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(54) **LUBRICANT FOR TWO-CYCLE ENGINES**

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(57) **ABSTRACT**

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A two-cycle engine lubricant comprising from about 10% to about 30% low ash detergent inhibitor; from about 10% to about 45% bio-based ester selected from the group consisting of castor oil, a synthetic polyol-based ester and mixtures thereof; from about 14% to about 37% polyalphaolefin; from about 7% to about 18% synthetic ester; from 2% to about 10% surfactant; and from about 2% to about 5% pour point depressant; by weight of the lubricant. Optionally, the subject two-cycle lubricant can also comprise up to about 20 weight percent solvent, such as Stoddard solvent, to improve miscibility of the lubricant with gasoline fuel. The subject lubricant can be pre-packaged with gasoline for use with small engines not equipped for direct lubricant injection. A method for making the subject lubricant composition so as to resist subsequent separation of the components into layers is also disclosed.

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LUBRICANT FOR TWO-CYCLE ENGINES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional patent application Serial No. 60/364,277, filed Mar. 13, 2002, as to all common subject matter contained herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates to a lubricant composition that provides excellent lubricity and miscibility when used in two-cycle engines. The invention also relates to a lubricant composition that, when mixed with engine fuel, reduces smoke and other particulate emissions produced by the combustion of such fuel and reduces the amount of fuel used. The compositions of the invention are believed useful in two-cycle engines that are either air-cooled or liquid-cooled.

[0004] 2. Description of Related Art

[0005] The use of lubricants and additives in engine oils for the purpose of reducing friction, corrosion and wear is well known. Two-cycle engines present particular challenges for engine lubricants because the lubricant must be incorporated into the fuel, either as a premix or by direct injection. Two-cycle engine lubricants should be readily miscible with gasoline, provide lubricity to moving engine parts such as pistons and engine bearings, and should not contribute to spark plug fouling or pre-ignition, or to the formation of undesirable smoke and other particulate emissions when the fuel is combusted. Furthermore, such two-cycle engine lubricants should flow well at low temperatures, remain shelf stable for at least six months, and preferably up to two years, to facilitate packaging, distribution and storage prior to use. Unfortunately, many conventional fuel and lubricant additives separate and lose their effectiveness over time, or become immiscible or otherwise ineffective at low temperatures, or contribute to the formation of smoke and other particulate emissions, particularly when used as an engine lubricant in two-cycle engines.

[0006] Rating criteria and performance standards for two-cycle engines have evolved considerably during the past 20 years to keep pace with the evolution of new engine technologies and the ever-expanding governmental regulatory requirements associated with their use. Oil and additive companies continue to work with engine manufacturers to develop better lubricants for the new generation of direct fuel injection engines. The old designations defined for two-cycle engine oil by the American Petroleum Institute (API) and Society of Automotive Engineers (SAE) are no longer applicable. The TC-W3 specification developed by the National Marine Manufacturer's Association (NMMA) is now required for all outboard engines and two new international designations, the "Global" system established by the International Organization for Standardization (ISO) from Europe and the "JASO" system established by the Japanese Automobile Standards Organization, have now been adopted worldwide to classify high temperature air-cooled two-cycle engine oils.

[0007] Global GD oils are synthetic or semi-synthetic, extreme temperature/anti-scuff/lubricity, low smoke, low

ash oils. Global GC oils are high lubricity/detergent, low smoke, semi-synthetic, low ash oils. Global GB oils do not require any synthetic to meet specifications, but contain detergent and/or lubricity additives and are typically low to medium ash oils. EGD oils have great detergency as identified in proposed Draft International Standard 13738. There is presently no JASO counterpart to EGD oils. JASO FC oils are comparable to GC oils and are typical of the low smoke type oils in the Japanese market. JASO FB oils are comparable to the GB oils but have high performance in lubricity but are not of the low smoke type. JASO FA rated oils are used primarily in Pacific Rim countries, have the absolute minimum acceptable performance level for two-cycle engines and are characterized by medium to high ash mineral oils with limited lubricity and detergency.

[0008] Published two-cycle engine oil qualification tests now include the following:

Test Type	General Description
NMMA, TC-W3, Mercury 15 HP Test	Piston Ring Sticking/Scuffing
JASO, M 340-92, Lubricity Test	Lubricity, Initial Torque
JASO, M 341-92, Detergency Test	Piston Ring Sticking, CCD Formation
JASO, M 342-92, Smoke Test	Visible Exhaust Smoke Formation
JASO, M 343-92, Exhaust System Blocking	Exhaust System Blocking Test
ISO CEC, "GD" Three Hour Detergency Test	Piston Ring Sticking, CCD Formation

[0009] Conventional two-cycle engine lubricants can typically comprise, for example, a neutral oil for general lubrication; bright stock base oils or another lubricity additive for piston lubrication; a detergent and dispersant for engine cleanliness and protection; polyisobutylene (PIB) or another similarly effective component for reducing carbon deposits and smoke; a solvent carrier or diluent to improve miscibility; and a pour point depressant for flowability at low temperatures. Even the more expensive, full synthetic lubricants now commercially available are believed to require PIB to achieve low smoke. Minor effective amount of various additive packages can also be included to reduce wear and corrosion of engine parts. Based upon the recommendations of engine manufacturers, two-cycle engine lubricants are typically combined with gasoline engine fuel at fuel-blend ratios ranging from about 16 to about 100 parts fuel per part of lubricant, by volume.

[0010] The use of overbased sulfonates in engine oil lubricants is disclosed, for example, in U.S. Pat. No. 2,585,520. Processes for making overbased sulfonates are disclosed, for example, in U.S. Pat. Nos. 4,129,589; 4,306,983; 4,347,147; 4,597,880; 4,617,135; and 5,259,966. Engine lubricant additives comprising overbased sulfonates and jobo oil are disclosed, for example, in U.S. Pat. Nos. 4,557,841; 4,664,821; 4,668,413; and 5,505,867.

[0011] In "Demand for Synthetic Lubricants on the Rise," *Chemical & Engineering News* (Sep. 7, 1998, p. 22), polyalphaolefins (PAO), oligomers of decene, are disclosed as being excellent components for use in synthetic lubricants due to their low volatility, stability, lubricity and low toxicity, but are said to have poor biodegradability and to be

three to five times as expensive as mineral oil. The addition of organic esters to polyalphaolefins is disclosed as being useful in making synthetic lubricants because the ester adds the polarity required to dissolve the additives.

[0012] Synthetic polyol esters are typically neopentyl polyol esters made by reacting monobasic fatty acids with polyhydric alcohols having a neopentyl structure. In polyol alcohol molecules having the neopentyl structure, there are no hydrogens on the beta-carbon. Eliminating the beta-hydrogen, which is typically the first site of thermal attack on diesters, improves the thermal stability of the polyol esters and allows them to be used a much higher temperatures. Polyol esters are known to be useful for blending with PAOs in passenger car motor oils.

[0013] Some companies are believed to have done work with synthetic esters and diesters as lubricants, especially for use in meeting the TC-W3 specifications for outboard motors. Others have sought to replace part or most of the oil component with polybutenes. While polybutenes are recognized as being cleaner burning, producing less soot than oils, they typically lack the lubricity of oil. Still others have experimented with the use of vegetable oils, although vegetable oils tend to solidify at low temperatures, are more readily oxidized, and degrade rapidly in high temperature service. An advantage of vegetable oils for use in lubricants is their biodegradability as compared to many petroleum-based hydrocarbons.

[0014] M. Woods, in "Think Green—Biodegradable Lubes Glow with Promise," *Lubes 'N Greases* (July 1997, pp. 14-18), reported the following as five types of biodegradable base stocks disclosed by Dr. J. Perez of Pennsylvania State University as being available to manufacturers who want to produce environmentally friendly lubricants: Polyalphaolefins (PAOs), particularly low molecular weight oligomers of alpha-decene; polyalkylene glycols (PAGs); dibasic acid esters (Diesters), particularly those made from adipic acid and other carboxylic acids esterified with alcohols; polyol esters (PE), and high oleic vegetable oils (HOVOs). Perez disclosed during the symposium on the "Worldwide Perspective on the Manufacture, Characterization and Application of Lubricant Base Oils" presented at an American Chemical Society national meeting in April 1997 that the biodegradable PAOs can have high volatility and shrink rubber seals; that diesters mixed with PAOs in synthetic lubricants have good oxidative stability and seal-swell properties but score low on tests of ultimate biodegradability; that the molecular weight of PEs often results in lubricants with higher viscosities; and that vegetable oils, mainly triglycerides, have high molecular weights, which can cause problems with flow at low temperatures, requiring proper blending and pour-point additives to produce satisfactory lubricants. In summary, Perez stated that the wide differences in chemical and physical properties make it very difficult to develop a universal biodegradable base stock to replace mineral oil base stock in traditional lubricants.

[0015] R. Goyan, R. Melley, P. Wissneer and W. Ong, in "Biodegradable Lubricants," *Lubrication Engineering* (July 1998, pp. 10-17) state that biodegradable lubricants should also meet the same performance characteristics, such as lubricity, viscosity, flow and cold pour characteristics, thermal and oxidative stability, corrosivity and compatibility as mineral-based lubricants. The article presents case study

summaries that are said to demonstrate the utility of biodegradable lubricants in saw guide oils, hydraulic valve actuator oils, turbine oils, and rail curve greases, but not as engine lubricants.

[0016] After investigating the use of canola oil, soybean oil and sunflower oil in combination with additive packages including antioxidants, thickeners, pour point depressants and industrial hydraulic packages, S. Lawate, R. Unger and C. Huang, "Vegetable Oil Lubricants," *Lubricants World* (May 1999, pp. 43-45) stated that the key considerations in formulating lubricants based on vegetable oils are akin to those with mineral oils—the choice of base oil and the choice of additive package. The authors further disclosed that it is typically necessary to use higher levels of pour point depressant and "co-solvents" to improve the low-temperature viscometrics and long-term fluidity of vegetable oil lubricants.

[0017] In discussing two-cycle engine advancements designed to improve fuel economy and reduce emissions, and more specifically the use of sliding plates over exhaust ports to reduce the loss of fuel/oil mixture at low engine speeds, in "Clean-up Time for Two-Stroke" in *Infineum Insight* (No. 4, January 2000), the author emphasizes the need for lubricants containing detergents and notes that adding detergent to a lubricant is "not as straightforward as it may sound." Detergent packages must be formulated to ensure that they are compatible with other components in the lubricant. "Ensuring this compatibility while targeting many very specific chemistries presents a challenging task for the additive manufacturer and lubricant formulator."

[0018] Notwithstanding the advances and improvements made in two-cycle engine lubricants in recent years, there remains a need for a two-cycle lubricant that exhibits excellent lubricity, and corrosion and wear protection, that retains its effectiveness and remains miscible at low temperatures, that reduces smoke and other particulate emissions when incorporated into gasoline, and that is shelf-stable. In order to be commercially viable for widespread use, such a lubricant must also be producible at a cost that is not prohibitive.

SUMMARY OF THE INVENTION

[0019] The compositions disclosed herein are preferred for use as lubricants in fuels for two-cycle engines. The compositions of the invention are particularly preferred for use as a total volume replacement for conventional lubricants presently used in two-cycle engines, no matter whether the lubricant is pre-mixed with gasoline or is separately injected. The subject compositions exhibit excellent lubricity, corrosion, wear and oxidation resistance, even at extreme pressures or low temperatures, are biodegradable and are readily miscible with gasoline. The lubricants of the invention are also effective for reducing smoke and other particulate emissions normally produced by two-cycle engines during use.

[0020] According to one preferred embodiment of the invention, a two-cycle engine lubricant is provided that comprises from about 10% to about 30% low ash detergent inhibitor; from about 10% to about 45% bio-based ester selected from the group consisting of castor oil, synthetic polyol-based ester, and mixtures thereof; from about 14% to about 37% polyalphaolefin; from about 7% to about 18%

synthetic ester; from 2% to about 10% surfactant; and from about 2% to about 5% pour point depressant, all by weight of the lubricant. Optionally, the subject two-cycle lubricant can also comprise up to about 20 wt. % solvent, such as Stoddard solvent, to improve miscibility of the lubricant with gasoline fuel, provided that the viscosity of the lubricant remains at least about 6.5 cSt at 100° C. following dilution with the solvent. The two-cycle engine lubricant as disclosed herein is preferably added to gasoline fuel at a fuel-to-oil ratio ranging from about 50 to about 100 parts fuel per part of lubricant, by volume, although it will be appreciated that either lower or higher treat rates may also be viable for some lubricants and applications.

[0021] According to another embodiment of the invention, the two-cycle engine lubricant as disclosed herein can also be mixed with gasoline and packaged for retail sale, especially for use in applications with relative small fuel tanks (a gallon or less) where premixed lubricant and fuel are required. The fuel and lubricant are desirably premixed in the ratio recommended by the engine manufacturer, and prepackaged fuel/lubricant mixtures in selected fuel-to-oil ratios such as, for example, 100 to 1 or 50 to 1 can be provided.

[0022] We have also discovered that the relative proportions and order of addition of some components can have a significant effect upon whether or not the lubricant composition of the invention will tend to form layers and separate, which can adversely affect both the utility and shelf life of the resultant product. According to another embodiment of the invention, to avoid layering or separation, the detergent inhibitor and PAO are premixed for about 10 to 15 minutes under high shear at a temperature ranging from about 120° to about 125° F. and then added to a second premixture of the castor oil, synthetic ester, pour point depressant, surfactant and, optionally, solvent that has itself been premixed for about 20 to 40 minutes under the same or similar conditions. The combined first and second premixes are then further mixed, preferably under high shear conditions at a temperature of about 120-125° F. for about 30 to 35 minutes, after which they are cooled to ambient conditions and packaged. Two-cycle engine lubricants made as disclosed herein are believed to exhibit excellent shelf stability and can be stored at least six months, and often up to two years or more, without detrimental separation of the components into layers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] The preferred compositions of the invention are more particularly described herein in relation to the preferred embodiment of a two-cycle engine lubricant that is miscible with gasoline. It should be understood, however, that the disclosed compositions can also have utility as lubricants or lubricant additives for other applications and lubricant systems.

[0024] The two-cycle engine lubricant of the invention preferably comprises detergent inhibitor, dehydrated castor oil, PAO, a synthetic ester, a surfactant, a pour point depressant and, optionally, a solvent. When properly prepared in accordance with the method of the invention, the subject lubricant is stable and does not separate into layers during a typical shelf life of six months to two years or more when mixed with gasoline. Care should be taken, however, to

follow the method of the invention because castor oil is not soluble in the other principal components and can form an immiscible layer unless properly combined with the other lubricant components.

[0025] While the detergent inhibitor component of the invention, preferably a low ash detergent inhibitor, can comprise one or more of many different commercially available products containing one or more nitrogen blends, it preferably does not comprise an overbased sulfonate. The low ash detergent inhibitor component, preferably Lubrizol® 600, Lubrizol® 420, or another similarly effective material, is preferably used in an amount ranging from about 10 up to about 30 weight percent of the lubricant. Lubrizol® 600 and Lubrizol® 420 are marketed by The Lubrizol Corporation of Wickliffe, Ohio. Lubrizol® 600 has a specific gravity of 0.932, a viscosity of 165 cSt (at 100° C.) and a pour point of -9° C. Lubrizol® 420 is a very low (0.2) ash detergent inhibitor that has a specific gravity of 0.92 and a viscosity of 100 cSt (at 100° C.). The detergent inhibitor component provides antioxidant, antiwear and anticorrosion protection in the subject lubricant, and it is believed that at least about 10 weight percent is needed to afford the desired degree of protection. Lubrizol® 600 is recommended by the manufacturer as a low ash performance package for use in non-outboard two cycle engine oils. To achieve the JASO FC performance level, the manufacturer recommends the use of from 4.8 to 9.3 weight percent Lubrizol® 600 in combination with PIB having a molecular weight of about 950 in the lubricant. We have learned that shelf stability is often improved where the amount of detergent inhibitor ranges from about 15 to about 25 weight percent, and lubricant compositions containing about 20 weight percent detergent inhibitor are particularly preferred. Alternatively, it will be appreciated that ashless detergent inhibitors can also be used in the lubricants of the invention.

[0026] The lubricant compositions of the invention preferably further comprise from about 10 to about 45 weight percent bio-based ester selected from the group consisting of dehydrated castor oil and a high performance synthetic polyol-based ester to provide lubricity and promote cleaner burning. Lubricant compositions comprising about 35 weight percent dehydrated castor oil are particularly preferred. Although greater amounts of the bio-based ester component can be used beneficially in the compositions of the invention, cost considerations can favor limiting the content to about 35 weight percent. Where the bio-based ester is castor oil and the amount of castor oil in the subject compositions approaches or exceeds about 45 weight percent, it may be desirable to reduce the amount of PAO in the formulation, and to increase the amount of synthetic ester and surfactant proportionally to improve solubility in the mixture. One preferred castor oil is AA® Standard castor oil, marketed by CasChem, Inc. of Bayonne, N.J. AA® Standard castor oil is a commercial, refined grade of castor oil that is a light colored viscous liquid with a molecular weight of about 928, a specific gravity of 0.959, a pour point of -10° F., a viscosity of 7.3 stokes at 25° C., and an acid value of 2. Another preferred castor oil for use in the compositions of the invention is XXX-1® Oil, marketed by CasChem, Inc. of Bayonne, N.J. XXX-1® Oil, a dehydrated castor oil recommended as a lubricant for food processing plants, is soluble in mineral oil and all common organic solvents except methanol and ethanol, has a specific gravity of 0.94, a viscosity of 2.8 stokes at 25° C., and a pour point of -40° F. Layering within the finished lubricant is more likely to occur when castor oil is used that contains water.

[0027] A preferred polyol-based ester for alternative use as the bio-based ester component in the subject two-cycle engine lubricant compositions is Agri-Pure™ 560 lubricant (AP-560), marketed by Cargill, Inc. of Chicago, Ill. AP-560 was developed to meet the extreme requirements of major OEM bio-hydraulic fluids (Caterpillar spec. for BF-1) and is also marketed for applications including general lubricating oils. AP-560 has a specific gravity of 0.924, a viscosity of 6.47 cSt at 100° C., and a pour point of minus 20° C.

[0028] The lubricant compositions of the invention preferably further comprise from about 14 to about 37 weight percent PAO, a synthetic oil comprising hydrogenated trimer and homopolymer of 1-decene, preferably having a viscosity ranging from about 2 to about 6 cSt at 100° C., and most preferably about 4 cSt. Lubricants containing PAO having a viscosity ranging from about 2 to about 4 cSt at 100° C. are believed to be more biodegradable than those with higher viscosity PAOs. Use of the preferred PAO in the subject compositions is believed to result in lubricants characterized by less smoke, good biodegradability, and lower engine operating temperatures than lubricants made with mineral oil. The use of PAOs having viscosities greater than about 6 cSt can cause the resultant lubricant to produce more smoke and other particulate emissions. The preferred PAOs as described herein are marketed, for example, by Chevron Oronite Corporation.

[0029] The compositions of the invention preferably further comprise from about 7 to about 18 weight percent synthetic ester. A preferred synthetic ester for use in the compositions of the invention is marketed by Hatco Corporation of Fords, N.J., under the trademark Hatco® 2976. Hatco® 2976 comprises 2-ethylhexyl 2-ethylhexanoate is a pure, low viscosity, single molecule synthetic ester having polar functionality and a well-hindered ester linkage that provides metal wetting and lubricity characteristics while maintaining a clean system. Hatco® 2976 has a specific gravity of 0.86, a viscosity of 1.1 cSt at 100° C. and a pour point of less than -7.5° C. Where the synthetic ester component is present in an amount less than about 7 weight percent, the miscibility of the resultant lubricant is reduced. Amounts of synthetic ester ranging up to about 20 weight percent can also be used in the subject compositions, although amounts greater than about 15 weight percent are not generally cost effective.

[0030] The compositions of the invention preferably further comprise from about 2 to about 5 weight percent of a pour point depressant that is designed to work in vegetable oils. A preferred component for use as a pour point depressant in the compositions of the invention is an ester, diethylhexyl adipate, marketed by Rhomax under the trademark Viscoplex® 10-930. Amounts less than about 1 weight percent are generally ineffective for depressing the pour point of the lubricant to the desired extent, while the use of amounts greater than about 5 percent is not needed, is not believed to be cost effective, and may even raise the pour point.

[0031] The compositions of the invention preferably further comprise from about 2 to about 10 weight percent, and most preferably about 5 weight percent, of a surfactant. A preferred surfactant for use in the invention is a polyolefin derivative marketed as a sodium sulfonate replacement under the trademark Addconate-H® by Gateway Additive Co., a subsidiary of The Lubrizol Corporation. Addconate-H® is a slightly hazy liquid having a specific gravity of 0.94, a viscosity of 4361 cSt at 100° F. and a viscosity index of

107. The preferred surfactant is said to comprise a highly branched succinic acid that can be neutralized with potassium hydroxide and amine. Although as little as about 2 weight percent surfactant can be used in making the subject compositions, it is believed that the use of about 5 weight percent surfactant lengthens the period that the composition can be stored and used without separation of the other components. The inclusion of a surfactant in the compositions of the invention is believed to be less important or even optional for lubricants otherwise made in accordance with the invention that contain a polyol-based ester such as AP-560.

[0032] The two-cycle engine lubricants of the invention can optionally comprise from 0 up to about 20 volume percent solvent to improve miscibility of the lubricant with the engine fuel. Where solvent is used, the lubricant is preferably diluted with up to about 2 parts solvent per 8 parts lubricant, by volume, where the lubricant is formulated as otherwise described above. Satisfactory results are achieved, for example, where the lubricant is diluted with an amount of solvent equal to about 1 part solvent per 9 parts, by volume, of the lubricant. Desirably, the amount of solvent that should be added is limited by the viscosity of the resultant lubricant, which should not be permitted to drop below about 6.5 cSt at 100° C. The solvent should desirably be compatible with the other components of the lubricant, not forming a precipitate or flocculant. A preferred solvent for use in the subject compositions is Stoddard Solvent, which is Well known to those of skill in the art, although other similarly effective solvents can likewise be used within the scope of the invention. The two-cycle engine lubricant as disclosed herein is preferably added to gasoline fuel at a fuel-to-oil ratio ranging from about 50 to about 100 parts fuel per part of lubricant, by volume, although it will be appreciated that higher or lower treat rates may also be viable for some lubricants and applications. For example, fuel-to-oil ratios of 16 to 1, 24 to 1 or 32 to 1 are believed to be recommended by some engine manufacturers.

[0033] The compositions of the invention are preferably made by premixing each of two groups of components that are then combined and further mixed as described below. When made as described herein, all the components are either soluble or miscible in each other and are desirably thoroughly dispersed to produce a lubricant that does not separate into layers during the expected conditions of storage and use. According to a particularly preferred embodiment of the invention, a first premixture is prepared by combining a first set of components comprising detergent inhibitor and PAO in a steam-jacketed, high shear mixer, wherein the first set of components is stirred or otherwise mixed for about 10 to about 15 minutes, most preferably at a temperature of about 120° to about 125° F. Although the mixing described herein can be performed at ambient conditions, with some associated warming due to the high shear conditions, mixing at temperatures within or near the stated range is preferred. A second premixture is prepared by combining a second set of components comprising the bio-based ester component, synthetic ester, surfactant and pour point depressant in a similar jacketed, high shear mixer, and stirring or otherwise mixing at a temperature preferably ranging from about 120° to about 125° F. for a period ranging from about 20 to about 40 minutes. The first premix is then desirably added to the second premix and stirred or otherwise mixed under high shear conditions at a temperature preferably ranging from about 120° to about 125° F. for

a period ranging from about 30 to about 35 minutes. The resultant product is then cooled to ambient temperature and packaged.

[0034] A convenient premixed, pre-packaged fuel/lubricant mixture suitable for use with small two-cycle engines having relatively small gas tanks (for example, from about 500 ml up to about a gallon) and lacking a direct lubricant injection system can be made by combining the cooled lubricant as described above with gasoline prior to packaging. The gasoline and lubricant are desirably combined in ratios corresponding to the fuel-to-oil ratios typically required by manufacturers of such two-cycle engines. Thus, for example, the two-cycle engine lubricant of the invention can be premixed and packaged at a fuel-to-oil ratio of about 50 to 1, or about 100 to 1, or at such other ratio as may be needed, typically by volume. Lubricants of the invention intended for use in pre-packaged fuel/lubricant mixtures will desirably include a solvent component as previously described.

[0035] The stability and various performance capabilities of some preferred two-cycle engine lubricants made in accordance with the invention are evaluated as set forth in the Examples provided below. For examples 1-20, samples of the resultant lubricants were visually observed for 72 hours following cooling to determine whether separation would occur, whether in the form of layering, flocculation or precipitation. In those examples where separation occurred, it is noted. In each case where separation is noted, it occurred in the form of layering. For Examples 1-20, "deposits" were determined by a Panel Oxidation Test. The Panel Oxidation Test is performed by spreading one gram of lubricant on a test panel, heating the test panel to 200° F. for 48 hours, and then comparing the test panel to a commercial standard. Samples that exhibit soot deposits on the panels indicate a likelihood for creating deposits when the lubricant is used in an engine. Where deposits on the test panel were noted in performing this test, "increased deposits" are mentioned in the comments below for each such example.

EXAMPLE 1

[0036] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 20 weight percent Lubrizol® 600 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 35 weight percent AA castor oil, 10 weight percent Hatco® 2976 synthetic ester, 5 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. No component separation was observed following cooling of the lubricant.

EXAMPLE 2

[0037] Another two-cycle engine lubricant composition was prepared as described in Example 1 except that 35 weight percent AP-560 polyol-based ester was substituted for the AA castor oil. No component separation was observed following cooling of the lubricant.

EXAMPLE 3

[0038] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 19 weight percent Lubrizol® 420 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 36 weight percent AA castor oil, 10 weight percent Hatco® 2976 synthetic ester, 5 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. Component separation was thereafter observed in the lubricant.

EXAMPLE 4

[0039] Another two-cycle engine lubricant composition was prepared as described in Example 3 except that 36 weight percent AP-560 polyol-based ester was substituted for the AA castor oil. No component separation was observed following cooling of the lubricant.

EXAMPLE 5

[0040] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 20 weight percent Lubrizol® 600 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 25 weight percent AA castor oil, 10 weight percent Hatco® 2976 synthetic ester, 5 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix together with 10 weight percent Stoddard Solvent and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. No component separation was thereafter observed in the lubricant.

EXAMPLE 6

[0041] Another two-cycle engine lubricant composition was prepared as described in Example 5 except that 25 weight percent AP-560 polyol-based ester was substituted for the M castor oil. No component separation was observed following cooling of the lubricant.

EXAMPLE 7

[0042] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 19 weight percent Lubrizol® 420 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A

second premixture was prepared by combining a second set of components comprising 26 weight percent M castor oil, 10 weight percent Hatco® 2976 synthetic ester, 5 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix together with 10 weight percent Stoddard Solvent and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. No component separation was thereafter observed in the lubricant.

EXAMPLE 8

[0043] Another two-cycle engine lubricant composition was prepared as described in Example 7 except that 36 weight percent AP-560 polyol-based ester was substituted for the M castor oil. No component separation was observed following cooling of the lubricant.

EXAMPLE 9

[0044] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 30 weight percent Lubrizol® 600 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 25 weight percent AA castor oil, 10 weight percent Hatco® 2976 synthetic ester, 5 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. Component separation was thereafter observed in the lubricant.

EXAMPLE 10

[0045] Another two-cycle engine lubricant composition was prepared as described in Example 9 except that 30 weight percent Lubrizol® 420 was substituted for the Lubrizol® 600. Component separation was observed following cooling of the lubricant.

EXAMPLE 11

[0046] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 10 weight percent Lubrizol® 600 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 45 weight percent M castor oil, 10 weight percent Hatco® 2976 synthetic ester, 5 weight percent Addconate-He surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred

under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. The lubricant exhibited no component separation but increased deposits were observed.

EXAMPLE 12

[0047] Another two-cycle engine lubricant composition was prepared as described in Example 11 except that 10 weight percent Lubrizol® 420 was substituted for the Lubrizol® 600. The resultant lubricant was cooled to ambient temperature. The lubricant exhibited no component separation but increased deposits were observed.

EXAMPLE 13

[0048] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 19 weight percent Lubrizol® 420 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 21 weight percent M castor oil, 20 weight percent AP-560 polyol-based ester, 10 weight percent Hatco® 2976 synthetic ester, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. No component separation was thereafter observed in the lubricant.

EXAMPLE 14

[0049] Another two-cycle engine lubricant composition was prepared as described in Example 13 except that 18 weight percent AA castor oil and 5 weight percent Viscoplex® 10-930 pour point depressant were substituted for the amounts previously used. No component separation was observed following cooling of the lubricant and there was no change in the pour point of the lubricant.

EXAMPLE 15

[0050] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 20 weight percent Lubrizol® 600 and 12 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 34 weight percent M castor oil, 20 weight percent XXX-1® Oil, 10 weight percent Hatco® 2976 synthetic ester, 2 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. The lubricant exhibited no component separation but increased deposits were observed.

EXAMPLE 16

[0051] Another two-cycle engine lubricant composition was prepared as described in Example 15 except that 40 weight percent 4 cSt PAO, 15 weight percent M castor oil and 1 weight percent Hatco® 2976 synthetic ester were substituted for the amounts previously used. Component separation was observed following cooling of the lubricant. This lubricant formulation was also significantly more expensive to produce than that of Example 15.

EXAMPLE 17

[0052] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 19 weight percent Lubrizol® 420 and 28 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 31 weight percent AP-560 polyol-based ester, 10 weight percent Hatco® 2976 synthetic ester, 10 weight percent Addconate-He surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. The lubricant exhibited no component separation but increased deposits were observed.

EXAMPLE 18

[0053] Another two-cycle engine lubricant composition was prepared as described in Example 17 except that 15 weight percent 4 cSt PAO was substituted for 28 weight percent, 24 weight percent M castor oil and 15 weight percent XXX-1® Oil were substituted for the 31 weight percent AP-560 polyol-based ester, 20 weight percent Hatco® 2976 synthetic ester was substituted for 10 weight percent, and 5 weight percent Addconate-H® surfactant was substituted for 10 weight percent. Component separation was observed following cooling of the lubricant.

EXAMPLE 19

[0054] A two-cycle engine lubricant was prepared by formulating first and second premixtures that were thereafter combined. A first premixture was prepared by combining a first set of components comprising 20 weight percent Lubrizol® 600 and 40 weight percent 4 cSt PAO in a steam-jacketed, high shear mixer, and stirring for about 15 minutes at a temperature ranging between about 120° and 125° F. A second premixture was prepared by combining a second set of components comprising 16 weight percent AA castor oil, 10 weight percent Hatco® 2976 synthetic ester, 2 weight percent Addconate-H® surfactant, and 2 weight percent Viscoplex® 10-930 pour point depressant in a similar jacketed, high shear mixer and stirring for about 35 minutes at a temperature ranging between 120° and 125° F. The first premix was then added to the second premix together with 10 weight percent Stoddard Solvent and stirred under high shear conditions for about 35 minutes at a temperature ranging between 120° and 125° F. The resultant lubricant was cooled to ambient temperature. No component separation was thereafter observed in the lubricant but the lubricant lacked the desired lubricity and the piston cylinder walls exhibited scuffing.

EXAMPLE 20

[0055] Another two-cycle engine lubricant composition was prepared as described in Example 20 except that 10 weight percent Lubrizol® 420 was substituted for the 20 weight percent Lubrizol® 600, 15 weight percent 4 cSt PAO was substituted for 40 weight percent, 65 weight percent AP-560 polyol-based ester was substituted for 16 weight percent AA castor oil, 8 weight percent Hatco® 2976 synthetic ester was substituted for 10 weight percent, and the surfactant and solvent were omitted. No component separation was observed following cooling of the lubricant. The lubricant exhibited no component separation but increased deposits were observed.

EXAMPLE 21

[0056] Another two-cycle engine lubricant was prepared as described in Example 1 except that 20 weight percent Lubrizol® 420 was substituted for the 20 weight percent Lubrizol® 600.

EXAMPLE 22

[0057] Another two-cycle engine lubricant was prepared as described in Example 2 except that 19 weight percent Lubrizol® 420 was substituted for the 20 weight percent Lubrizol® 600.

EXAMPLE 23

[0058] Another two-cycle engine lubricant is prepared as described in Example 22. During the final mixing stage, the lubricant is diluted with 10 volume percent Stoddard Solvent.

EXAMPLE 24

[0059] A pre-packaged mixture of gasoline and two-cycle engine lubricant is made by premixing the lubricant of Example 23 with gasoline in a fuel-to-oil ratio of about 50 to 1. The lubricant is readily miscible with the gasoline, and the mixture is packaged or bottled for retail sale in volumes that are suitable for a single fueling or refueling, especially with devices having fuel tanks holding, for example, from 500 ml up to a gallon or more of fuel/oil mixture. Pre-packaging a premixed fuel and two-cycle engine lubricant in this manner facilitates use by a consumer in devices having small two-cycle engines that are not equipped for direct lubricant injection.

EXAMPLE 25

[0060] The performance of the subject lubricant as compared to a commercially available two-cycle engine oil and to other candidate lubricant compositions was further tested in a two-cycle leaf blower study. In the leaf blower study, fourteen leaf blower units were purchased new and operated until they would no longer start or until they seized. The units were then rated for cleanliness, disassembled, and photographed. Control units (Nos. 1, 9 and 12) were treated at a 50 to 1 fuel-to-oil ratio with a lubricant packaged with the leaf blowers and labeled "Homelite Exact Mix 2 Cycle Engine Oil." Homelite is a division of Deere & Co., Charlotte, N.C. Two leaf blower units (Nos. 6 & 14) were operated with the same fuel and were lubricated at the same fuel-to-oil ratio with the two-cycle engine lubricant of the invention as described in Example 1 above. The other 9 leaf blower units were operated using the same fuel and lubricated with other candidate lubricants formulated as shown in Table I below:

TABLE I

Candidates	A	B	C	D	E	F	G	H	I
Unit #	4	7	8	2	3	5	10	11	13
Hybase 400M	20	0	0	20	20	20	0	0	0
Hybase 231C	0	0	20	0	0	0	0	0	0
Lubrizol 600	0	0	0	0	0	0	20	0	20
Castor Oil AA-1	35	55	35	21	20	35	35	54	0
Castor Oil technical	0	0	0	0	0	0	0	0	35
Hatco 2976	10	10	10	10	10	10	10	10	10
Viscoplex 10-930	2	2	2	2	2	2	2	2	2
4 cSt PAO	28	28	28	17	17	28	27	28	28
75 SUS oil	0	0	0	25	25	0	0	0	0
Addconate H	5	5	5	5	5	5	5	5	5
Jojoba Oil	0	0	0	0	1	0	1	1	0
Totals	100	100	100	100	100	100	100	100	100
Treat rate	1 in 50	1 in 100	1 in 50	1 in 50	1 in 50				

[0061] All units were taken to an outdoor caged area and started. Units 1 through 6 were refilled every 30 minutes and the fuel usage was recorded. After the first 30 hours, all units were retrofitted to draw fuel from a gallon container. This allowed the units to run constantly for up to 6 hours without stopping to refuel. At the end of the day the were shut down, disassembled and evaluated.

[0062] Some of the early tests failed due to excessive deposits in the exhaust port of the engine. All of the control units run with commercially available reference oil had stuck piston rings and showed scoring on the cylinder walls. Additionally, the control units had oil dripping from the exhaust horn, air filter, and from the body, which was messy and attracted dirt. The units operated using the lubricant of the invention had small quantities of varnish and gum

deposits but no scoring or stuck piston rings. Additionally, these units did not have the oil drippage exhibited by the control units and were substantially cleaner at the end of the test.

[0063] All of the units run with the lubricant of the invention or with the candidate two-cycle engine oils exhibited substantially better fuel economy than the commercially available reference oil used in the control units and were more biodegradable as determined by the ratio of the biological oxygen demand to the chemical oxygen demand (BOD/COD ratio).

[0064] The leaf blower test results are tabulated in Table II below:

TABLE II

Leaf Blower Data						
Blower Unit #	Test Fluid	Hours to Failure*	Fuel Usage MI/Hr	Treat Rate	Soot 1 = Clean 10 = Dirty	Oil on Unit 1 = Clean 10 = Dirty
1	Control	71	755	1:50	9	8
2	Candidate D	18	563	1:50	7	2
3	Candidate E	26	401	1:50	2	1
4	Candidate A	27	460	1:50	3	1
5	Candidate F	29	194	1:100	2	1
6	Example 1	97	515	1:50	5	3
7	Candidate B	76	387	1:50	3	3
8	Candidate C	23	345	1:50	2	1
9	Control	90	735	1:50	8	10
10	Candidate G	41	520	1:50	5	6
11	Candidate H	17	390	1:50	3	5
12	Control	78	715	1:50	9	10
13	Candidate I	49.5	550	1:50	5	6
14	Example 1	98.5	515	1:50	4	6

Note:

Control fluids use commercially available 2 cycle engine oil. All blower units came with a sample of this oil in the box.

*Failure was determined by either not being able to start the unit or that the unit had froze up.

[0065] This leaf blower study demonstrates that the two-cycle engine lubricant of the invention is better than the tested conventional lubricant in the areas of cleanliness, reduced smoke, soot left on equipment, fuel economy and durability.

EXAMPLE 26

[0066] To evaluate the detergency of formulations made in accordance with the invention, lubricants made in accordance with Examples 1, 2, 21 and 22 above were evaluated by the Southwest Research Institute in San Antonio, Tex., in relation to a standard JATRE-1 reference oil following the ISO—CEC L-79-T-97 3-Hour Detergency Test developed by the 2T Engine Oil Subcommittee of JASO. The procedure is designed to evaluate the performance of a two-stroke-cycle gasoline engine lubricant relative to engine cleanliness when tested in a single cylinder engine. Under the procedure, particular attention is given to the following characteristics: Piston ring sticking; piston land deposits; piston ring groove deposits; piston skirt deposits; piston undercrown deposits; piston crown deposits and cylinder head deposits.

[0067] The engine selected for this evaluation is a Honda SK-50 MM air-cooled, single cylinder, two-stroke-cycle gasoline engine with the following specifications:

Displacement	49.4 cm ³
Cylinder bore	39.0 cm
Stroke	41.4 mm
Compression ratio	7.0:1

[0068] Before using an engine for the first time, the transmission was disabled, the cooling fan blades were removed by machining, the oil injection pump was disabled, the engine left shroud was modified by removing the cooling air exhaust guide plate, and the muffler assembly was fitted with exhaust gas temperature and sample taps. Before beginning testing, the engine was assembled using a new cylinder, piston, piston ring set, small end rod bearing, small end rod pin, pin clips and gaskets. During assembly, all friction surfaces were lubricated with JATRE-1.

[0069] A 20 minute run-in using unleaded gasoline and JATRE-1 at 50:1 fuel-to-oil ratio was conducted at the following specifications:

	Stage 1	Stage 2
Duration, mins.	10	10
Engine Speed, rpm	4000 ± 20	6000 ± 20
Torque, Nm	1.76 ± 0.18	4.25 Minimum
Spark Plug Gasket, ° C.	160 ± 2	260 ± 3
Exhaust Gas CO, %	Record	6.4 ± 0.1

[0070] Upon completion of the run-in, the engine was disassembled and inspected for abnormalities. With the exception of the cylinder, the new parts used to build the engine for the run-in were not used for test purposes.

[0071] A baseline test using JATRE-1 reference oil was conducted before any candidates were tested. All candidates

for the date were compared against this baseline. The candidates were tested on the same cylinder and crankshaft assembly as the baseline, and all candidates were required to complete the test within 24 hours after the end of the baseline test. Before beginning testing, the engine was reassembled using a new cylinder, piston, piston ring set, small end rod bearing, small end rod pin, pin clips and gaskets. During assembly, all friction surfaces were lubricated with JATRE-1. The test was then conducted using unleaded gasoline mixed with the lubricant to be evaluated at 50:1 fuel-to-oil ratio for 190 minutes at the following conditions:

	Stage 1	Stage 2
Duration, mins.	10	180
Engine Speed, rpm	6000 ± 20	6000 ± 20
Torque, Nm	1.76 ± 0.18	WOT
Spark Plug Gasket, ° C.	Full cooling	260 ± 2
Exhaust Gas CO, %	Record	6.4 ± 0.1
Inlet Air Temp., ° C.	—	30 ± 5

[0072] Upon completion, the engine was disassembled for inspection. The piston, piston rings and cylinder head were rated using JPI-5S-34-91 rating manual and color chips. The initial ratings were then corrected by applying the appropriate weighted detergency corrections factor from the following table:

Rated Item	Factor
Top Piston Ring Sticking	2.3
Second Piston Ring Sticking	2.0
Top Land Deposits	1.0
Second Land Deposits	0.6
Top Ring Groove Deposits	1.3
Second Ring Groove Deposits	1.2
Piston Skirt Deposits	0.5
Piston Undercrown Deposits	0.5
Piston Crown Deposits	0.3
Cylinder Head Deposits	0.3

[0073] Additional visual inspections of the condition of the spark plug, the cylinder exhaust port, the piston pin and small end bearing were conducted as a supplement to the ratings.

[0074] The procedure described above was thereafter repeated for each of four candidate lubricants made according to the present invention. Those candidates were lubricants made according to EXAMPLES 1, 2, 21 and 22 as described previously.

[0075] Following the conclusion of the tests, the detergency index of each tested lubricant was calculated as follows:

$$DI = \frac{(\text{Sum } CCR)}{(\text{Sum } BCR)} \times 100$$

[0076] An index number of less than 100 indicates performance of the candidate lubricant was not as good as the baseline JATRE-1 lubricant.

[0077] The piston skirt deposit index of each tested lubricant was calculated as follows:

$$PI = \frac{[CCPSDR]}{[BCPSDR]} \times 100$$

[0078] The test results are reproduced below:

	JATRE-1	EX. 1	EX. 2	EX. 21	EX. 22
Top Ring	11.5	11.5	20.7	23.0	23.0
2d Ring	19.0	10.0	19.0	10.0	18.0
Top Land	4.5	3.6	5.0	4.5	4.6
2d Land	2.4	2.2	3.7	3.1	3.7
Top Ring Groove	1.3	1.7	2.5	0.9	1.0
2d Ring Groove	2.2	0.4	2.2	0.4	1.1
Piston Skirt	3.9	3.0	3.9	3.4	3.9
Undercrown	1.4	1.0	1.4	1.2	2.6
Piston Crown	2.6	2.7	2.9	2.6	2.6
Cylinder Head	2.5	2.4	2.5	2.6	2.7
Totals	51.3	38.5	63.8	51.7	63.2
Detergency Index	100	75	124	101	123
Piston Skirt Index	100	77	100	87	100

[0079] Based upon the data determined through the foregoing detergency tests, compositions made in accordance with Examples 2, 22 and 23 are believed to meet the proposed ISO standard for air and liquid-cooled two-stroke-cycle engines. This is the most severe standard at this time.

[0080] Other alterations and modifications of the invention will likewise become apparent to those of ordinary skill in the art upon reading the present disclosure, and it is intended that the scope of the invention disclosed herein be limited only by the broadest interpretation of the appended claims to which the inventors are legally entitled.

What is claimed:

1. A two-cycle engine lubricant comprising from about 10% to about 30% low ash detergent inhibitor; from about 10% to about 45% bio-based ester selected from castor oil, a synthetic polyol-based ester, and mixtures thereof; from about 14% to about 37% polyalphaolefin; from about 7% to about 18% synthetic ester; from 2% to about 10% surfactant; and from about 2% to about 5% pour point depressant, by weight of the lubricant.

2. The lubricant of claim 1, further comprising up to about 20 vol. % of a compatible solvent.

3. The lubricant of claim 2, comprising about 10 vol. % solvent.

4. The lubricant of claim 2 wherein the lubricant viscosity is not less than about 6.5 cSt at 100° C.

5. The lubricant of claim 2 wherein the solvent is Stoddard Solvent.

6. The lubricant of claim 1, comprising from about 10 wt. % to about 25 wt. % low ash detergent inhibitor.

7. The lubricant of claim 6, comprising about 20 wt. % low ash detergent inhibitor.

8. The lubricant of claim 1 wherein the detergent inhibitor is ashless.

9. The lubricant of claim 1, comprising from about 15 wt. % to about 40 wt. % of a bio-based ester selected from castor oil, synthetic polyol-based ester, and mixtures thereof.

10. The lubricant of claim 9, comprising from about 20 wt. % to about 40 wt. % castor oil.

11. The lubricant of claim 9, comprising from about 20 wt. % to about 40 wt. % synthetic polyol-based ester.

12. The lubricant of claim 9, comprising a mixture of about 20 wt. % castor oil and about 20 wt. % synthetic polyol-based ester.

13. The lubricant of claim 9, further comprising up to about 20 vol. % solvent.

14. The lubricant of claim 13 comprising about 10 vol. % solvent.

15. The lubricant of claim 13 wherein the solvent is Stoddard Solvent.

16. The lubricant of claim 1 wherein the polyalphaolefin is a synthetic oil comprising hydrogenated trimer and homopolymer of 1-decene.

17. The lubricant of claim 9 wherein the polyalphaolefin is a synthetic oil comprising hydrogenated trimer and homopolymer of 1-decene.

18. The lubricant of claim 1 comprising about 25 wt. % polyalphaolefin.

19. The lubricant of claim 1 wherein the polyalphaolefin has a viscosity ranging between about 2 and about 6 cSt at 100° C.

20. The lubricant of claim 19 wherein the polyalphaolefin has a viscosity ranging between about 2 cSt and about 4 cSt at 100° C.

21. A biodegradable lubricant having the composition of claim 20.

22. The lubricant of claim 1 wherein the synthetic ester comprises 2-ethylhexyl 2-ethylhexanoate.

23. The lubricant of claim 1 wherein the pour point depressant comprises diethylhexyl adipate.

24. The lubricant of claim 9 wherein the pour point depressant comprises diethylhexyl adipate.

25. The lubricant of claim 1 wherein the surfactant is a polyolefin derivative that comprises a highly branched succinic acid that can be neutralized with potassium hydroxide and amine.

26. The lubricant of claim 1 in combination with gasoline.

27. The combination of claim 26 wherein the lubricant and gasoline are premixed and packaged.

28. The combination of claim 27 wherein the gasoline and lubricant are packaged in a ratio of about 50 to 1 by volume.

29. The combination of claim 27 wherein the gasoline and lubricant are packaged in a ratio of about 100 to 1 by volume.

30. The combination of claim 27 wherein the lubricant is diluted with a solvent before premixing with gasoline.

31. The combination of claim 26 wherein the lubricant is biodegradable.

32. A method for making a two-cycle engine lubricant comprising the steps of:

preparing a first premixture by combining a first set of components comprising from about 10 wt. % to about 30 wt. % of a low ash detergent inhibitor and from about 14 wt. % to about 37 wt. % polyalphaolefin, by weight of the lubricant, and mixing the combined first set of components under high shear conditions for about 10 to about 15 minutes;

preparing a second premixture by combining a second set of components comprising from about 10 wt. % to about 45 wt. % bio-based ester selected from the group consisting of castor oil, a synthetic polyol-based ester and mixtures thereof, from about 7 wt. % to about 18 wt. % synthetic ester, from 2 wt. % to about 10 wt. % surfactant and from about 2 wt. % to about 5 wt. % pour

point depressant, by weight of the lubricant, and mixing the combined second set of components under high shear conditions for a period ranging from about 20 to about 40 minutes; and

thereafter adding the first premixture to the second premixture and mixing under high shear conditions for a period ranging from about 30 to about 35 minutes to form the lubricant composition.

33. The method of claim 32 wherein mixing takes place at a temperature ranging between about 120° and about 125° F.

34. The method of claim 32 wherein the first and second premixtures are further combined with up to about 20 vol. % solvent.

35. The method of claim 34 wherein the first and second premixtures are combined with about 10 vol. % solvent.

36. The method of claim 34 wherein the solvent is Stoddard Solvent.

37. The method of claim 34 wherein the viscosity of the resultant lubricant is not reduced below about 6.5 cSt at 100° C.

38. The method of claim 32 wherein the lubricant is then cooled to ambient temperature.

39. The method of claim 38 wherein the cooled lubricant is then packaged.

40. The method of claim 34 wherein the cooled lubricant is mixed with gasoline and then packaged.

41. The method of claim 40 wherein the gasoline and cooled lubricant are mixed in a ratio of about 50 to 1 by volume.

42. The method of claim 40 wherein the gasoline and cooled lubricant are mixed in a ratio of about 100 to 1 by volume.

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