

**LOW ASH LUBRICATING COMPOSITION FOR IMPROVED PISTON
CLEANLINESS IN MOTORCYCLE APPLICATIONS**

TECHNICAL FIELD

[0001] The present disclosure relates to lubricating compositions and, in particular, low ash lubricating compositions suitable for motorcycle applications.

BACKGROUND

[0002] In a motorcycle, a common fluid provides lubrication to the engine as well as driveline components including a transmission and/or a clutch. As such, lubricating compositions used in motorcycle engines are formulated to have a balance of both friction properties suitable for the driveline and lubrication properties suitable for the engine. This is in contrast to lubricants for other vehicles, such as passenger cars, where the engine is lubricated by one type of lubricant and the driveline is lubricated with a second type of lubricant. This dual-purpose fluid in motorcycle applications causes formulation challenges because it is often desirable to reduce viscosity and friction in the engine crankcase to improve fuel economy but, on the other hand, it is important to maintain sufficient friction in a transmission and/or clutch assembly for proper operation. Thus, lubricants formulated for passenger car applications are generally not suitable for motorcycle applications because the passenger car fluid may exhibit, among other features, too low of a coefficient of friction for lubricating the transmission and/or clutch componentry of most motorcycles. In view of the unique challenges for motorcycle lubricants, the industry and various manufacturers have developed standards to evaluate lubricant quality and performance for motorcycle applications.

[0003] In particular, the JASO T903 standard defines performance requirements for four-stroke motorcycle lubricants and is widely adopted by lubricant producers and original equipment manufacturers (OEM) for motorcycles. The T903 standard generally includes three main portions relating to engine performance, clutch friction performance, and certain compositional limits. The current standard has been in use since 2016 and was recently updated in 2023 and, in view of these updates, lubricants that satisfied the 2016 standards may no longer be suitable under the updated requirements. Moreover, it is anticipated that a further update to this standard with enhanced performance requirements is forthcoming in 2028, and lubricants that might satisfy the 2023 standards will likely not satisfy the heightened requirements anticipated in 2028 for motorcycle lubrication.

[0004] Additionally, many OEM motorcycle manufacturers require other performance requirements relating to piston cleanliness. One common performance requirement for evaluating piston cleanliness is the so-called Hot Tube Test (JIS Method No. JPI-5S-55-99) and generally performed at 280°C. This test uses a glass tube heated in an aluminum block to gauge the degree of lacquer formation, if any, when a lubricant is subjected to high temperatures, and is believed to estimate piston under-crown conditions and, in some instances, relates to piston cleanliness in air-cooled and/or four-stroke motorcycle engines. Higher ratings at the end of the test indicate less deposits or greater thermal stability of the lubricant. Motorcycle manufactures are seeking to require performance of this test at even higher temperatures, such as at 290°C, but lubricants configured to achieve performance at these higher temperatures often fail the ash and/or phosphorus limits required in the updated T903 standards for 2023 and the even stricter standards anticipated in 2028.

SUMMARY

[0005] The present disclosure relates to a motorcycle lubricating compositions, and in one embodiment, a finished motorcycle lubricating composition comprising: one or more base oils of lubricating viscosity; an aminic antioxidant providing at least about 300 ppm of antioxidant nitrogen to the finished motorcycle lubricating composition; a mixed-metal detergent system providing about 800 to about 3000 ppm of calcium and about 200 to about 1000 ppm of magnesium to the finished motorcycle lubricating composition; a weight ratio of the magnesium from the detergent system to the antioxidant nitrogen from the aminic antioxidant (Mg/N) of about 0.8 to about 2.8; and wherein the finished motorcycle lubricating composition has a piston cleanliness rating of 5 or higher in the Hot Tube Test pursuant to JPI-5S-55-99 at about 290°C.

[0006] In yet other approaches or embodiments, the finished motorcycle lubricating composition of the previous paragraph may include other features or embodiments in any combination. These other features or embodiments may include one or more of the following: wherein a weight ratio of the magnesium and the calcium from the detergent system relative to the antioxidant nitrogen from the aminic antioxidant (Mg + Ca)/(N) is about 5.0 to about 8.0; and/or wherein the detergent system includes calcium sulfonate, calcium phenate, and magnesium sulfonate; and/or wherein the lubricating composition includes about 0.9 to about 1.5 weight percent of the aminic antioxidant; and/or wherein the aminic antioxidant is selected from the group consisting of an aromatic amine, an alkylated

diphenylamine, a nonyl diphenylamine, a di-nonyl diphenylamine, an octyl diphenylamine, a di-octyl diphenylamine, a phenyl-alpha-naphthylamine, an alkylated phenyl-alpha-naphthylamine, a hindered non-aromatic amine, or combinations thereof; and/or wherein at least about 40 weight percent of total nitrogen in the finished motorcycle lubricating composition is provided by the antioxidant nitrogen from the aminic antioxidant; and/or wherein the finished motorcycle lubricating composition lubricates a motorcycle engine crankcase and a transmission including a wet clutch from a common reservoir; and/or wherein the finished motorcycle lubricating composition has a total phosphorus level of 1000 ppm or less; and/or wherein the finished motorcycle lubricating composition has a total base number (TBN) as measured by ASTM D2896 of at least about 8.0 mg KOH/g; and/or wherein the finished motorcycle lubricating composition is provided by a motorcycle lubricating composition and a booster additive package, wherein the motorcycle lubricating composition includes one or more calcium-containing detergent additives providing the calcium in the detergent system and the booster additive package includes one or more magnesium-containing detergent additives providing the magnesium in the detergent system; and/or wherein the motorcycle lubricating composition includes a first portion of the aminic antioxidant and the booster additive package includes a second portion of the aminic antioxidant; and/or wherein the second portion of the aminic antioxidant provides about 70 to about 80 weight percent of the antioxidant nitrogen in the finished motorcycle lubricating composition; and/or wherein the finished motorcycle lubricating composition has a total sulfated ash content as measured by ASTM D872 of less than about 1.0 weight percent.

[0007] In yet other approaches or embodiments, a booster additive package for top-treating a motorcycle lubricating composition to form a finished motorcycle lubricating composition is described herein. In one aspect, the booster additive package includes an aminic antioxidant in amounts to provide about 200 ppm to about 360 ppm of antioxidant nitrogen to the finished motorcycle lubricating composition; one or more magnesium-containing detergent additives in amounts to provide about 200 ppm to about 1000 ppm of magnesium to the finished motorcycle lubricating composition; and wherein the booster additive package is configured, upon top-treating a motorcycle lubricating composition, to form the finished motorcycle lubricating composition having a weight ratio of magnesium-to-antioxidant nitrogen (Mg/N) of about 0.8 to about 2.8 and wherein a first portion of the antioxidant nitrogen is provided from the motorcycle lubricating composition and a second portion of the antioxidant nitrogen is provided by the booster additive package; and wherein

the finished motorcycle lubricating composition has a piston cleanliness rating of 5 or higher in the Hot Tube Test run pursuant to JPI-5S-55-99 at about 290°C.

[0008] In yet other approaches or embodiments, the booster additive package of the previous paragraph may include one or more other features or embodiments in any combination. These other features or embodiments may include one or more of the following: wherein the booster additive package consists only of the one or more magnesium-containing detergent additives; and/or wherein the one or more magnesium-containing detergents is one or more overbased magnesium sulfonate detergent additives; and/or wherein the aminic antioxidant is selected from the group consisting of an aromatic amine, an alkylated diphenylamine, a nonyl diphenylamine, a di-nonyl diphenylamine, an octyl diphenylamine, a di-octyl diphenylamine, a phenyl-alpha-naphthylamine, an alkylated phenyl-alpha-naphthylamine, a hindered non-aromatic amine, or combinations thereof; and/or wherein at least about 40 weight percent of the total nitrogen in the finished motorcycle lubricating composition is provided by the aminic antioxidant; and/or wherein the second portion of the aminic antioxidant provides about 70 to about 80 weight percent of the total antioxidant nitrogen in the finished motorcycle lubricating composition.

[0009] In yet further approaches or embodiments, a method for improving piston cleanliness of a motorcycle engine is provided herein. In one aspect, the method includes providing a motorcycle lubricating composition including one or more calcium-containing detergent additives and one or more aminic antioxidants providing a first portion of antioxidant nitrogen; adding a booster additive package to the motorcycle lubricating composition to form a finished motorcycle lubricating composition to lubricate a motorcycle engine crankcase and a motorcycle transmission from a common reservoir, wherein the booster additive package includes one or more magnesium-containing detergent additives and one or more aminic antioxidants providing a second portion of the antioxidant nitrogen; and wherein the finished motorcycle lubricating composition has a piston cleanliness rating of 5 or higher in the Hot Tube Test pursuant to JPI-5S-55-99 at about 290°C.

[0010] In yet further approaches or embodiments, the method of the previous paragraph may include other features, steps, or embodiments in any combination. The other features, steps, or embodiments may include one or more of the following: wherein the finished motorcycle lubricating composition includes (i) one or more base oils of lubricating viscosity; (ii) combined aminic antioxidant from the motorcycle lubricant and the booster additive package of at least about 300 ppm; (iii) a mixed-metal detergent system providing about 800

to about 3000 ppm of calcium and about 200 to about 1000 ppm of magnesium; and wherein a weight ratio of the magnesium from the detergent system to the total antioxidant nitrogen from the combined aminic antioxidant (Mg/N) is about 0.8 to about 2.8; and/or wherein the booster additive packaging consists only of the one or more magnesium-containing detergent additives; and/or wherein the one or more magnesium-containing detergents is one or more overbased magnesium sulfonate detergent additives; and/or wherein the aminic antioxidant of the motorcycle lubricating composition, the booster additive package, or both is selected from the group comprising an aromatic amine, an alkylated diphenylamine, a nonyl diphenylamine, a di-nonyl diphenylamine, an octyl diphenylamine, a di-octyl diphenylamine, a phenyl-alpha-naphthylamine, an alkylated phenyl-alpha-naphthylamine, a hindered non-aromatic amine, or combinations thereof; and/or wherein at least about 40 weight percent of the total nitrogen in the finished motorcycle lubricating composition is provided by the combined aminic antioxidant from the booster additive package and the motorcycle lubricating composition; and/or wherein the second portion of the aminic antioxidant provides about 70 to about 80 weight percent of the total antioxidant nitrogen in the finished motorcycle lubricating composition; and/or wherein the finished motorcycle lubricating composition has a total sulfated ash content of 1.0 weight percent or less as measured pursuant to ASTM D872.

[0011] In yet further approaches or embodiments, a use is described herein of any embodiment of the finished motorcycle lubricating compositions of this summary and/or any embodiment of the booster additive package of this summary for achieving a piston cleanliness rating of a finished motorcycle lubricant of 5 or higher in the Hot Tube Test pursuant to JPI-5S-55-99 at about 290°C.

DETAILED DESCRIPTION

[0012] The present disclosure relates to finished lubricating compositions configured for motorcycles and also to methods of lubricating a motorcycle engine, transmission, and clutch assembly with the finished lubricating compositions provided from a common sump. As noted in the Background, the Hot Tube Test (HTT) of JIS method No. JPI-5S-55-99 is a performance test commonly required by many OEM motorcycle manufacturers to simulate piston cleanliness, and generally simulates deposit-forming tendencies of lubricants. It has been discovered, however, that finished motorcycle lubricants achieving passing performance at prior test conditions of 280°C do not necessarily achieve passing performance at enhanced

test conditions of 290°C or, if acceptable performance is achievable at the higher temperatures, then it often requires a composition with unacceptably higher ash and/or phosphorus contents. For instance, a higher total base number (TBN) of a lubricant often aids in passing the HTT, but increasing detergent metals sufficient to achieve TBN levels for passing HTT performance at higher temperatures tends to unacceptably increase the total ash content of the lubricant at the same time.

[0013] Unexpectedly, it has been discovered herein that balancing certain elemental relationships of calcium and/or magnesium detergent metals to antioxidant nitrogen achieves passing HTT performance at elevated temperatures (such as 290°C) while still allowing the finished lubricants to maintain T903 certifications for 2023 (and the likely requirements for 2028) in terms of ash and/or phosphorus contents. In one embodiment, for instance, the finished motorcycle lubricating compositions herein include one or more base oils of lubricating viscosity; an aminic antioxidant providing at least about 300 ppm of antioxidant nitrogen to the motorcycle lubricating composition; a detergent system providing about 800 to about 3000 ppm of calcium and about 200 to about 1000 ppm of magnesium to the motorcycle lubricating composition; a weight ratio of the magnesium from the detergent system to nitrogen from the aminic antioxidant (Mg/N) of about 0.8 to about 2.8 and/or a weight ratio of combined magnesium and calcium from the detergent system to nitrogen from the aminic antioxidant (Mg+Ca)/(N) of about 5 to about 8. Such finished motorcycle lubricating compositions achieve passing performance in Hot Tube Test of JPI-5S-55-99 when performed at 290°C, which is a piston cleanliness rating of 5.0 or higher, 6.0 or higher, 7.0 or higher, or 8.0 or higher.

[0014] In some embodiments, the finished motorcycle lubricating compositions also have an overall TBN of at least 8 mg KOH/g or at least about 8.2 mg KOH/g and, in other embodiments, an overall TBN of about 8 to about 15 mg KOH/g, about 8 to about 12 mg KOH/g, or about 8 to about 10 mg KOH/g. Preferably, the detergent systems of the compositions herein provide about 70 to about 90 percent (or about 70 to about 80 percent) of the finished fluid's TBN where the detergent systems may have a TBN of about 6 to about 10 mg KOH/g or about 6 to about 8 mg KOH/g. As used herein, unless noted otherwise, TBN is determined by ASTM D2896.

[0015] In other embodiments, the finished motorcycle lubricating compositions also have sulfated ash levels (SASH), as measured pursuant to ASTM D872, of less than 1.2 percent, preferably less than 1.0 percent, and more preferably less than 0.9 percent suitable for the

T903 standards. The finished motorcycle lubricating compositions herein also have a phosphorus level of less than 1200 ppm, less than 1000 ppm, less than 980 ppm, or less than 950 ppm.

[0016] Turning to more of the specifics, the present application relates to a finished motorcycle lubricating composition (or finished motorcycle lubricant) having the various embodiments and/or relationships noted above, which can be achieved (i) by directly formulating the finished motorcycle lubricant or (ii) by using a booster additive package configured as top-treat for motorcycle lubricants. In the context of using a booster, a motorcycle lubricant refers to a composition with one or more base oils of lubricating viscosity, one or more dispersants, one or more detergents (preferably only calcium-containing detergents), one or more antioxidants, one or more antifoam additives, and optionally viscosity index improvers configured for use in a motorcycle but not meeting the elemental relationships as discovered herein. The booster additive packages, when used, include at least nitrogen from one or more aminic antioxidants, magnesium-containing detergent additives (preferably only magnesium-containing detergents), and optional amounts of process oil/base oil of lubricating viscosity as top-treats for the motorcycle lubricants to achieve the relationships of the finished motorcycle lubricants.

[0017] The Detergent System

[0018] The finished motorcycle lubricating compositions herein include a mixed-metal detergent or mixed-metal detergent system. In embodiments, the mixed-metal systems of the finished lubricants herein generally includes multiple detergent additives including two or more alkali or alkaline metal salts of phenates, sulfonates, calixarates, salixarates, salicylates, carboxylic acids, sulfurized derivatives thereof, or combinations thereof. Preferably, the detergents are mixed-metal containing sulfonates, salicylates, and/or phenates, and most preferably, mixed metal-containing detergents providing certain amounts of calcium and/or magnesium relative to the antioxidant nitrogen. As discussed more below, the motorcycle lubricating composition may be a calcium-only lubricant with the magnesium provided in a booster package such that when the booster is added to the motorcycle lubricating composition, it provides the finished motorcycle lubricating having the mixed-metal detergent system with the various relationships herein. Alternatively, the motorcycle lubricating compositions here may be formulated as finished lubricants including the mixed-metal systems herein with the noted relationships.

[0019] Suitable detergents and their methods of preparation are described in greater detail in numerous patent publications, including US 7,732,390 and references cited therein, which are incorporated herein by reference. The finished motorcycle lubricant compositions herein may include about 0.1 to about 5 weight percent of any individual and/or total detergent additives, and in other approaches, about 0.15 to about 3 weight percent, and in yet other approaches, about 0.5 to 2.6 weight percent of individual and/or total detergent additives so long as the metal amounts and relationships noted herein are satisfied.

[0020] The detergent system herein is a mixed-metal system providing at least calcium and magnesium in the form of phenate and/or sulfonate detergents and, more preferably, overbased calcium phenate, overbased calcium sulfonate, overbased magnesium phenate, and/or overbased magnesium sulfonate, with at least a weight ratio of the magnesium from the detergent system to nitrogen from the aminic antioxidant (Mg/N) of about 0.8 to about 2.8 (in other approaches, about 0.8 to about 1.0 or, in further approaches, about 1.5 to about 1.8) and/or a weight ratio of magnesium and calcium from the detergent system to nitrogen from the aminic antioxidant (Mg+Ca)/(N) of about 5 to about 8 (in other approaches, about 6 to about 8, or in further approaches, about 5 to about 6).

[0021] In terms of calcium, the detergent system provides about 800 to about 3000 ppm of calcium or about 800 to about 2500 ppm calcium. In other embodiments, the detergent systems provide about 2000 to about 3000 ppm of calcium, about 2200 to about 2800 ppm of calcium, or about 2400 to about 2600 ppm of calcium. In yet other embodiments, the detergent system provides about 900 to about 2000 ppm of calcium, about 900 to about 1800 ppm of calcium, or about 900 to about 1600 ppm of calcium. Preferably, the calcium is provided by a combination of sulfonate and phenate detergent additives, and most preferably, overbased calcium sulfonate and/or overbased calcium phenate detergents.

[0022] In terms of magnesium, the detergent system provides about 200 to about 1000 ppm of magnesium or about 250 to about 950 ppm magnesium. In other approaches, the detergent systems provides about 200 to about 300 ppm of magnesium, about 220 to about 300 ppm of calcium, or about 250 to about 300 ppm of magnesium. In yet other approaches, the detergent system provides about 800 to about 1000 ppm of magnesium, about 850 to about 1000 ppm of magnesium, or about 900 to about 1000 ppm of magnesium. Preferably, the magnesium is provided by sulfonate and/or phenate detergent additives and, most preferably, overbased sulfonate detergents.

[0023] In the embodiment of the finished motorcycle lubricant, the amounts of the calcium and magnesium noted above are formulated as the detergent system in a single fluid configured as the finished lubricant. In the embodiment of the booster and the motorcycle lubricant, it is preferred that the magnesium content is provided by one or more detergents in the booster and the calcium content is provided by one or more detergents in the motorcycle lubricant (e.g., the booster provides the magnesium and the motorcycle lubricant provides the calcium). Amounts in the booster and motorcycle lubricant can be adjusted as needed to achieve the amounts noted above in the finished motorcycle lubricant.

[0024] Generally, suitable detergents in the system, subject to the noted amounts, types, and relationships for the detergents herein discussed above, may include linear or branched alkali or alkaline earth metal salts, such as calcium or magnesium, of petroleum sulfonic acids and long chain mono- or di-alkylaryl sulfonic acids with the aryl group being benzyl, tolyl, and xylyl and/or various phenates or derivatives of phenates. Examples of suitable detergents include, but are not limited to, low-based/neutral and overbased variations of the following detergents: calcium phenates, calcium sulfur containing phenates, calcium sulfonates, calcium calixarates, calcium salixarates, calcium salicylates, calcium carboxylic acids, calcium phosphorus acids, calcium mono- and/or di-thiophosphoric acids, calcium alkyl phenols, calcium sulfur coupled alkyl phenol compounds, calcium methylene bridged phenols, magnesium phenates, magnesium sulfur containing phenates, magnesium sulfonates, magnesium calixarates, magnesium salixarates, magnesium salicylates, magnesium carboxylic acids, magnesium phosphorus acids, magnesium mono- and/or di-thiophosphoric acids, magnesium alkyl phenols, magnesium sulfur coupled alkyl phenol compounds, magnesium methylene bridged phenols. Sodium containing detergents may optionally be included so long as performance, relationships, and/or ratios as noted herein are not impacted and may optionally include sodium phenates, sodium sulfur containing phenates, sodium sulfonates, sodium calixarates, sodium salixarates, sodium salicylates, sodium carboxylic acids, sodium phosphorus acids, sodium mono- and/or di-thiophosphoric acids, sodium alkyl phenols, sodium sulfur coupled alkyl phenol compounds, or sodium methylene bridged phenols.

[0025] The detergent additives may be neutral, low-based, or overbased and, preferably, overbased as noted above. As understood, overbased detergent additives are well-known in the art and may be alkali or alkaline earth metal overbased detergent additives. Such detergent additives may be prepared by reacting a metal oxide or metal hydroxide with a

substrate and carbon dioxide gas. The substrate is typically an acid, for example, an acid such as an aliphatic substituted sulfonic acid, an aliphatic substituted carboxylic acid, or an aliphatic substituted phenol.

[0026] The term “overbased” relates to metal salts, such as metal salts of sulfonates, carboxylates, salicylates and/or phenates, wherein the amount of metal present exceeds the stoichiometric amount. Such salts may have a conversion level in excess of 100% (i.e., they may comprise more than 100% of the theoretical amount of metal needed to convert the acid to its “normal,” “neutral” salt). The expression “metal ratio,” often abbreviated as MR, is used to designate the ratio of total chemical equivalents of metal in the overbased salt to chemical equivalents of the metal in a neutral salt according to known chemical reactivity and stoichiometry. In a normal or neutral salt, the MR is one and in an overbased salt, MR, is greater than one. They are commonly referred to as overbased, hyperbased, or superbased salts and may be salts of organic sulfur acids, carboxylic acids, or phenols.

[0027] As used herein, the term “TBN” is used to denote the Total Base Number in mg KOH/g as measured by the method of ASTM D2896. An overbased detergent of the lubricating oil compositions herein may have a total base number (TBN) of about 200 mg KOH/gram or greater, or about 250 mg KOH/gram or greater, or about 350 mg KOH/gram or greater, or about 375 mg KOH/gram or greater, or about 400 mg KOH/gram or greater or about 200 mg KOH/gram to about 450 mg KOH/gram or any range therein. The overbased detergent may have a metal to substrate ratio of from 1.1:1 or less, or from 2:1 or less, or from 4:1 or less, or from 5:1 or less, or from 7:1 or less, or from 10:1 or less, or from 12:1 or less, or from 15:1 or less, or from 20:1 or less.

[0028] Preferably, the detergents are overbased, but the finished motorcycle lubricants herein may also include optional low-based or neutral detergents as long the performance noted herein is maintained. When a low-based or neutral detergent is incorporated into the detergent system, it generally has a TBN of up to 175 mg KOH/g, up to 150 mg KOH/g, up to 100 mg KOH/g, or up to 50 mg KOH/g. The low-based/neutral detergent may include a calcium, sodium, or magnesium-containing detergent. Examples of suitable low-based/neutral detergent include, but are not limited to, calcium sulfonates, calcium phenates, calcium salicylates, magnesium sulfonates, magnesium phenates, and/or magnesium salicylates.

[0029] In some embodiments, the detergent used in the lubricants herein is a combination of overbased calcium sulfonate, overbased calcium phenate, and overbased magnesium

sulfonate with each having a total base number of 200 to 450 and, in other approaches, with the overbased calcium detergents having a TBN of about 200 to about 350 and the overbased magnesium detergents having a TBN of about 300 to about 450. The above described TBN values reflect those of finished detergent components that have been diluted in a base oil.

[0030] In other embodiments, the TBN of the detergents herein may reflect a neat or non-diluted version of the detergent component. For example, the fluids herein may include overbased calcium sulfonate or an overbased calcium phenate, as a neat additive, having a TBN of about 300 to about 450, and in other approaches, about 380 to about 420, and/or overbased magnesium sulfonate as a neat additive having a TBN of about 500 to about 700, and in other approaches, about 600 to about 700.

[0031] In some embodiments, the detergent systems herein have effective amounts of detergent additives to provide a certain detergent total base number (TBN) to the lubricant, as measured pursuant to ASTM D2896, of about 6 mg KOH/g to about 10 mg KOH/g, which is effective to aid in achieving the passing Hot Tube Test results noted herein. In these embodiments, the detergent systems may have a TBN from calcium detergents of about 2 to about 6.5 mg KOH/g and a TBN from magnesium detergents of about 1 to about 4.5 mg KOH/g. In some optional embodiments, about 10 to about 65 percent of the detergent system TBN is provided by magnesium-containing detergents and, in other optional embodiments, about 10 to about 20 percent or about 40 to about 65 percent of the detergent TBN is from the magnesium-containing detergents herein. Generally, about 70 to about 90 percent or 70 to about 80 percent of the finished fluid TBN is provided by the detergent systems herein.

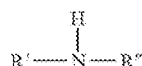
[0032] In terms of soap contribution to the lubricants herein, the detergent systems herein may optionally provide about 0.5 to about 0.75 weight percent of soap to the lubricants including both calcium-containing soap and magnesium-containing soap. In some optional embodiments, the soap content is about 0.25 percent to about 0.7 percent of calcium-containing soap and about 0.05 to about 0.4 percent of magnesium-containing soap. Of the soap contributions, generally about 10 to about 60 percent is magnesium-containing soap. Soap content generally refers to the amount of neutral organic acid salt and reflects a detergent's cleansing ability, or detergency, and dirt suspending ability. In one approach, the soap content of a lubricant can be determined by ASTM D3712. In another approach, further discussion on determining soap content can be found in FUELS AND LUBRICANTS

HANDBOOK, TECHNOLOGY, PROPERTIES, PERFORMANCE, AND TESTING, George Totten, editor, ASTM International, 2003, relevant portions thereof incorporated herein by reference.

[0033] Aminic Antioxidant

[0034] The finished motorcycle lubricants herein also include one or more antioxidants and, preferably, one or more aminic antioxidants contributing aminic nitrogen. In approaches or embodiments, the aminic antioxidants may include, but are not limited to, antioxidants selected from aromatic amines, alkylated diphenylamines, phenyl- α -naphthylamines, alkylated phenyl- α -naphthylamines, hindered non-aromatic amines, and the like, or combinations thereof. The total amount of antioxidant in the finished motorcycle lubricating compositions herein is in an amount to deliver at least about 300 ppm of antioxidant nitrogen and, in some approaches, about 300 ppm to about 400 ppm of antioxidant nitrogen. In other approaches, the finished motorcycle lubricating compositions herein may include up to about 1.5 weight percent of the aminic antioxidant, or about 0.9 to about 1.5 weight percent of the aminic antioxidant. In some approaches, the nitrogen from the aminic antioxidant is at least about 40 weight percent of the total nitrogen in the finished motorcycle lubricant, and in other approaches, about 40 to about 50 weight percent of the total nitrogen in the finished motorcycle lubricant composition. As shown in the Examples below, when the contributions of the detergent metals relative to the nitrogen provided by the aminic antioxidant is limited to a certain ranges and ratios, then the finished lubricants herein achieve passing performance in the Hot Tube Test and maintain low ash at the same time.

[0035] In some approaches, the aminic antioxidant may be one or more aromatic amine antioxidants and may include, but are not limited to, diarylamines having the formula:



wherein R' and R'' each independently represents a substituted or unsubstituted aryl group having from 6 to 30 carbon atoms. If substituted, suitable substituents for the aryl group of R' and R'' include aliphatic hydrocarbon groups such as alkyl having from 1 to 30 carbon atoms, hydroxy groups, halogen radicals, carboxylic acid or ester groups, or nitro groups. The aryl group may be substituted or unsubstituted phenyl or naphthyl, particularly wherein one or both of the aryl groups are substituted with at least one alkyl having from 4 to 30 carbon atoms, preferably from 4 to 18 carbon atoms, most preferably from 4 to 9 carbon

atoms. In approaches, one or both aryl groups may be substituted, e.g., mono-alkylated diphenylamine, di-alkylated diphenylamine, C9 alkylated diphenyl amines, or mixtures of mono- and di-alkylated diphenylamines.

[0036] Examples of diarylamines that may be used include, but are not limited to: diphenylamine; various alkylated diphenylamines, 3-hydroxydiphenylamine, N-phenyl-1,2-phenylenediamine, N-phenyl-1,4-phenylenediamine, monobutyldiphenyl-amine, dibutyl-diphenylamine, monooctyldiphenylamine, dioctyldiphenylamine, monononyl-diphenylamine, dinonyldiphenylamine, monotetradecyldiphenylamine, ditetradecyl-diphenylamine, phenyl-alpha-naphthylamine, monooctyl phenyl-alpha-naphthylamine, phenyl-beta-naphthylamine, monoheptyldiphenylamine, diheptyl-diphenylamine, p-oriented styrenated diphenylamine, mixed butyloctyldiphenylamine, and mixed octylstyryl-diphenylamine.

[0037] In other approaches, suitable antioxidants may include aromatic amine antioxidants. Examples of phenolic antioxidants include N,N'-di-sec-butyl-phenylene-diamine, 4-isopropylamino diphenylamine, phenyl-alpha-naphthyl amine, phenyl-alpha-naphthyl amine, and ring-alkylated diphenylamines.

[0038] In embodiments of the finished motorcycle lubricant, the amounts of the antioxidant nitrogen and aminic antioxidants noted above are formulated into a single fluid configured as the finished motorcycle lubricant. In embodiments of the booster additive package and the motorcycle lubricant, it is preferred that the aminic antioxidant nitrogen is provided in both the booster additive package and the motorcycle lubricant. In such embodiments using the booster additive package, about 70 to about 80 weight percent of the aminic antioxidant nitrogen is provided in the booster additive package and about 20 to about 30 weight percent of the aminic antioxidant nitrogen is provided in the motorcycle lubricant. Amounts in the booster additive package and the motorcycle lubricant can be adjusted as needed to achieve the amounts noted above in the finished motorcycle lubricant.

[0039] Metal Dihydrocarbyl Dithiophosphate Compounds

[0040] The finished motorcycle lubricants herein may optionally include one or more metal dihydrocarbyl dithiophosphate compounds, such as but not limited to, a zinc dihydrocarbyl dithiophosphate compound (ZDDP). In one approach, the one or more optional metal dihydrocarbyl dithiophosphate compounds of the lubricant herein may provide at least about 800 ppm of phosphorus to the motorcycle lubricant, and in other approaches, about 800 ppm to about 1,000 ppm phosphorus. In the embodiments using the booster,

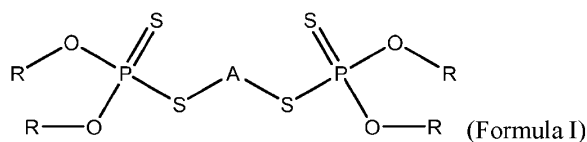
preferably, the booster does not include any of the metal dihydrocarbyl dithiophosphate compounds as such compounds are provided in the motorcycle lubricant.

[0041] Suitable metal dihydrocarbyl dithiophosphates compounds may include between 5 to about 10 weight percent metal (such as, about 6 to about 9 weight percent metal), and about 8 to about 18 weight percent sulfur (such as about 12 to about 18 weight percent sulfur, or about 8 to about 15 weight percent sulfur) and sufficient phosphorus to provide the above-noted phosphorus contents. Suitable metal dihydrocarbyl dithiophosphate compounds may comprise dihydrocarbyl dithiophosphate metal salts wherein the metal may be an alkali metal, alkaline earth metal, aluminum, lead, tin, molybdenum, manganese, nickel, copper, titanium, zirconium, zinc, or combinations thereof. Preferably, the metal is zinc.

[0042] The alkyl groups on the metal dihydrocarbyl dithiophosphate compounds herein may be derived from primary alcohols, secondary alcohols, phenols, and/or mixtures thereof. For example, all of the alkyl groups of metal dihydrocarbyl dithiophosphate compounds herein may be derived from a primary alcohol (such as, but not limited to, 2-ethylhexyl alcohol, isobutyl alcohol, and the like) or from a mixture of primary and secondary alcohols (such as, but not limited to, 2-ethyl hexanol, isobutanol, and isopropanol for instance).

[0043] The metal dihydrocarbyl dithiophosphate compounds herein may be derived from, but not limited to, alcohols selected from 2-ethylhexanol, methylheptanol, heptanol, octanol, nonanol, decanol, dodecanol, and/or iso-variants thereof. Examples of suitable metal dihydrocarbyl dithiophosphate compounds include, but are not limited, to: zinc O,O-di(C₈₋₁₄-alkyl)dithiophosphate; zinc O,O-bis(2-ethylhexyl) dithiophosphate; zinc O,O-diisooctyl dithiophosphate; zinc O,O-bis(dodecylphenyl) dithiophosphate; zinc O,O-diisodecyl dithiophosphate; zinc O,O-bis(6-methylheptyl) dithiophosphate; zinc O,O-dioctyl dithiophosphate; zinc O,O-dipentyl dithiophosphate; zinc O-(2-methylbutyl)-O-(2-methylpropyl)dithiophosphate; and zinc O-(3-methylbutyl)-O-(2-methylpropyl) dithiophosphate, or combinations thereof.

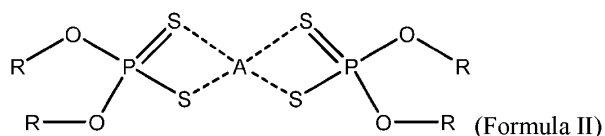
[0044] In approaches or embodiments, the metal dihydrocarbyl dithiophosphate compound suitable for motorcycle lubricants may also have a structure of Formula I:



wherein each R in Formula I independently contains from 3 to 18 carbon atoms. For example, each R may independently be ethyl, n-propyl, i-propyl, n-butyl, i-butyl, sec-butyl,

amyl, n-hexyl, i-hexyl, n-octyl, decyl, dodecyl, octadecyl, 2-ethylhexyl, phenyl, butylphenyl, cyclohexyl, methylcyclopentyl, propenyl, butenyl. The number of carbon atoms in each R group in the formula above will generally be about 3 or greater, about 4 or greater, about 6 or greater, or about 8 or greater. In some embodiments, each R group may average 6 to 10 carbons and, in some instances 8 to 10 carbons. In Formula I, A is a metal, such as aluminum, lead, tin, molybdenum, manganese, nickel, copper, titanium, zirconium, zinc, or combinations thereof and, preferably, A is zinc. When the metal dihydrocarbyl dithiophosphate compound has the structure shown in Formula I and with A being zinc, the compound may have about 4 to about 9 weight percent phosphorus and about 6 to about 9 weight percent zinc.

[0045] In some approaches or embodiments, it is understood in the art that a more accurate representation of the sulfur-zinc coordination arrangement may be represented by the symmetrical arrangement shown below with the chemical structure of Formula II that may be used herein as interchangeable with Formula I shown above. It is also understood that the structures shown in Formulas I and II may be present as monomer, dimer, trimer, or oligomer (such as a tetramer).



[0046] Dihydrocarbyl dithiophosphate metal salts may be prepared in accordance with known techniques by first forming a dihydrocarbyl dithiophosphoric acid (DDPA), usually by reaction of one or more alcohols or phenols with P_2S_5 and then neutralizing the formed DDPA with a metal compound, such as zinc oxide. For example, DDPA may be made by reacting mixtures of alcohols including the suitable amounts of primary alcohols (and if needed, suitable blends of primary and secondary alcohols) with P_2S_5 . In this case, the DDPA includes alkyl groups predominately derived from primary alcohols or both primary and secondary alcohols as needed to meet the required primary alcohol content in the final product. Alternatively, multiple DDPAs can be prepared where the alkyl groups on one DDPA are derived entirely from secondary alcohols and the alkyl groups on another DDPA are derived entirely from primary alcohols. The DDPAs are then blended together to form a mixture of DDPAs having alkyl groups meeting the noted primary alcohol content.

[0047] Dispersants

[0048] The finished motorcycle lubricating compositions herein also include one or more dispersants. In approaches, the one or more dispersants provide at least about 400 ppm nitrogen or up to about 1000 ppm nitrogen. In other approaches, the one or more dispersants provide about 400 to about 900 ppm nitrogen or about 450 to about 800 ppm nitrogen or about 450 to about 600 ppm dispersant nitrogen. In some approaches, the one or more dispersants may be post treated with a boron compound, and in such approach, may also provide at least about 100 ppm boron or at least about 150 ppm of boron to the lubricating compositions and, in other approaches, about 100 ppm to about 700 ppm, about 150 ppm to about 600 ppm, about 180 ppm to about 400 ppm, or about 190 ppm to about 300 ppm of boron. In other approaches, the lubricating compositions include up to about 5 weight percent of dispersant, or about 0.5 to about 5.0 weight percent of dispersants, about 1 to about 4 weight percent, about 2 to about 4 weight percent, or about 2.5 to about 3.5 weight percent of dispersants. In the embodiments using the booster, preferably, the booster does not include any of the dispersant as the dispersants are provided in the motorcycle lubricant compositions.

[0049] Dispersants are often known as ashless-type dispersants because, prior to mixing in a lubricating composition, they do not contain ash-forming metals and they do not normally contribute any ash when added to a lubricant. Ashless-type dispersants are characterized by a polar group attached to a relatively high molecular weight hydrocarbon chain. Typical ashless dispersants include N-substituted long chain alkenyl succinimides. Examples of N-substituted long chain alkenyl succinimides include polyisobutylene succinimide with the number average molecular weight of the polyisobutylene substituent being in the range about 350 to about 50,000, or to about 5,000, or to about 3,000, or to about 2,000, or to about 1,500 as measured by GPC. Succinimide dispersants and their preparation are disclosed, for instance in US 7,897,696 or US 4,234,435, which are both incorporated herein by reference. The alkenyl substituent may be prepared from polymerizable monomers containing about 2 to about 16, or about 2 to about 8, or about 2 to about 6 carbon atoms. Succinimide dispersants are typically the imide formed from a polyamine, typically a poly(ethyleneamine).

[0050] In approaches, preferred amines for the dispersants may be selected from polyamines and hydroxyamines. Examples of polyamines that may be used include, but are not limited to, diethylene triamine (DETA), triethylene tetramine (TETA), tetraethylene pentamine (TEPA), and higher homologues such as pentaethylamine hexamine (PEHA), and

the like. In some approaches, a so-called heavy polyamine may be used, which is a mixture of polyalkylene-polyamines comprising small amounts of lower polyamine oligomers such as TEPA and PEHA (pentaethylene hexamine) but primarily oligomers with 6 or more nitrogen atoms, 2 or more primary amines per molecule, and more extensive branching than conventional polyamine mixtures. A heavy polyamine preferably includes polyamine oligomers containing 7 or more nitrogens per molecule and with 2 or more primary amines per molecule.

[0051] In some embodiments, polyisobutylene (PIB), when included, is a preferred reactant to form the dispersants and may have greater than 50 mol%, greater than 60 mol%, greater than 70 mol%, greater than 80 mol%, or greater than 90 mol% content of terminal double bonds. Such PIB is also referred to as highly reactive PIB (“HR-PIB”). HR-PIB having a number average molecular weight ranging from about 800 to about 5000, as determined by GPC, is suitable for use in embodiments of the present disclosure. Conventional PIB typically has less than 50 mol%, less than 40 mol%, less than 30 mol%, less than 20 mol%, or less than 10 mol% content of terminal double bonds.

[0052] An HR-PIB having a number average molecular weight ranging from about 900 to about 3,000 may be suitable, as determined by GPC. Such HR-PIB is commercially available, or can be synthesized by the polymerization of isobutene in the presence of a non-chlorinated catalyst such as boron trifluoride, as described in US 4,152,499 and/or US 5,739,355. When used in the aforementioned thermal ene reaction, HR-PIB may lead to higher conversion rates in the reaction, as well as lower amounts of sediment formation, due to increased reactivity. A suitable method is described in U.S. Patent No. 7,897,696. In one embodiment, the present disclosure further comprises at least one dispersant derived from polyisobutylene succinic anhydride (“PIBSA”). The PIBSA may have an average of between about 1.0 and about 2.0 succinic acid moieties per polymer.

[0053] In some approaches, any of the dispersants herein may also be post-treated by conventional methods by a reaction with any of a variety of agents. Suitable post treat agents include boron, urea, thiourea, dimercapto-thiadiazoles, carbon disulfide, aldehydes, ketones, carboxylic acids, hydrocarbon-substituted succinic anhydrides, maleic anhydride, nitriles, epoxides, carbonates, cyclic carbonates, hindered phenolic esters, and phosphorus compounds. (See, e.g., US 7,645,726; US 7,214,649; US 8,048,831; and US 5,241,003, which are all incorporated herein by reference in their entireties.)

[0054] When a boron compound is used as a post-treating reagent, it can be selected from boron oxide, boron halides, boron acids and esters of boron acids in an amount to provide from about 0.1 atomic proportion of boron for each mole of the nitrogen composition to about 20 atomic proportions of boron for each atomic proportion of nitrogen used. The dispersant post-treated with boron may contain from about 0.05 weight percent to about 2.0 weight percent, or in other approaches, about 0.05 weight percent to about 0.7 weight percent boron, based on the total weight of the borated dispersant.

[0055] In other approaches, carboxylic acid may also be used as a post-treating reagent and can be saturated or unsaturated mono-, di-, or poly-carboxylic acid. Examples of carboxylic acids include, but are not limited to, maleic acid, fumaric acid, succinic acid, and naphthalic diacid (e.g., 1,8-naphthalic diacid). Anhydrides can also be used as a post-treating reagent and can be selected from the group consisting of mono-unsaturated anhydride (e.g., maleic anhydride), alkyl or alkylene-substituted cyclic anhydrides (e.g., succinic anhydride or glutamic anhydride), and aromatic carboxylic anhydrides (including naphthalic anhydride, e.g., 1,8-naphthalic anhydride).

[0056] In one embodiment, the process of post-treating the dispersant includes first forming the succinimide product, as described above, and then further reacting the succinimide product with the post treating agent, such as a boron compound, such as boric acid. In some cases, the dispersants herein may be post-treated with more than one post-treatment agents. For example, the dispersant may be post-treated with a boron compound, such as boric acid, and also an anhydride, such as maleic anhydride and/or 1,8-naphthalic anhydride.

[0057] Base Oil or Base Oil Blend

[0058] The base oil used in the finished motorcycle lubricating compositions, the motorcycle lubricants, and/or the booster packages herein may be oils of lubricating viscosity and selected from any of the base oils in API Groups I to V as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines. The five base oil groups are generally set forth in Table 1 below:

[0059] Table 1

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

[0060] Groups I, II, and III are mineral oil process stocks. Group IV base oils contain true synthetic molecular species, which are produced by polymerization of olefinically unsaturated hydrocarbons. Many Group V base oils are also true synthetic products and may include diesters, polyol esters, polyalkylene glycols, alkylated aromatics, polyphosphate esters, polyvinyl ethers, and/or polyphenyl ethers, and the like, but may also be naturally occurring oils, such as vegetable oils. It should be noted that although Group III base oils are derived from mineral oil, the rigorous processing that these fluids undergo causes their physical properties to be very similar to some true synthetics, such as PAOs. Therefore, oils derived from Group III base oils may be referred to as synthetic fluids in the industry. Group II+ may comprise high viscosity index Group II.

[0061] The base oil blend used in the disclosed lubricating oil composition may be a mineral oil, animal oil, vegetable oil, synthetic oil, synthetic oil blends, or mixtures thereof. Suitable oils may be derived from hydrocracking, hydrogenation, hydrofinishing, unrefined, refined, and re-refined oils, and mixtures thereof.

[0062] Unrefined oils are those derived from a natural, mineral, or synthetic source without or with little further purification treatment. Refined oils are similar to the unrefined oils except that they have been treated in one or more purification steps, which may result in the improvement of one or more properties. Examples of suitable purification techniques are solvent extraction, secondary distillation, acid or base extraction, filtration, percolation, and the like. Oils refined to the quality of an edible may or may not be useful. Edible oils may also be called white oils. In some embodiments, lubricating oil compositions are free of edible or white oils.

[0063] Re-refined oils are also known as reclaimed or reprocessed oils. These oils are obtained similarly to refined oils using the same or similar processes. Often these oils are additionally processed by techniques directed to removal of spent additives and oil breakdown products.

[0064] Mineral oils may include oils obtained by drilling or from plants and animals or any mixtures thereof. For example, such oils may include, but are not limited to, castor oil, lard oil, olive oil, peanut oil, corn oil, soybean oil, and linseed oil, as well as mineral lubricating oils, such as liquid petroleum oils and solvent-treated or acid-treated mineral lubricating oils of the paraffinic, naphthenic or mixed paraffinic-naphthenic types. Such oils

may be partially or fully hydrogenated, if desired. Oils derived from coal or shale may also be useful.

[0065] Useful synthetic lubricating oils may include hydrocarbon oils such as polymerized, oligomerized, or interpolymerized olefins (e.g., polybutylenes, polypropylenes, propyleneisobutylene copolymers); poly(1-hexenes), poly(1-octenes), trimers or oligomers of 1-decene, e.g., poly(1-decenes), such materials being often referred to as α -olefins, and mixtures thereof; alkyl-benzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di-(2-ethylhexyl)-benzenes); polyphenyls (e.g., biphenyls, terphenyls, alkylated polyphenyls); diphenyl alkanes, alkylated diphenyl alkanes, alkylated diphenyl ethers and alkylated diphenyl sulfides and the derivatives, analogs and homologs thereof or mixtures thereof. Polyalphaolefins are typically hydrogenated materials.

[0066] Other synthetic lubricating oils include polyol esters, diesters, liquid esters of phosphorus-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, and the diethyl ester of decane phosphonic acid), or polymeric tetrahydrofurans. Synthetic oils may be produced by Fischer-Tropsch reactions and typically may be hydroisomerized Fischer-Tropsch hydrocarbons or waxes. In one embodiment oils may be prepared by a Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid oils.

[0067] The major amount of base oil included in a lubricating composition may be selected from the group consisting of Group I, Group II, a Group III, a Group IV, a Group V, and a combination of two or more of the foregoing, and wherein the major amount of base oil is other than base oils that arise from provision of additive components or viscosity index improvers in the composition. In another embodiment, the major amount of base oil included in a lubricating composition may be selected from the group consisting of Group II, a Group III, a Group IV, a Group V, and a combination of two or more of the foregoing, and wherein the major amount of base oil is other than base oils that arise from provision of additive components or viscosity index improvers in the composition.

[0068] The amount of the oil of lubricating viscosity present may be the balance remaining after subtracting from 100 wt% the sum of the amount of the performance additives inclusive of viscosity index improver(s) and/or pour point depressant(s) and/or other top treat additives. For example, the oil of lubricating viscosity that may be present in a finished fluid may be a major amount, such as greater than about 50 wt%, greater than about 60 wt%, greater than about 70 wt%, greater than about 80 wt%, greater than about 85 wt%, or greater than about 90 wt%.

[0069] The base oil systems herein, in some approaches or embodiments, include one or more of a Group I to Group V base oils and the lubricating compositions herein may have a KV100 of about 2 to about 20 cSt, in other approaches, about 2 to about 15 cSt, about 3 to about 12 cSt, in yet other approaches, about 4 to about 12 cSt, and in other approaches about 6 to about 12 cSt.

[0070] Optional Additives

[0071] The finished motorcycle lubricating oil compositions herein may also include a number of optional additives to meet performance standards. Those optional additives are described in the following paragraphs.

[0072] Other Antiwear Agents

[0073] The finished motorcycle lubricating oil compositions herein also may optionally contain one or more antiwear agents. Examples of suitable antiwear agents include, but are not limited to, a metal thiophosphate; a metal dialkyldithiophosphate; a phosphoric acid ester or salt thereof; a phosphate ester(s); a phosphite; a phosphorus-containing carboxylic ester, ether, or amide; a sulfurized olefin; thiocarbamate-containing compounds including, thiocarbamate esters, alkylene-coupled thiocarbamates, and bis(S-alkyldithiocarbamyl) disulfides; and mixtures thereof. A suitable antiwear agent may be a molybdenum dithiocarbamate. The phosphorus containing antiwear agents are more fully described in European Patent 612 839. The metal in the dialkyl dithio phosphate salts may be an alkali metal, alkaline earth metal, aluminum, lead, tin, molybdenum, manganese, nickel, copper, titanium, or zinc. A useful antiwear agent may be zinc dialkyldithiophosphate.

[0074] Further examples of suitable antiwear agents include titanium compounds, tartrates, tartrides, oil soluble amine salts of phosphorus compounds, sulfurized olefins, phosphites (such as dibutyl phosphite), phosphonates, thiocarbamate-containing compounds, such as thiocarbamate esters, thiocarbamate amides, thiocarbamic ethers, alkylene-coupled thiocarbamates, and bis(S-alkyldithiocarbamyl) disulfides. The tartrate or tartride may contain alkyl-ester groups, where the sum of carbon atoms on the alkyl groups may be at least 8. The antiwear agent may in one embodiment include a citrate.

[0075] The antiwear agent may be present in ranges including about 0 wt% to about 15 wt%, or about 0.01 wt% to about 10 wt%, or about 0.05 wt% to about 5 wt%, or about 0.1 wt% to about 3 wt% of the lubricating oil composition.

[0076] Boron-Containing Compounds

[0077] The finished motorcycle lubricating oil compositions herein may optionally contain one or more boron-containing compounds. Examples of boron-containing compounds include borate esters, borated fatty amines, borated epoxides, borated detergents, and borated dispersants, such as borated succinimide dispersants, as disclosed in U.S. Patent No. 5,883,057. The boron-containing compound, if present, can be used in an amount sufficient to provide up to about 8 wt%, about 0.01 wt% to about 7 wt%, about 0.05 wt% to about 5 wt%, or about 0.1 wt% to about 3 wt% of the lubricating oil composition.

[0078] Extreme Pressure Agents

[0079] The finished motorcycle lubricating oil compositions herein also may optionally contain one or more extreme pressure agents. Extreme Pressure (EP) agents that are soluble in the oil include sulfur- and chlorosulfur-containing EP agents, chlorinated hydrocarbon EP agents and phosphorus EP agents. Examples of such EP agents include chlorinated wax; organic sulfides and polysulfides such as dibenzyl disulfide, bis(chlorobenzyl) disulfide, dibutyl tetrasulfide, sulfurized methyl ester of oleic acid, sulfurized alkyl phenol, sulfurized dipentene, sulfurized terpene, and sulfurized Diels-Alder adducts; phosphosulfurized hydrocarbons such as the reaction product of phosphorus sulfide with turpentine or methyl oleate; phosphorus esters such as the dihydrocarbyl and trihydrocarbyl phosphites, e.g., dibutyl phosphite, diheptyl phosphite, dicyclohexyl phosphite, pentylphenyl phosphite; dipentylphenyl phosphite, tridecyl phosphite, distearyl phosphite and polypropylene substituted phenyl phosphite; metal thiocarbamates such as zinc dioctyldithiocarbamate and barium heptylphenol diacid; amine salts of alkyl and dialkylphosphoric acids, including, for example, the amine salt of the reaction product of a dialkyldithiophosphoric acid with propylene oxide; and mixtures thereof.

[0080] Friction Modifiers

[0081] The finished motorcycle lubricating oil compositions herein also may optionally contain one or more friction modifiers. Suitable friction modifiers may comprise metal containing and metal-free friction modifiers and may include, but are not limited to, imidazolines, amides, amines, succinimides, alkoxyated amines, alkoxyated ether amines, amine oxides, amidoamines, nitriles, betaines, quaternary amines, imines, amine salts, amino guanadine, alkanolamides, phosphonates, metal-containing compounds, glycerol esters, sulfurized fatty compounds and olefins, sunflower oil other naturally occurring plant or

animal oils, dicarboxylic acid esters, esters or partial esters of a polyol and one or more aliphatic or aromatic carboxylic acids, and the like.

[0082] Suitable friction modifiers may contain hydrocarbyl groups that are selected from straight chain, branched chain, or aromatic hydrocarbyl groups or mixtures thereof, and may be saturated or unsaturated. The hydrocarbyl groups may be composed of carbon and hydrogen or hetero atoms such as sulfur or oxygen. The hydrocarbyl groups may range from about 12 to about 25 carbon atoms. In some embodiments the friction modifier may be a long chain fatty acid ester. In another embodiment the long chain fatty acid ester may be a mono-ester, or a di-ester, or a (tri)glyceride. The friction modifier may be a long chain fatty amide, a long chain fatty ester, a long chain fatty epoxide derivatives, or a long chain imidazoline.

[0083] Other suitable friction modifiers may include organic, ashless (metal-free), nitrogen-free organic friction modifiers. Such friction modifiers may include esters formed by reacting carboxylic acids and anhydrides with alkanols and generally include a polar terminal group (e.g. carboxyl or hydroxyl) covalently bonded to an oleophilic hydrocarbon chain. An example of an organic ashless nitrogen-free friction modifier is known generally as glycerol monooleate (GMO) which may contain mono-, di-, and tri-esters of oleic acid. Other suitable friction modifiers are described in U.S. Pat. No. 6,723,685, herein incorporated by reference in its entirety.

[0084] Aminic friction modifiers may include amines or polyamines. Such compounds can have hydrocarbyl groups that are linear, either saturated or unsaturated, or a mixture thereof and may contain from about 12 to about 25 carbon atoms. Further examples of suitable friction modifiers include alkoxylated amines and alkoxylated ether amines. Such compounds may have hydrocarbyl groups that are linear, either saturated, unsaturated, or a mixture thereof. They may contain from about 12 to about 25 carbon atoms. Examples include ethoxylated amines and ethoxylated ether amines.

[0085] The amines and amides may be used as such or in the form of an adduct or reaction product with a boron compound such as a boric oxide, boron halide, metaborate, boric acid or a mono-, di- or tri-alkyl borate. Other suitable friction modifiers are described in U.S. Pat. No. 6,300,291, herein incorporated by reference in its entirety.

[0086] A friction modifier may optionally be present in ranges such as about 0 wt% to about 10 wt%, or about 0.01 wt% to about 8 wt%, or about 0.1 wt% to about 4 wt%.

[0087] Molybdenum-containing component

[0088] The finished motorcycle lubricating oil compositions herein also may optionally contain one or more molybdenum-containing compounds. An oil-soluble molybdenum compound may have the functional performance of an antiwear agent, an antioxidant, a friction modifier, or mixtures thereof. An oil-soluble molybdenum compound may include molybdenum dithiocarbamates, molybdenum dialkylidithiophosphates, molybdenum dithiophosphinates, amine salts of molybdenum compounds, molybdenum xanthates, molybdenum thioxanthates, molybdenum sulfides, molybdenum carboxylates, molybdenum alkoxides, a trinuclear organo-molybdenum compound, and/or mixtures thereof. The molybdenum sulfides include molybdenum disulfide. The molybdenum disulfide may be in the form of a stable dispersion. In one embodiment the oil-soluble molybdenum compound may be selected from the group consisting of molybdenum dithiocarbamates, molybdenum dialkylidithiophosphates, amine salts of molybdenum compounds, and mixtures thereof. In one embodiment the oil-soluble molybdenum compound may be a molybdenum dithiocarbamate.

[0089] Suitable examples of molybdenum compounds which may be used include commercial materials sold under the trade names such as Molyvan® 822, Molyvan® A, Molyvan® 2000 and Molyvan® 855 from R. T. Vanderbilt Co., Ltd., and Adeka Sakura-Lube® S-165, S-200, S-300, S-310G, S-525, S-600, S-700, and S-710 available from Adeka Corporation, and mixtures thereof. Suitable molybdenum components are described in US 5,650,381; US RE 37,363 E1; US RE 38,929 E1; and US RE 40,595 E1, incorporated herein by reference in their entireties.

[0090] Additionally, the molybdenum compound may be an acidic molybdenum compound. Included are molybdic acid, ammonium molybdate, sodium molybdate, potassium molybdate, and other alkaline metal molybdates and other molybdenum 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. Alternatively, the compositions can be provided with molybdenum by molybdenum/sulfur complexes of basic nitrogen compounds as described, for example, in U.S. Pat. Nos. 4,263,152; 4,285,822; 4,283,295; 4,272,387; 4,265,773; 4,261,843; 4,259,195 and 4,259,194; and WO 94/06897, incorporated herein by reference in their entireties.

[0091] Another class of suitable organo-molybdenum compounds are trinuclear molybdenum compounds, such as those of the formula $\text{Mo}_3\text{S}_k\text{L}_n\text{Q}_z$ and mixtures thereof,

wherein S represents sulfur, L represents independently selected ligands having organo groups with a sufficient number of carbon atoms to render the compound soluble or dispersible in the oil, n is from 1 to 4, k varies from 4 through 7, Q is selected from the group of neutral electron donating compounds such as water, amines, alcohols, phosphines, and ethers, and z ranges from 0 to 5 and includes non-stoichiometric values. At least 21 total carbon atoms may be present among all the ligands' organo groups, such as at least 25, at least 30, or at least 35 carbon atoms. Additional suitable molybdenum compounds are described in U.S. Pat. No. 6,723,685, herein incorporated by reference in its entirety.

[0092] The oil-soluble molybdenum compound may be present in an amount sufficient to provide about 0.5 ppm to about 2000 ppm, about 1 ppm to about 700 ppm, about 1 ppm to about 550 ppm, about 5 ppm to about 300 ppm, or about 20 ppm to about 250 ppm of molybdenum.

[0093] Transition Metal-containing compounds

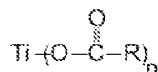
[0094] The finished motorcycle lubricating compositions herein may also include one or more oil-soluble transition metal-containing compounds or a metalloid. The transition metals may include, but are not limited to, titanium, vanadium, copper, zinc, zirconium, molybdenum, tantalum, tungsten, and the like. Suitable metalloids include, but are not limited to, boron, silicon, antimony, tellurium, and the like.

[0095] In an embodiment, an oil-soluble transition metal-containing compound may function as antiwear agents, friction modifiers, antioxidants, deposit control additives, or more than one of these functions. In an embodiment the oil-soluble transition metal-containing compound may be an oil-soluble titanium compound, such as a titanium (IV) alkoxide. Among the titanium containing compounds that may be used in, or which may be used for preparation of the oils-soluble materials of, the disclosed technology are various titanium (IV) compounds such as titanium (IV) oxide; titanium (IV) sulfide; titanium (IV) nitrate; titanium (IV) alkoxides such as titanium methoxide, titanium ethoxide, titanium propoxide, titanium isopropoxide, titanium butoxide, titanium 2-ethylhexoxide; and other titanium compounds or complexes including but not limited to titanium phenates; titanium carboxylates such as titanium (IV) 2-ethyl-1-3-hexanedioate or titanium citrate or titanium oleate; and titanium (IV) (triethanolaminate)isopropoxide. Other forms of titanium encompassed within the disclosed technology include titanium phosphates such as titanium dithiophosphates (e.g., dialkyldithiophosphates) and titanium sulfonates (e.g., alkylbenzenesulfonates), or, generally, the reaction product of titanium compounds with

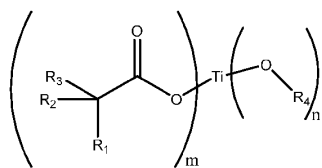
various acid materials to form salts, such as oil-soluble salts. Titanium compounds can thus be derived from, among others, organic acids, alcohols, and glycols. Ti compounds may also exist in dimeric or oligomeric form, containing Ti--O--Ti structures. Such titanium materials are commercially available or can be readily prepared by appropriate synthesis techniques which will be apparent to the person skilled in the art. They may exist at room temperature as a solid or a liquid, depending on the particular compound. They may also be provided in a solution form in an appropriate inert solvent.

[0096] In one embodiment, the titanium can be supplied as a Ti-modified dispersant, such as a succinimide dispersant. Such materials may be prepared by forming a titanium mixed anhydride between a titanium alkoxide and a hydrocarbyl-substituted succinic anhydride, such as an alkenyl- (or alkyl) succinic anhydride. The resulting titanate-succinate intermediate may be used directly or it may be reacted with any of a number of materials, such as (a) a polyamine-based succinimide/amide dispersant having free, condensable --NH functionality; (b) the components of a polyamine-based succinimide/amide dispersant, i.e., an alkenyl- (or alkyl-) succinic anhydride and a polyamine, (c) a hydroxy-containing polyester dispersant prepared by the reaction of a substituted succinic anhydride with a polyol, aminoalcohol, polyamine, or mixtures thereof. Alternatively, the titanate-succinate intermediate may be reacted with other agents such as alcohols, aminoalcohols, ether alcohols, polyether alcohols or polyols, or fatty acids, and the product thereof either used directly to impart Ti to a lubricant, or else further reacted with the succinic dispersants as described above. As an example, 1 part (by mole) of tetraisopropyl titanate may be reacted with about 2 parts (by mole) of polyisobutene-substituted succinic anhydride at 140-150° C for 5 to 6 hours to provide a titanium modified dispersant or intermediate. The resulting material (30 g) may be further reacted with a succinimide dispersant from polyisobutene-substituted succinic anhydride and a polyethylenepolyamine mixture (127 grams + diluent oil) at 150° C for 1.5 hours, to produce a titanium-modified succinimide dispersant.

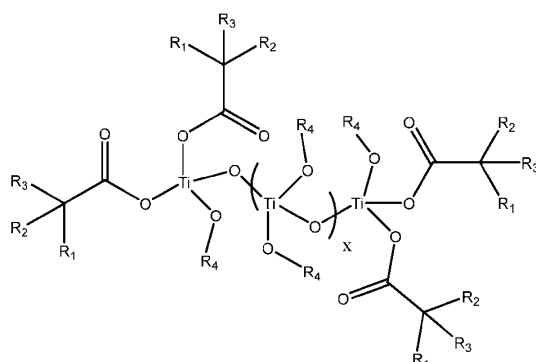
[0097] Another titanium containing compound may be a reaction product of titanium alkoxide and C₆ to C₂₅ carboxylic acid. The reaction product may be represented by the following formula:



wherein n is an integer selected from 2, 3 and 4, and R is a hydrocarbyl group containing from about 5 to about 24 carbon atoms, or by the formula:



wherein $m + n = 4$ and n ranges from 1 to 3, R_4 is an alkyl moiety with carbon atoms ranging from 1-8, R_1 is selected from a hydrocarbyl group containing from about 6 to 25 carbon atoms, and R_2 and R_3 are the same or different and are selected from a hydrocarbyl group containing from about 1 to 6 carbon atoms, or the titanium compound may be represented by the formula:



wherein x ranges from 0 to 3, R_1 is selected from a hydrocarbyl group containing from about 6 to 25 carbon atoms, R_2 , and R_3 are the same or different and are selected from a hydrocarbyl group containing from about 1 to 6 carbon atoms, and R_4 is selected from a group consisting of either H, or C₆ to C₂₅ carboxylic acid moiety.

[0098] Suitable carboxylic acids may include, but are not limited to caproic acid, caprylic acid, lauric acid, myristic acid, palmitic acid, stearic acid, arachidic acid, oleic acid, erucic acid, linoleic acid, linolenic acid, cyclohexanecarboxylic acid, phenylacetic acid, benzoic acid, neodecanoic acid, and the like.

[0099] In an embodiment the oil soluble titanium compound may be present in the lubricating oil composition in an amount to provide from 0 to 3000 ppm titanium by weight or 25 to about 1500 ppm titanium by weight or about 35 ppm to 500 ppm titanium by weight or about 50 ppm to about 300 ppm.

[0100] Viscosity Index Improvers

[0101] The finished motorcycle lubricating oil compositions herein also may optionally contain one or more viscosity index improvers. Suitable viscosity index improvers may include polyolefins, olefin copolymers, ethylene/propylene copolymers, polyisobutenes,

hydrogenated styrene-isoprene polymers, styrene/maleic ester copolymers, hydrogenated styrene/butadiene copolymers, hydrogenated isoprene polymers, alpha-olefin maleic anhydride copolymers, polymethacrylates, polyacrylates, polyalkyl styrenes, hydrogenated alkenyl aryl conjugated diene copolymers, or mixtures thereof. Viscosity index improvers may include star polymers and suitable examples are described in US Publication No. 20120101017A1.

[0102] The lubricating oil compositions herein also may optionally contain one or more dispersant viscosity index improvers in addition to a viscosity index improver or in lieu of a viscosity index improver. Suitable viscosity index improvers may include functionalized polyolefins, for example, ethylene-propylene copolymers that have been functionalized with the reaction product of an acylating agent (such as maleic anhydride) and an amine; polymethacrylates functionalized with an amine, or esterified maleic anhydride-styrene copolymers reacted with an amine.

[0103] The total amount of viscosity index improver and/or dispersant viscosity index improver may be about 0 wt% to about 20 wt%, about 0.1 wt% to about 15 wt%, about 0.1 wt% to about 12 wt%, or about 0.5 wt% to about 10 wt%, of the lubricating oil composition.

[0104] Other Optional Additives

[0105] Other additives may be selected to perform one or more functions required of a finished motorcycle lubricating fluid. Further, one or more of the mentioned additives may be multi-functional and provide functions in addition to or other than the function prescribed herein.

[0106] The other performance additives may be in addition to specified additives of the present disclosure and/or may comprise one or more of metal deactivators, viscosity index improvers, detergents, ashless TBN boosters, friction modifiers, antiwear agents, corrosion inhibitors, rust inhibitors, dispersants, dispersant viscosity index improvers, extreme pressure agents, antioxidants, foam inhibitors, demulsifiers, emulsifiers, pour point depressants, seal swelling agents and mixtures thereof. Typically, fully-formulated lubricating oil will contain one or more of these performance additives.

[0107] Suitable metal deactivators may include derivatives of benzotriazoles (typically tolyltriazole), dimercaptiothiadiazole derivatives, 1,2,4-triazoles, benzimidazoles, 2-alkyldithiobenzimidazoles, or 2-alkyldithiobenzothiazoles; foam inhibitors including copolymers of ethyl acrylate and 2-ethylhexylacrylate and optionally vinyl acetate; demulsifiers including trialkyl phosphates, polyethylene glycols, polyethylene oxides,

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

[0108] Suitable foam inhibitors include silicon-based compounds, such as siloxane.

[0109] Suitable pour point depressants may include polymethylmethacrylates or mixtures thereof. Pour point depressants may be present in an amount sufficient to provide from about 0 wt% to about 1 wt%, about 0.01 wt% to about 0.5 wt%, or about 0.02 wt% to about 0.04 wt% based upon the final weight of the lubricating oil composition.

[0110] Suitable rust inhibitors may be a single compound or a mixture of compounds having the property of inhibiting corrosion of ferrous metal surfaces. Non-limiting examples of rust inhibitors useful herein include oil-soluble high molecular weight organic acids, such as 2-ethylhexanoic acid, lauric acid, myristic acid, palmitic acid, oleic acid, linoleic acid, linolenic acid, behenic acid, and cerotic acid, as well as oil-soluble polycarboxylic acids including dimer and trimer acids, such as those produced from tall oil fatty acids, oleic acid, and linoleic acid. Other suitable corrosion inhibitors include long-chain alpha, omega-dicarboxylic acids in the molecular weight range of about 600 to about 3000 and alkenylsuccinic acids in which the alkenyl group contains about 10 or more carbon atoms such as, tetrapropenylsuccinic acid, tetradecenylsuccinic acid, and hexadecenylsuccinic acid. Another useful type of acidic corrosion inhibitors are the half esters of alkenyl succinic acids having about 8 to about 24 carbon atoms in the alkenyl group with alcohols such as the polyglycols. The corresponding half amides of such alkenyl succinic acids are also useful. A useful rust inhibitor is a high molecular weight organic acid.

[0111] The rust inhibitor, if present, can be used in an amount sufficient to provide about 0 wt% to about 5 wt%, about 0.01 wt% to about 3 wt%, about 0.1 wt% to about 2 wt%, based upon the final weight of the lubricating oil composition.

[0112] In general terms, a suitable lubricant including the detergent metals herein may include additive components in the ranges listed in the following table.

[0113] Table 2: Suitable Finished Motorcycle Lubricating Compositions

Component	Wt. % (Suitable Embodiments)	Wt. % (Suitable Embodiments)
Metal dihydrocarbyl dithiophosphate	0.1 – 6.0	0.5 – 3.0
Detergent Systems	0.02 – 5.0	0.2 – 2.0
Succinimide Dispersant(s)	0 – 8.0	1 – 6.0
Aminic Antioxidant(s)	0.1 – 5.0	0.01 – 3.0
Ashless TBN booster(s)	0.0 – 1.0	0.01 – 0.5

Corrosion inhibitor(s)	0.0 – 5.0	0.0 – 2.0
Ash-free phosphorus compound(s)	0.0 – 6.0	0.0 – 4.0
Antifoaming agent(s)	0.0 – 5.0	0.001 – 0.15
Antiwear agent(s)	0.0 – 1.0	0.0 – 0.8
Pour point depressant(s)	0.0 – 5.0	0.01 – 1.5
Viscosity index improver(s)	0.0 – 25.0	0.1 – 15.0
Dispersant viscosity index improver(s)	0.0 – 10.0	0.0 – 5.0
Friction modifier(s)	0.00 – 5.0	0.01 – 2.0
Base oil	<u>Balance</u>	<u>Balance</u>
Total	100	100

[0114] The percentages of each component above represent the weight percent of each component, based upon the weight of the final lubricating oil composition. The remainder of the lubricating oil composition consists of one or more base oils. Additives used in formulating the compositions described herein may be blended into the base oil individually or in various sub-combinations. However, it may be suitable to blend all of the components concurrently using an additive concentrate (i.e., additives plus a diluent, such as a hydrocarbon solvent). Fully formulated lubricants conventionally contain an additive package, referred to herein as a dispersant/inhibitor package or DI package, that will supply the characteristics that are required in the formulation.

DEFINITIONS

[0115] For purposes of this disclosure, the chemical elements are identified in accordance with the Periodic Table of the Elements, CAS version, Handbook of Chemistry and Physics, 75th Ed. Additionally, general principles of organic chemistry are described in "Organic Chemistry", Thomas Sorrell, University Science Books, Sausalito: 1999, and "March's Advanced Organic Chemistry", 5th Ed., Ed.: Smith, M.B. and March, J., John Wiley & Sons, New York: 2001, the entire contents of which are hereby incorporated by reference.

[0116] As described herein, compounds may optionally be substituted with one or more substituents, such as are illustrated generally above, or as exemplified by particular classes, subclasses, and species of the disclosure.

[0117] Unless otherwise apparent from the context, the term "major amount" is understood to mean an amount greater than or equal to 50 weight percent, for example, from about 80 to about 98 weight percent relative to the total weight of the composition. Moreover, as used herein, the term "minor amount" is understood to mean an amount less than 50 weight percent relative to the total weight of the composition.

[0118] As used herein, the term "hydrocarbyl group" or "hydrocarbyl" is used in its

ordinary sense, which is well-known to those skilled in the art. Specifically, it refers to a group having a carbon atom directly attached to the remainder of a molecule and having a predominantly hydrocarbon character. Examples of hydrocarbyl groups include: (1) hydrocarbon substituents, that is, aliphatic (e.g., alkyl or alkenyl), alicyclic (e.g., cycloalkyl, cycloalkenyl) substituents, and aromatic-, aliphatic-, and alicyclic-substituted aromatic substituents, as well as cyclic substituents wherein the ring is completed through another portion of the molecule (e.g., two substituents together form an alicyclic radical); (2) substituted hydrocarbon substituents, that is, substituents containing non-hydrocarbon groups which, in the context of the description herein, do not alter the predominantly hydrocarbon substituent (e.g., halo (especially chloro and fluoro), hydroxy, alkoxy, mercapto, alkylmercapto, nitro, nitroso, amino, alkylamino, and sulfoxy); (3) hetero-substituents, that is, substituents which, while having a predominantly hydrocarbon character, in the context of this description, contain other than carbon in a ring or chain otherwise composed of carbon atoms. Hetero-atoms include sulfur, oxygen, nitrogen, and encompass substituents such as pyridyl, furyl, thienyl, and imidazolyl. In general, no more than two, or as a further example, no more than one, non-hydrocarbon substituent will be present for every ten carbon atoms in the hydrocarbyl group; in some embodiments, there will be no non-hydrocarbon substituent in the hydrocarbyl group.

[0119] As used herein the term "aliphatic" encompasses the terms alkyl, alkenyl, alkynyl, each of which being optionally substituted as set forth below.

[0120] As used herein, an "alkyl" group refers to a saturated aliphatic hydrocarbon group containing 1-12 (e.g., 1-8, 1-6, or 1-4) carbon atoms. An alkyl group can be straight or branched. Examples of alkyl groups include, but are not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, tert-butyl, n-pentyl, n-heptyl, or 2-ethylhexyl. An alkyl group can be substituted (i.e., optionally substituted) with one or more substituents such as halo, phospho, cycloaliphatic [e.g., cycloalkyl or cycloalkenyl], heterocycloaliphatic [e.g., heterocycloalkyl or heterocycloalkenyl], aryl, heteroaryl, alkoxy, aroyl, heteroaroyl, acyl [e.g., (aliphatic)carbonyl, (cycloaliphatic)carbonyl, or (heterocycloaliphatic)carbonyl], nitro, cyano, amido [e.g., (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl) carbonylamino, (heterocycloalkylalkyl) carbonylamino, heteroarylcarbonylamino, heteroaralkyl carbonylamino alkylaminocarbonyl, cycloalkylaminocarbonyl, heterocycloalkylaminocarbonyl, arylaminocarbonyl, or heteroarylaminocarbonyl], amino [e.g., aliphaticamino, cycloaliphatic amino, or

heterocycloaliphaticamino], sulfonyl [e.g., aliphatic-SO₂-], sulfinyl, sulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, carboxy, carbamoyl, cycloaliphaticoxy, heterocycloaliphaticoxy, aryloxy, heteroaryloxy, aralkyloxy, heteroarylalkoxy, alkoxy carbonyl, alkyl carbonyloxy, or hydroxy. Without limitation, some examples of substituted alkyls include carboxyalkyl (such as HOOC-alkyl, alkoxy carbonylalkyl, and alkyl carbonyloxyalkyl), cyanoalkyl, hydroxyalkyl, alkoxyalkyl, acylalkyl, aralkyl, (alkoxyaryl)alkyl, (sulfonylamino)alkyl (such as (alkyl-SO₂-amino)alkyl), aminoalkyl, amidoalkyl, (cycloaliphatic)alkyl, or haloalkyl.

[0121] As used herein, an "alkenyl" group refers to an aliphatic carbon group that contains 2-8 (e.g., 2-12, 2-6, or 2-4) carbon atoms and at least one double bond. Like an alkyl group, an alkenyl group can be straight or branched. Examples of an alkenyl group include, but are not limited to allyl, isoprenyl, 2-butenyl, and 2-hexenyl. An alkenyl group can be optionally substituted with one or more substituents such as halo, phospho, cycloaliphatic [e.g., cycloalkyl or cycloalkenyl], heterocycloaliphatic [e.g., heterocycloalkyl or heterocycloalkenyl], aryl, heteroaryl, alkoxy, aroyl, heteroaroyl, acyl [e.g., (aliphatic) carbonyl, (cycloaliphatic)carbonyl, or (heterocycloaliphatic)carbonyl], nitro, cyano, amido [e.g., (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl) carbonylamino, (heterocycloalkylalkyl) carbonylamino, heteroaryl carbonylamino, heteroaralkylcarbonylamino alkylamino carbonyl, cycloalkylaminocarbonyl, heterocycloalkylaminocarbonyl, arylaminocarbonyl, or heteroarylaminocarbonyl], amino [e.g., aliphaticamino, cycloaliphaticamino, heterocycloaliphaticamino, or aliphatic sulfonylamino], sulfonyl [e.g., alkyl-SO₂-, cycloaliphatic-SO₂-, or aryl-SO₂-], sulfinyl, sulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, carboxy, carbamoyl, cycloaliphaticoxy, heterocycloaliphaticoxy, aryloxy, heteroaryloxy, aralkyloxy, heteroaralkoxy, alkoxy carbonyl, alkyl carbonyloxy, or hydroxy. Without limitation, some examples of substituted alkenyls include cyanoalkenyl, alkoxyalkenyl, acylalkenyl, hydroxyalkenyl, aralkenyl, (alkoxyaryl)alkenyl, (sulfonylamino)alkenyl (such as (alkyl-SO₂-amino)alkenyl), aminoalkenyl, amidoalkenyl, (cycloaliphatic)alkenyl, or haloalkenyl.

[0122] As used herein, an "alkynyl" group refers to an aliphatic carbon group that contains 2-8 (e.g., 2-12, 2-6, or 2-4) carbon atoms and has at least one triple bond. An alkynyl group can be straight or branched. Examples of an alkynyl group include, but are not limited to, propargyl and butynyl. An alkynyl group can be optionally substituted with one or more substituents such as aroyl, heteroaroyl, alkoxy, cycloalkyloxy, heterocycloalkyloxy, aryloxy,

heteroaryloxy, aralkyl oxy, nitro, carboxy, cyano, halo, hydroxy, sulfo, mercapto, sulfanyl [e.g., aliphaticsulfanyl or cycloaliphaticsulfanyl], sulfinyl [e.g., aliphaticsulfinyl or cycloaliphaticsulfinyl], sulfonyl [e.g., aliphatic-SO₂-, aliphaticamino-SO₂-, or cycloaliphatic-SO₂-], amido [e.g., aminocarbonyl, alkylaminocarbonyl, alkylcarbonylamino, cycloalkylaminocarbonyl, heterocycloalkylaminocarbonyl, cycloalkylcarbonylamino, arylamino carbonyl, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl) carbonylamino, (cycloalkylalkyl) carbonylamino, heteroaralkylcarbonylamino, heteroaryl carbonylamino or heteroaryl amino carbonyl], urea, thiourea, sulfamoyl, sulfamide, alkoxy carbonyl, alkyl carbonyloxy, cyclo aliphatic, heterocycloaliphatic, aryl, heteroaryl, acyl [e.g., (cycloaliphatic) carbonyl or (hetero cyclo aliphatic)carbonyl], amino [e.g., aliphaticamino], sulfoxy, oxo, carboxy, carbamoyl, (cycloaliphatic)oxy, (heterocyclo aliphatic) oxy, or (heteroaryl)alkoxy.

[0123] As used herein, an "amino" group refers to -NR^XR^Y wherein each of R^X and R^Y is independently hydrogen, alkyl, cycloalkyl, (cycloalkyl)alkyl, aryl, aralkyl, heterocycloalkyl, (heterocycloalkyl)alkyl, heteroaryl, carboxy, sulfanyl, sulfinyl, sulfonyl, (alkyl)carbonyl, (cycloalkyl)carbonyl, ((cycloalkyl)alkyl)carbonyl, arylcarbonyl, (aralkyl)carbonyl, (heterocyclo alkyl) carbonyl, ((heterocycloalkyl)alkyl)carbonyl, (heteroaryl)carbonyl, or (heteroaralkyl) carbonyl, each of which being defined herein and being optionally substituted. Examples of amino groups include alkylamino, dialkylamino, or arylamino. When the term "amino" is not the terminal group (e.g., alkylcarbonylamino), it is represented by -NR^X-. R^X has the same meaning as defined above.

[0124] As used herein, a "cycloalkyl" group refers to a saturated carbocyclic mono- or bicyclic (fused or bridged) ring of 3-10 (e.g., 5-10) carbon atoms. Examples of cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, adamantyl, norbornyl, cubyl, octahydro-indenyl, decahydro-naphthyl, bicyclo[3.2.1]octyl, bicyclo[2.2.2]octyl, bicyclo[3.3.1]nonyl, bicyclo[3.3.2.]decyl, bicyclo[2.2.2]octyl, adamantyl, or ((aminocarbonyl)cycloalkyl)cycloalkyl.

[0125] As used herein, a "heterocycloalkyl" group refers to a 3-10 membered mono- or bicyclic (fused or bridged) (e.g., 5- to 10-membered mono- or bicyclic) saturated ring structure, in which one or more of the ring atoms is a heteroatom (e.g., N, O, S, or combinations thereof). Examples of a heterocycloalkyl group include piperidyl, piperazyl, tetrahydropyranyl, tetrahydrofuryl, 1,4-dioxolanyl, 1,4-dithianyl, 1,3-dioxolanyl, oxazolidyl, isoxazolidyl, morpholinyl, thiomorpholyl, octahydrobenzofuryl, octahydrochromenyl, octahydrothio chromenyl, octahydroindolyl, octahydropyrindinyl, decahydroquinolyl,

octahydrobenzo[*b*] thiophenyl, 2-oxa-bicyclo[2.2.2]octyl, 1-aza-bicyclo[2.2.2]octyl, 3-aza-bicyclo[3.2.1]octyl, and 2,6-dioxo-tricyclo[3.3.1.0]nonyl. A monocyclic heterocycloalkyl group can be fused with a phenyl moiety to form structures, such as tetrahydroisoquinoline, which would be categorized as heteroaryls.

[0126] A "heteroaryl" group, as used herein, refers to a monocyclic, bicyclic, or tricyclic ring system having 4 to 15 ring atoms wherein one or more of the ring atoms is a heteroatom (e.g., N, O, S, or combinations thereof) and in which the monocyclic ring system is aromatic or at least one of the rings in the bicyclic or tricyclic ring systems is aromatic. A heteroaryl group includes a benzofused ring system having 2 to 3 rings. For example, a benzofused group includes benzo fused with one or two 4 to 8 membered heterocycloaliphatic moieties (e.g., indolizyl, indolyl, isoindolyl, 3H-indolyl, indolinyl, benzo[*b*]furyl, benzo[*b*]thiophenyl, quinolinyl, or isoquinolinyl). Some examples of heteroaryl are pyridyl, 1H-indazolyl, furyl, pyrrolyl, thienyl, thiazolyl, oxazolyl, imidazolyl, tetrazolyl, benzofuryl, isoquinolinyl, benzthiazolyl, xanthene, thioxanthene, phenothiazine, dihydroindole, benzo[1,3]dioxole, benzo[*b*]furyl, benzo[*b*] thiophenyl, indazolyl, benzimidazolyl, benzthiazolyl, puryl, cinnolyl, quinolyl, quinazolyl, cinnolyl, phthalazyl, quinazolyl, quinoxalyl, isoquinolyl, 4H-quinolizyl, benzo-1,2,5-thiadiazolyl, or 1,8-naphthyridyl.

[0127] Without limitation, monocyclic heteroaryls include furyl, thiophenyl, 2H-pyrrolyl, pyrrolyl, oxazolyl, thiazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, 1,3,4-thiadiazolyl, 2H-pyranyl, 4-H-pranyl, pyridyl, pyridazyl, pyrimidyl, pyrazolyl, pyrazyl, or 1,3,5-triazyl. Monocyclic heteroaryls are numbered according to standard chemical nomenclature.

[0128] Without limitation, bicyclic heteroaryls include indolizyl, indolyl, isoindolyl, 3H-indolyl, indolinyl, benzo[*b*]furyl, benzo[*b*]thiophenyl, quinolinyl, isoquinolinyl, indolizyl, isoindolyl, indolyl, benzo[*b*]furyl, benzo[*b*]thiophenyl, indazolyl, benzimidazolyl, benzthiazolyl, purinyl, 4H-quinolizyl, quinolyl, isoquinolyl, cinnolyl, phthalazyl, quinazolyl, quinoxalyl, 1,8-naphthyridyl, or pteridyl. Bicyclic heteroaryls are numbered according to standard chemical nomenclature.

[0129] As used herein, the term "treat rate" refers to the weight percent of a component in the lubricating fluids.

[0130] The weight average molecular weight (M_w) and the number average molecular weight (M_n) may be determined with a gel permeation chromatography (GPC) instrument obtained from Waters or the like instrument and the data processed with Waters Empower

Software or the like software. The GPC instrument may be equipped with a Waters Separations Module and Waters Refractive Index detector (or the like optional equipment). The GPC operating conditions may include a guard column, 4 Agilent PLgel columns (length of 300×7.5 mm; particle size of 5 μ , and pore size ranging from 100-10000 Å) with the column temperature at about 40 °C. Un-stabilized HPLC grade tetrahydrofuran (THF) may be used as solvent, at a flow rate of 1.0 mL/min. The GPC instrument may be calibrated with commercially available poly(methyl methacrylate) (PMMA) standards having a narrow molecular weight distribution ranging from 960 – 1,568,000 g/mol. The calibration curve can be extrapolated for samples having a mass less than 500 g/mol. Samples and PMMA standards can be dissolved in THF and prepared at concentration of 0.1 to 0.5 wt. % and used without filtration. GPC measurements are also described in US 5,266,223, which is incorporated herein by reference. The GPC method additionally provides molecular weight distribution information; *see, for example*, W. W. Yau, J. J. Kirkland and D. D. Bly, “Modern Size Exclusion Liquid Chromatography”, John Wiley and Sons, New York, 1979, also incorporated herein by reference.

EXAMPLES

[0131] A better understanding of the present disclosure and its many advantages may be clarified with the following examples. The following examples are illustrative and not limiting thereof in either scope or spirit. Those skilled in the art will readily understand that variations of the components, methods, steps, and devices described in these examples can be used. Unless noted otherwise or apparent from the context of discussion in the Examples below and throughout this disclosure, all percentages, ratios, and parts noted in this disclosure are by weight.

[0132] EXAMPLE 1

[0133] Finished motorcycle lubricants were evaluated for lacquer formation from the Hot Tube Test (HTT) at 290°C when run pursuant to JIS Method No JPI-5S-55-99. The finished motorcycle lubricants of this Example were prepared by top-treating a booster additive composition with a motorcycle lubricant. All starting motorcycle lubricants of this Example were the same and included dispersants, detergents (overbased calcium sulfonate and overbased calcium phenate), ZDDP antiwear additives, an aminic antioxidant (di-nonyl diphenylamine), an antifoam additive, and a viscosity index improver in a base oil blend to achieve KV100 of about 10 to about 11 cSt (ASTM D425). The booster additive

compositions of this Example included one of magnesium sulfonate detergent (overbased magnesium sulfonate), an aminic antioxidant (di-nonyl diphenylamine), or both. The starting motorcycle lubricant of this Example provided the fluid relationships of Table 3. The comparative and inventive booster additive compositions for this Example were provided in Table 4 below, and the comparative and finished motorcycle lubricants of this Example (e.g., motorcycle lubricant of Table 3 plus booster of Table 4) provided the fluid relationships of Table 5 below.

[0134] Table 3: Motorcycle Lubricant

	Amount
Dispersant Nitrogen, ppm	496
Antioxidant Nitrogen, ppm	87.5
Total Nitrogen, ppm	583.5
Boron, ppm	201
Calcium, ppm	2437
Magnesium, ppm	0
Phosphorus, ppm	938
Zinc, ppm	1027

[0135] Table 4: Booster Additive Compositions

	Compare 1	Compare 2	Compare 3	Invent 1	Compare 4
Dispersant Nitrogen, ppm	0	0	0	0	0
Antioxidant Nitrogen, ppm	0	262.5	0	262.5	175
Total Nitrogen, ppm	0	262.5	0	262.5	175
Boron, ppm	0	0	0	0	0
Calcium, ppm	0	0	0	0	0
Magnesium, ppm	0	0	288	288	197
Phosphorus, ppm	0	0	0	0	0
Zinc, ppm	0	0	0	0	0

Note: amounts from booster are those to be provided in finished motorcycle lubricant when the booster and motorcycle lubricant are combined

[0136] As shown in Table 4, comparative 1 did not have a booster composition (e.g., was just the starting motorcycle lubricant), Comparative 2 included only the aminic antioxidant in the booster providing the noted nitrogen amounts to the finished motorcycle lubricant, Comparative 3 included only the overbased magnesium detergent in the booster providing the noted magnesium amounts in the finished motorcycle lubricant, Inventive 1 included both the aminic antioxidant and the overbased magnesium detergent providing the noted amounts of nitrogen and magnesium to the finished motorcycle lubricant, and Comparative 4 included both the aminic antioxidant and overbased magnesium detergent but provided lower amounts of both the nitrogen and magnesium to the finished motorcycle lubricant. The comparative and inventive boosters of Table 4 were then added to the motorcycle lubricant of Table 3 to form the finished lubricants of Table 5 below.

[0137] Table 5: Finished Motorcycle Lubricants

	Compare 1	Compare 2	Compare 3	Invent 1	Compare 4
Dispersant Nitrogen, ppm	496	496	496	496	496
Antioxidant Nitrogen,	87.5	350	87.5	350	262.5
Total Nitrogen, ppm	583.5	846	853.5	846	758.5
Boron, ppm	201	201	200	207	214
Calcium, ppm	2379.5	2379.5	2379.5	2379.5	2379.5
Magnesium, ppm	-	-	288	288	192
Phosphorus, ppm	938	934	945	935	938
Zinc, ppm	1027	2543	1030	1029	1030
Mg/AO Nitrogen	0	0	3.3	0.82	0.73
(Mg + Ca)/ AO Nitrogen	27.2	6.8	30.5	7.2	9.8
% AO nitrogen	15	41.4	15	41.4	34.6
% AO nitrogen - Booster	0	75	0	75	66.6
TBN (ASTM D2896)	7.5	8.7	8.8	9.7	9.3
TBN from Ca detergents	6.15	6.15	6.15	6.15	6.15
TBN from Mg detergents	0	0	1.23	1.23	0.82

[0138] The finished motorcycle lubricants of Table 5 were evaluated for varnish pursuant to the Hot Tube Test (HTT) at 290°C when run pursuant to JIS Method No JPI-5S-55-99 and sulfated ash pursuant to ASTM D872. Result are provided in Table 6 below.

[0139] Table 6: Finished Motorcycle Lubricants

	Compare 1	Compare 2	Compare 3	Invent 1	Compare 4
Hot Tube test rating (method A) *	0	0	0	8.0	0.5
SASH (ASTM D872)	1.0	1.0	1.15	1.15	1.10
	FAIL	FAIL	FAIL	PASS	FAIL

*Passing is a rating of 5.0 or greater

[0140] As shown in Table 6, only the inventive finished motorcycle lubricant demonstrated passing piston cleanliness when having SASH levels of 1.2 weight percent or lower within the specifications of the T903 standards for 2016 and 2023.

[0141] EXAMPLE 2

[0142] Finished motorcycle lubricants were prepared without use of a starting motorcycle lubricant and booster from the previous Example. In this Example, the finished motorcycle lubricants were directly formulated as having the various relationships of calcium, magnesium, and antioxidant nitrogen discovered to aid in piston cleanliness performance.

[0143] Similar to Example 1, the finished motorcycle lubricants of this Example were evaluated for lacquer formation from the Hot Tube Test (HTT) at 290°C when run pursuant to JIS Method No JPI-5S-55-99. Except for the detergent and antioxidant amounts, all finished motorcycle lubricants of this Example were the same and included the amounts of dispersants (providing dispersant nitrogen), ZDDP antiwear additives, an antifoam additive,

and a viscosity index improver in a base oil blend to achieve KV100 of about 10 to about 11 cSt (ASTM D425). The detergents were varied to form the finished lubricants of Table 7 and included one of overbased magnesium sulfonate, overbased calcium sulfonate, and/or overbased calcium phenate to provide the calcium and magnesium amounts of Table 7. An antioxidant was also included to provide the antioxidant nitrogen amounts of Table 7 and was the same as an aminic antioxidant of Example 1 (di-nonyl diphenylamine). The Inventive finished motorcycle lubricants of this Example provided the fluid relationships of Table 7 below.

[0144] Table 7: Finished Motorcycle Lubricants

	Invent 2	Invent 3	Invent 4
Dispersant Nitrogen, ppm	496	496	496
Antioxidant Nitrogen, ppm	350	350	350
Total Nitrogen, ppm	846	846	846
Boron, ppm	195	196	201
Calcium, ppm	903	1408	1420
Magnesium, ppm	960	624	624
Phosphorus, ppm	873	876	872
Zinc, ppm	927	926	926
Mg/AO Nitrogen	2.7	1.78	1.78
(Mg + Ca)/ AO Nitrogen	5.1	5.5	5.5
% AO nitrogen	41.4	41.4	41.4
% AO nitrogen - Booster	75	75	75
TBN (ASTM D2896)	8.6	8.3	8.4
TBN from Ca detergents	2.3	3.5	3.6
TBN from Mg detergents	4.1	2.7	2.7

[0145] The finished motorcycle lubricants of Table 7 were also evaluated for varnish pursuant to the Hot Tube Test (HTT) at 290°C when run pursuant to JIS Method No JPI-5S-55-99 and sulfated ash pursuant to ASTM D872. Result are provided in Table 8 below.

[0146] Table 8: Finished Motorcycle Lubricants

	Invent 2	Invent 3	Invent 4
Hot Tube test rating (method A) *	5.0	5.0	7.5
SASH (ASTM D872)	0.95	0.95	0.95
	PASS	PASS	PASS

*Passing is a rating of 5.0 or greater

[0147] It is noted that, as used in this specification and the appended claims, the singular forms “a,” “an,” and “the,” include plural referents unless expressly and unequivocally limited to one referent. Thus, for example, reference to “an antioxidant” includes two or more different antioxidants. As used herein, the term “include” and its grammatical variants

are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that can be substituted or added to the listed items

[0148] For the purposes of this specification and appended claims, unless otherwise indicated, all numbers expressing quantities, percentages or proportions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by the present disclosure. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

[0149] It is to be understood that each component, compound, substituent or parameter disclosed herein is to be interpreted as being disclosed for use alone or in combination with one or more of each and every other component, compound, substituent or parameter disclosed herein.

[0150] It is further understood that each range disclosed herein is to be interpreted as a disclosure of each specific value within the disclosed range that has the same number of significant digits. Thus, for example, a range from 1 to 4 is to be interpreted as an express disclosure of the values 1, 2, 3 and 4 as well as any range of such values.

[0151] It is further understood that each lower limit of each range disclosed herein is to be interpreted as disclosed in combination with each upper limit of each range and each specific value within each range disclosed herein for the same component, compounds, substituent or parameter. Thus, this disclosure to be interpreted as a disclosure of all ranges derived by combining each lower limit of each range with each upper limit of each range or with each specific value within each range, or by combining each upper limit of each range with each specific value within each range. That is, it is also further understood that any range between the endpoint values within the broad range is also discussed herein. Thus, a range from 1 to 4 also means a range from 1 to 3, 1 to 2, 2 to 4, 2 to 3, and so forth.

[0152] Furthermore, specific amounts/values of a component, compound, substituent or parameter disclosed in the description or an example is to be interpreted as a disclosure of either a lower or an upper limit of a range and thus can be combined with any other lower or upper limit of a range or specific amount/value for the same component, compound,

substituent or parameter disclosed elsewhere in the application to form a range for that component, compound, substituent or parameter.

[0153] While particular embodiments have been described, alternatives, modifications, variations, improvements, and substantial equivalents that are or can be presently unforeseen can arise to applicants or others skilled in the art. Accordingly, the appended claims as filed and as they can be amended are intended to embrace all such alternatives, modifications variations, improvements, and substantial equivalents.

CLAIMS

What is claimed is:

1. A finished motorcycle lubricating composition comprising:
one or more base oils of lubricating viscosity;
an aminic antioxidant providing at least about 300 ppm of antioxidant nitrogen to the finished motorcycle lubricating composition;
a mixed-metal detergent system providing about 800 to about 3000 ppm of calcium and about 200 to about 1000 ppm of magnesium to the finished motorcycle lubricating composition;
a weight ratio of the magnesium from the detergent system to the antioxidant nitrogen from the aminic antioxidant (Mg/N) of about 0.8 to about 2.8; and
wherein the finished motorcycle lubricating composition has a piston cleanliness rating of 5 or higher in the Hot Tube Test pursuant to JPI-5S-55-99 at about 290°C.
2. The finished motorcycle lubricating composition of claim 1, wherein a weight ratio of the magnesium and the calcium from the detergent system relative to the antioxidant nitrogen from the aminic antioxidant (Mg + Ca)/(N) is about 5.0 to about 8.0
3. The finished motorcycle lubricating composition of claim 1, wherein the detergent system includes calcium sulfonate, calcium phenate, and magnesium sulfonate.
4. The finished motorcycle lubricating composition of claim 3, wherein the lubricating composition includes about 0.9 to about 1.5 weight percent of the aminic antioxidant.
5. The finished motorcycle lubricating composition of claim 4, wherein the aminic antioxidant is selected from the group consisting of an aromatic amine, an alkylated diphenylamine, a nonyl diphenylamine, a di-nonyl diphenylamine, an octyl diphenylamine, a di-octyl diphenylamine, a phenyl-alpha-naphthylamine, an alkylated phenyl-alpha-naphthylamine, a hindered non-aromatic amine, or combinations thereof.

6. The finished motorcycle lubricating composition of claim 1, wherein at least about 40 weight percent of total nitrogen in the finished motorcycle lubricating composition is provided by the antioxidant nitrogen from the aminic antioxidant.
7. The finished motorcycle lubricating composition of claim 1, wherein the finished motorcycle lubricating composition lubricates a motorcycle engine crankcase and a transmission including a wet clutch from a common reservoir.
8. The finished motorcycle lubricating composition of claim 1, wherein the finished motorcycle lubricating composition has a total phosphorus level of 1000 ppm or less.
9. The finished motorcycle lubricating composition of claim 8, wherein the finished motorcycle lubricating composition has a total base number (TBN) as measured by ASTM D2896 of at least about 8.0 mg KOH/g.
10. The finished motorcycle lubricating composition of claim 1, wherein the finished motorcycle lubricating composition is provided by a motorcycle lubricating composition and a booster additive package, wherein the motorcycle lubricating composition includes one or more calcium-containing detergent additives providing the calcium in the detergent system and the booster additive package includes one or more magnesium-containing detergent additives providing the magnesium in the detergent system.
11. The finished motorcycle lubricating composition of claim 10, wherein the motorcycle lubricating composition includes a first portion of the aminic antioxidant and the booster additive package includes a second portion of the aminic antioxidant.
12. The finished motorcycle lubricating composition of claim 11, wherein the second portion of the aminic antioxidant provides about 70 to about 80 weight percent of the antioxidant nitrogen in the finished motorcycle lubricating composition.
13. The finished motorcycle lubricating composition of claim 1, wherein the finished motorcycle lubricating composition has a total sulfated ash content as measured by ASTM D872 of less than about 1.0 weight percent.

14. A booster additive package for top-treating a motorcycle lubricating composition to form a finished motorcycle lubricating composition, the booster additive package comprising:

an aminic antioxidant in amounts to provide about 200 ppm to about 360 ppm of antioxidant nitrogen to the finished motorcycle lubricating composition;

one or more magnesium-containing detergent additives in amounts to provide about 200 ppm to about 1000 ppm of magnesium to the finished motorcycle lubricating composition; and

wherein the booster additive package is configured, upon top-treating a motorcycle lubricating composition, to form the finished motorcycle lubricating composition having a weight ratio of magnesium-to-antioxidant nitrogen (Mg/N) of about 0.8 to about 2.8 and wherein a first portion of the antioxidant nitrogen is provided from the motorcycle lubricating composition and a second portion of the antioxidant nitrogen is provided by the booster additive package; and

wherein the finished motorcycle lubricating composition has a piston cleanliness rating of 5 or higher in the Hot Tube Test run pursuant to JPI-5S-55-99 at about 290°C.

15. The booster additive package of claim 14, wherein the booster additive package consists only of the one or more magnesium-containing detergent additives.

16. The booster additive package of claim 15, wherein the one or more magnesium-containing detergents is one or more overbased magnesium sulfonate detergent additives.

17. The booster additive package of claim 14, wherein the aminic antioxidant is selected from the group consisting of an aromatic amine, an alkylated diphenylamine, a nonyl diphenylamine, a di-nonyl diphenylamine, an octyl diphenylamine, a di-octyl diphenylamine, a phenyl-alpha-naphthylamine, an alkylated phenyl-alpha-naphthylamine, a hindered non-aromatic amine, or combinations thereof.

18. The booster additive package of claim 14, wherein at least about 40 weight percent of the total nitrogen in the finished motorcycle lubricating composition is provided by the aminic antioxidant.

19. The booster additive package of claim 18, wherein the second portion of the aminic antioxidant provides about 70 to about 80 weight percent of the total antioxidant nitrogen in the finished motorcycle lubricating composition.

20. A method for improving piston cleanliness of a motorcycle engine, the method comprising

providing a motorcycle lubricating composition including one or more calcium-containing detergent additives and one or more aminic antioxidants providing a first portion of antioxidant nitrogen;

adding a booster additive package to the motorcycle lubricating composition to form a finished motorcycle lubricating composition to lubricate a motorcycle engine crankcase and a motorcycle transmission from a common reservoir, wherein the booster additive package includes one or more magnesium-containing detergent additives and one or more aminic antioxidants providing a second portion of the antioxidant nitrogen; and

wherein the finished motorcycle lubricating composition has a piston cleanliness rating of 5 or higher in the Hot Tube Test pursuant to JPI-5S-55-99 at about 290°C.

21. The method of claim 20, wherein the finished motorcycle lubricating composition includes (i) one or more base oils of lubricating viscosity; (ii) combined aminic antioxidant from the motorcycle lubricant and the booster additive package of at least about 300 ppm; (iii) a mixed-metal detergent system providing about 800 to about 3000 ppm of calcium and about 200 to about 1000 ppm of magnesium; and wherein a weight ratio of the magnesium from the detergent system to the total antioxidant nitrogen from the combined aminic antioxidant (Mg/N) is about 0.8 to about 2.8.

22. The method of claim 20, wherein the booster additive packaging consists only of the one or more magnesium-containing detergent additives.

22. The method of claim 22, wherein the one or more magnesium-containing detergents is one or more overbased magnesium sulfonate detergent additives.

23. The method of claim 20, wherein the aminic antioxidant of the motorcycle lubricating composition, the booster additive package, or both is selected from the group comprising an aromatic amine, an alkylated diphenylamine, a nonyl diphenylamine, a dinonyl diphenylamine, an octyl diphenylamine, a di-octyl diphenylamine, a phenyl-alpha-naphthylamine, an alkylated phenyl-alpha-naphthylamine, a hindered non-aromatic amine, or combinations thereof.

24. The method of claim 20, wherein at least about 40 weight percent of the total nitrogen in the finished motorcycle lubricating composition is provided by the combined aminic antioxidant from the booster additive package and the motorcycle lubricating composition.

25. The method of claim 24, wherein the second portion of the aminic antioxidant provides about 70 to about 80 weight percent of the total antioxidant nitrogen in the finished motorcycle lubricating composition.

26. The method of claim 24, wherein the finished motorcycle lubricating composition has a total sulfated ash content of 1.0 weight percent or less as measured pursuant to ASTM D872.