils. Any foam inhibitor or anti-foam known by a person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable foam inhibitors or anti-foam inhibitors include silicone oils or polydimethylsiloxanes, fluorosilicones, alkoxylated aliphatic acids, polyethers (e.g., polyethylene glycols), branched polyvinyl ethers, alkyl acrylate polymers, alkyl methacrylate polymers, polyalkoxyamines and combinations thereof. In some embodiments, the foam inhibitors or anti-foam inhibitors comprises glycerol monostearate, polyglycol palmitate, a trialkyl monothiophosphate, an ester of sulfonated ricinoleic acid, benzoylacetone, methyl salicylate, glycerol monooleate, or glycerol dioleate.

The amount of the foam inhibitors or anti-foam inhibitors may vary from about 0.001 wt. % to about 5 wt. %, from about 0.05 wt. % to about 3 wt. %, or from about 0.1 wt. % to about 1 wt. %, based on the total weight of the lubricating oil composition.

Pour Point Depressants

5 The lubricating oil composition of the present invention can contain one or more pour point depressants that can lower the pour point of the lubricating oil composition. Any pour point depressant known by a person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable pour point depressants include polymethacrylates, alkyl acrylate polymers, alkyl methacrylate polymers, di(tetra-
10 paraffin phenol)phthalate, condensates of tetra-paraffin phenol, condensates of a chlorinated paraffin with naphthalene and combinations thereof. In some embodiments, the pour point depressant comprises an ethylene-vinyl acetate copolymer, a condensate of chlorinated paraffin and phenol, polyalkyl styrene or the like. The amount of the pour point depressant may vary from about 0.01 wt. % to about 10 wt. %, from about 0.05 wt. % to about 5 wt. %, or from about 0.1 wt. % to about 3 wt. %, based on the total weight of the lubricating oil composition.

Demulsifiers

 In one embodiment, the lubricating oil composition of the present invention does not contain one or more demulsifiers. In another embodiment, the lubricating oil
20 composition of the present invention can contain one or more demulsifiers that can promote oil-water separation in lubricating oil compositions that are exposed to water or steam. Any demulsifier known by a person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable demulsifiers include anionic surfactants (e.g., alkyl-naphthalene sulfonates, alkyl benzene sulfonates and the like), nonionic alkoxylated
25 alkyl phenol resins, polymers of alkylene oxides (e.g., polyethylene oxide, polypropylene oxide, block copolymers of ethylene oxide, propylene oxide and the like), esters of oil soluble acids, polyoxyethylene sorbitan ester and combinations thereof. The amount of the demulsifier may vary from about 0.01 wt. % to about 10 wt. %, from about 0.05 wt. % to about 5 wt. %, or from about 0.1 wt. % to about 3 wt. %, based on the total weight of the
30 lubricating oil composition.

Corrosion Inhibitors

 The lubricating oil composition of the present invention can contain one or more corrosion inhibitors that can reduce corrosion. Any corrosion inhibitor known by a

person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable corrosion inhibitor include half esters or amides of dodecylsuccinic acid, phosphate esters, thiophosphates, alkyl imidazolines, sarcosines and combinations thereof. The amount of the corrosion inhibitor may vary from about 0.01 wt. % to about 5 wt. %, from about 0.05 wt. % to about 3 wt. %, or from about 0.1 wt. % to about 1 wt. %, based on the total weight of the lubricating oil composition.

Extreme Pressure Agents

The lubricating oil composition of the present invention can contain one or more extreme pressure (EP) agents that can prevent sliding metal surfaces from seizing under conditions of extreme pressure. Any extreme pressure agent known by a person of ordinary skill in the art may be used in the lubricating oil composition. Generally, the extreme pressure agent is a compound that can combine chemically with a metal to form a surface film that prevents the welding of asperities in opposing metal surfaces under high loads. Non-limiting examples of suitable extreme pressure agents include sulfurized animal or vegetable fats or oils, sulfurized animal or vegetable fatty acid esters, fully or partially esterified esters of trivalent or pentavalent acids of phosphorus, sulfurized olefins, dihydrocarbyl polysulfides, sulfurized Diels-Alder adducts, sulfurized dicyclopentadiene, sulfurized or co-sulfurized mixtures of fatty acid esters and monounsaturated olefins, co-sulfurized blends of fatty acid, fatty acid ester and alpha-olefin, functionally-substituted dihydrocarbyl polysulfides, thia-aldehydes, thia-ketones, epithio compounds, sulfur-containing acetal derivatives, co-sulfurized blends of terpene and acyclic olefins, and polysulfide olefin products, amine salts of phosphoric acid esters or thiophosphoric acid esters and combinations thereof. The amount of the extreme pressure agent may vary from about 0.01 wt. % to about 5 wt. %, from about 0.05 wt. % to about 3 wt. %, or from about 0.1 wt. % to about 1 wt. %, based on the total weight of the lubricating oil composition.

Rust Inhibitors

The lubricating oil composition of the present invention can contain one or more rust inhibitors that can inhibit the corrosion of ferrous metal surfaces. Any rust inhibitor known by a person of ordinary skill in the art may be used in the lubricating oil composition. Non-limiting examples of suitable rust inhibitors include nonionic polyoxyalkylene agents, e.g., polyoxyethylene lauryl ether, polyoxyethylene higher alcohol ether, polyoxyethylene nonylphenyl ether, polyoxyethylene octylphenyl ether, polyoxyethylene octyl stearyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitol

monostearate, polyoxyethylene sorbitol monooleate, and polyethylene glycol monooleate; stearic acid and other fatty acids; dicarboxylic acids; metal soaps; fatty acid amine salts; metal salts of heavy sulfonic acid; partial carboxylic acid ester of polyhydric alcohol; phosphoric esters; (short-chain) alkenyl succinic acids; partial esters thereof and nitrogen-containing derivatives thereof; synthetic alkarylsulfonates, e.g., metal dinonylnaphthalene sulfonates; and the like and mixtures thereof. The amount of the rust inhibitor may vary from about 0.01 wt. % to about 10 wt. %, from about 0.05 wt. % to about 5 wt. %, or from about 0.1 wt. % to about 3 wt. %, based on the total weight of the lubricating oil composition.

The lubricating oil composition of the present invention can contain one or more metal deactivators. Non-limiting examples of suitable metal deactivators include disalicylidene propylenediamine, triazole derivatives, thiadiazole derivatives, and mercaptobenzimidazoles.

VII

The lubricating oil composition of the present invention can contain one or more viscosity index improvers. Non-limiting examples of suitable viscosity index improvers include, but are not limited to, olefin copolymers, such as ethylene-propylene copolymers, styrene-isoprene copolymers, hydrated styrene-isoprene copolymers, polybutene, polyisobutylene, polymethacrylates, vinylpyrrolidone and methacrylate copolymers and dispersant type viscosity index improvers. These viscosity modifiers can optionally be grafted with grafting materials such as, for example, maleic anhydride, and the grafted material can be reacted with, for example, amines, amides, nitrogen-containing heterocyclic compounds or alcohol, to form multifunctional viscosity modifiers (dispersant-viscosity modifiers). Other examples of viscosity modifiers include star polymers (e.g., a star polymer comprising isoprene/styrene/isoprene triblock). Yet other examples of viscosity modifiers include poly alkyl(meth)acrylates of low Brookfield viscosity and high shear stability, functionalized poly alkyl(meth)acrylates with dispersant properties of high Brookfield viscosity and high shear stability, polyisobutylene having a weight average molecular weight ranging from 700 to 2,500 Daltons and mixtures thereof. The amount of the viscosity index improvers may vary from about 0.01 wt. % to about 25 wt. %, from about 0.05 wt. % to about 20 wt. %, or from about 0.3 wt. % to about 15 wt. %, based on the total weight of the lubricating oil composition.

Metal Deactivators

In some embodiments, the lubricating oil composition comprises at least a metal deactivator. Some non-limiting examples of suitable metal deactivators include disalicylidene propylenediamine, triazole derivatives, thiadiazole derivatives, and mercaptobenzimidazoles.

5 The additives disclosed herein may be in the form of an additive concentrate having more than one additive. The additive concentrate may comprise a suitable diluent, such as a hydrocarbon oil of suitable viscosity. Such diluent can be selected from the group consisting of natural oils (e.g., mineral oils), synthetic oils and combinations thereof. Some non-limiting examples of the mineral oils include paraffin-based oils, naphthenic-based oils, asphaltic-
10 based oils and combinations thereof. Some non-limiting examples of the synthetic base oils include polyolefin oils (especially hydrogenated alpha-olefin oligomers), alkylated aromatic, polyalkylene oxides, aromatic ethers, and carboxylate esters (especially diester oils) and combinations thereof. In some embodiments, the diluent is a light hydrocarbon oil, both natural or synthetic. Generally, the diluent oil can have a viscosity from about 13 centistokes
15 to about 35 centistokes at 40° C.

 Generally, it is desired that the diluent readily solubilizes the lubricating oil soluble additive of the invention and provides an oil additive concentrate that is readily soluble in the lubricant base oil stocks or fuels. In addition, it is desired that the diluent not introduce any undesirable characteristics, including, for example, high volatility, high viscosity, and
20 impurities such as heteroatoms, to the lubricant base oil stocks and thus, ultimately to the finished lubricant or fuel.

 The present invention further provides an oil soluble additive concentrate composition comprising an inert diluent and from 2.0 % to 90% by weight, preferably 10% to 50% by weight based on the total concentrate, of an oil soluble additive composition according to the
25 present invention.

 The following examples are presented to exemplify embodiments of the invention but are not intended to limit the invention to the specific embodiments set forth. Unless indicated to the contrary, all parts and percentages are by weight. All numerical values are approximate. When numerical ranges are given, it should be understood that embodiments

outside the stated ranges may still fall within the scope of the invention. Specific details described in each example should not be construed as necessary features of the invention.

EXAMPLES

The following examples are intended for illustrative purposes only and do not limit in any way the scope of the present invention.

The lubricating oil compositions for evaluating their performances were prepared from the below-mentioned additives. All the lubricating oil compositions were prepared to have a viscosity grade (SAE viscosity grade) of 10W-30.

Salicylate A: Ca salicylate having TBN of 280 on an active basis.

Salicylate B: Ca salicylate having TBN of 300 on an active basis.

Sulfonate: An oil concentrate of Ca sulfonate.

Phenate: An oil concentrate of Ca phenate.

Additionally, each of the examples contain 7.1 wt. % primary ZnDTP, 7.1 wt. % secondary

ZnDTP, 0.5 wt. % amine antioxidant, and 50 wt. ppm of foam inhibitor.

The lubricating oil compositions were evaluated according to the High Frequency Reciprocating Rig (*HFRR*) Evaluation and JASCO T903:2011 as described below.

Friction Performance

[High Frequency Reciprocating Rig (*HFRR*) Evaluation]

The friction coefficient was determined in terms of a metal-metal friction coefficient.

The ***HFRR*** test rig is an industry recognized test for determining lubricant performance using a tribometer. The PCS instrument uses an electromagnetic vibrator to oscillate a specimen (the ball) over a small amplitude while pressing it against a fixed specimen (a flat disk). The amplitude and frequency of the oscillation and the load are variable. The frictional force between the ball and flat disk and the electrical contact resistance (ECR) are measured. The flat, stationary specimen is held in a bath to which the lubricating oil is added, and can be heated. For this test, the tribometer was set up to run at >50 Hz for >60 minutes, using 6 mm ball on flat specimens of 52100 steel. The load was 1.0 kg and the temperature was 100 °C. In this test, a smaller coefficient of friction corresponds to a more effective lubricating friction modifier additive. The ***HFRR*** friction performance data are presented in Table 2.

JASO T903:2011 Procedure:

The lubricant compositions were subjected to a clutch system friction test as described in JASO T903:2011. The test evaluates three main clutch parameters: static friction, relating to clutch-slip; dynamic friction, relating to clutch feel/uptake; and stop time, relating to synchronization time. A clutch performance index is then assigned to the lubricating composition, which can be classified as JASO MA, JASO MA1, or JASO MA2 (high friction, suitable for wet clutch applications), or JASO MB (low friction, more suitable for dry clutch applications).

For a lubricating composition to claim JASO MB performance, all three indices must fall within the values specified for the MB category, or two indices must fall within the values specified for the MB category and one within the values specified for the MA category, or one index must fall within the values specified for the MB category and two within the values specified for the MA category, as set forth below in Table 1.

Table 1

Parameter	Index	JASO MA	JASO MA2	JASO MA1	JASO MB
Dynamic Friction Index	DFI	$1.30 \leq \text{DFI} < 2.50$	$1.85 \leq \text{DFI} < 2.50$	$1.30 \leq \text{DFI} < 1.85$	$0.5 \leq \text{DFI} < 1.30$
Static Friction Index	SFI	$1.25 \leq \text{SFI} < 2.50$	$1.70 \leq \text{SFI} < 2.50$	$1.25 \leq \text{SFI} < 1.70$	$0.5 \leq \text{SFI} < 1.25$
Stop Time Index	STI	$1.45 \leq \text{STI} < 2.50$	$1.85 \leq \text{STI} < 2.50$	$1.45 \leq \text{STI} < 1.85$	$0.5 \leq \text{STI} < 1.45$

The JASO T903:2011 clutch performance data are presented in Table 2.

Table 2

Examples>	1	2	3	4	5	6	7	8	Comp A	B	C	D
Dispersant A	1.25	1.25	1.25	1.25	1.25	-	1.25	1.25	-	-	-	1.25
Dispersant B	1.25	1.25	1.25	1.25	1.25	-	1.25	1.25	2.5	2.5	2.5	1.25
Salicylate A	2.88	-	2.88	2.88	-	-	2.88	5.76	-	-	-	-
Salicylate B	-	2.88	-	-	3.52	3.52	-	-	-	-	-	-
Molybdenum Succinimide	0.8	0.8	0.5	1.0	0.8	0.8	0.8	0.8	-	-	0.8	0.8
Phenate	0.42	0.42	0.42	0.42	-	2.3	-	0.21	2.3	-	2.3	2.3
Sulfonate	-	-	-	-	-	-	0.25	-	-	1.37	-	-
HFRR Friction Coefficient	0.062	0.062	0.071	0.062	0.059	0.098	0.079	0.107	0.151	0.136	0.113	0.09
JASO Classification	MB	MB	MB	MB	MB	MB	MB	MB	MA/ MA2	MA	MA/ MA2	MA/ MA2
DFI	1.71	1.63	1.97	1.83	1.79	1.47	1.87	1.77	2.06	2.00	2.10	2.00
SFI	0.50	0.50	1.16	1.16	0.53	0.80	0.91	0.69	2.27	1.45	2.38	2.27
STI	1.57	1.48	1.87	1.81	1.71	1.41	1.77	1.65	2.13	2.03	2.11	2.08

Examples 1-8 all qualified as MB oils whereas comparative examples A to D failed to qualify as MB oils. Examples 1-8 has lower friction coefficients (<0.1), which means the compositions have improved friction benefits over comparative examples A to D. The MB oils all meet OEM requirements for friction and fuel economy performance in four cycle gasoline engines of motorcycles equipped with a dry clutch.

It will be understood that various modifications may be made to the embodiments disclosed herein. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. For example, the functions described above and implemented as the best mode for operating the present invention are for illustration purposes only. Other arrangements and methods may be implemented by those skilled in the art without departing from the scope and spirit of this invention. Moreover, those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

5 WHAT IS CLAIMED IS:

1. A MoDTC-free lubricating oil composition for motorcycles which comprises an engine and a dry clutch, wherein the composition comprises:
 - 10 a. at least 40 wt.% of an oil of lubricating viscosity based on the weight of the lubricating oil composition,
 - b. a molybdenum compound, and
 - c. a salicylate detergent having a TBN 100-450 on active basis in accordance with ASTM Standard No. D2896, wherein the salicylate detergent is a calcium alkylsalicylate detergent derived from C₁₄₋₁₈ normal alpha olefins, and wherein the
15 calcium alkylsalicylate detergent is present in an amount of 0.1 – 10 wt. %.
2. The lubricating oil composition of claim 1, wherein the molybdenum compound is a molybdenum succinimide.
20
3. The lubricating oil composition of claim 1, wherein the salicylate detergent has a TBN of 150 - 450.
4. The lubricating oil composition of claim 1, wherein the salicylate detergent has a
25 TBN of 200 - 400.
5. The lubricating oil composition of claim 1, wherein the salicylate detergent has a TBN of 250 - 400.
- 30 6. The lubricating oil composition of claim 1, wherein the salicylate detergent has a TBN of 250 - 350.
7. Use of the lubricating oil composition according to any one of the preceding claims to lubricate the engine of a motorcycle which comprises an engine and a clutch, wherein the composition lubricates the engine but not the clutch.
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8. Use of the lubricating oil composition of any one of the claims 1 to 6 to lubricate four cycle gasoline engines of motorcycles equipped with a dry clutch.

9. A method for lubricating the engine of a motorcycle which comprises an engine and a clutch, with a MoDTC-free lubricating oil composition, wherein the composition comprises:

- 10
- a. at least 40 wt. % of an oil of lubricating viscosity based on the total weight of the lubricating oil composition,
 - b. a molybdenum compound, and
 - c. a salicylate detergent having a TBN 100-450 on active basis in accordance with ASTM Standard No. D2896, and

15 wherein the composition lubricates the engine but not the clutch; wherein the salicylate detergent is a calcium alkylsalicylate detergent derived from C₁₄₋₁₈ normal alpha olefins, and wherein the calcium alkylsalicylate detergent is present in an amount of 0.1 – 10 wt. %..

20 10. The method of claim 9, wherein the molybdenum compound is a molybdenum succinimide.

11. The method of claim 9, wherein the salicylate detergent has a TBN 150 - 450.

12. The method of claim 9, wherein the salicylate detergent has a TBN 200 – 400

25 13. The method of claim 9, wherein the salicylate detergent has a TBN 250 - 400.

14. The method of claim 9, wherein the salicylate detergent has a TBN 250 - 350.

15. The method of claim 9, wherein the clutch is a dry clutch.