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(54) **LUBRICATION OF AN AUTOMATIC TRANSMISSION WITH REDUCED WEAR ON A NEEDLE BEARING**

SCHMIERUNG EINES AUTOMATIKGETRIEBES MIT GERINGEM VERSCHLEISS AN EINEM NADELLAGER

LUBRIFICATION D'UNE TRANSMISSION AUTOMATIQUE À USURE RÉDUITE SUR UN ROULEMENT À AIGUILLES

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(73) Proprietor: **The Lubrizol Corporation**
Wickliffe, OH 44092-2298 (US)

(72) Inventors:
• **ABRAHAM, William D.**
Wickliffe, Ohio 44092-2298 (US)
• **ISHIZAKI, Keita**
Tokyo 104-0043 (JP)

(74) Representative: **D Young & Co LLP**
3 Noble Street
London EC2V 7BQ (GB)

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Description

BACKGROUND

[0001] The disclosed technology relates to lubricant formulations that provide good resistance to wear. They may be especially useful when used for lubrication of a needle bearing in an automatic transmission.

[0002] European Patent Application Publication 0761805A, Ward et al., 12 March 1997 discloses a lubricating/functional fluid composition which exhibits in use antiwear and antifoaming properties.

[0003] U.S. Patent Application Publication 2005/00146656, Sumiejski et al., January 20, 2005, discloses a lubricating composition useful for the lubrication of automotive transmissions. The lubricating composition comprises a hydrocarbyl phosphite, the condensation product of at least one fatty acid with a polyamine, a borate ester, a borated dispersant, and an oil of lubricating viscosity.

[0004] U.S. Patent Application Publication 2007/0142237, Degonia et al., June 21, 2007, discloses a lubricant composition, e.g., a gear oil. It contains a base oil which typically has a viscosity of 2 - 15 or 2 - 10 cSt. It also contains a boron-containing compound, which may be a nitrogen-containing compound, e.g., succinimide or a borate ester or amide, e.g., borated epoxides or borated fatty acid esters of glycerol. The amount of the boron compound may provide 5 to 500 or 11-100 ppm B. A sulfur-containing, phosphorus-containing compound is also present; dibutyl hydrogen phosphonate is disclosed.

[0005] U.S. Patent Application Publication 2014/0031268, Sumiejski et al., January 30, 2014, discloses a lubricant for a continuously variable transmission. The lubricant includes a functionalized dispersant treated with (among others) a borating agent; a di-C3-C6 alkyl phosphite, and a trialkyl borate. The lubricant composition may have a KV100 of up to about 12 mm²/s, e.g., 2-10 or 6-8. The dispersant may contain 0.4 to 1.2 percent by weight boron from the borating agent.

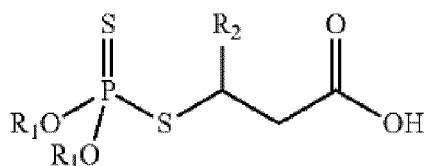
[0006] U.S. Patent Application Publication 2014/0107001, Saccomando et al., April 17, 2014, discloses a lubricant for an automatic transmission which contains certain aromatic condensation products. It is prepared in an oil having KV100 of 1 or 2 to 8 to 10 mm²/s, and the overall lubricant composition may have a KV100 of 1 or 1.5 to 10 or to 15 or to 20 mm²/s. Other components that may be present include a dispersant. Succinimide dispersants are disclosed as well as post-treated dispersant with, e.g., boron compounds. A supplemental friction modifier may be present, such as fatty phosphites, borated fatty epoxides, or borated fatty acids of glycerol. One formulation contains 0.15% of a borate ester friction modifier and 0.30% phosphite and phosphonate friction modifiers. Another formulation contains 0.2% phosphite friction modifier.

[0007] U.S. Patent Application Publication 2015/0376544, Kakao et al., December 31, 2015, discloses a lubricating composition for transmissions comprising a lubricant base oil comprising a mineral base oil having ca 100 °C kinematic viscosity of 1.5 mm²/s or higher and 3.5 mm²/s or lower and certain other defined parameters, in an amount of 50 to 97 percent by mass on the total base oil composition mass basis, and a monoester-based oil having a 100 °C kinematic viscosity of 2 to 10 mm²/s in an amount of 3 to 10 percent by mass; as well as a phosphorus acid ester and a boronated ashless dispersant.

[0008] U.S. Patent Application Publication 2016/0130524, Gao et al., May 12, 2016, discloses a low viscosity ester lubricant for use in high temperature applications, such as for a crankcase lubricant. The ester exhibits a KV100 of 1 to 4 centistokes. The lubricant optionally contains one or more dispersants, among those listed being alkylsuccinic derivatives. These products may be post-treated with various reagents including (among others) boron compounds such as borate esters. In one example, a low Zn dialkyl dithiophosphate is present.

[0009] U.S. Patent Application Publication 2016/0108337, Abraham et al., April 21, 2016, discloses a lubricant composition and method of lubricating a transmission. The lubricating composition may have a kinematic viscosity at 100 °C of 3.6 to 4.8 cSt or 4.0 to 4.2 cSt. It may comprise an oil of lubricating viscosity of 2.8 to 3.6 cSt. The lubricant contains 1.2 to 5.0% of a borated dispersant and two phosphorus-containing compounds in an amount to deliver 360 to 950 ppm of phosphorus. The reaction product (i.e., borated dispersant) may contain 0.2 to 0.6 weight percent boron. An optional component is a friction modifier; among the list of these are included borated glycerol esters and borated fatty epoxides.

[0010] U.S. Patent 9,090,850, Edwards et al., July 28, 2015, discloses a lubricant containing a dithiophosphate ester of the structure



It may optionally contain a phosphite antiwear agent. It may optionally contain one or more boron-containing compounds,

examples of which include borate esters and borated succinimide dispersants. The lubricant composition may have a viscosity at 100 °C between 2 and 30 cSt or between 4 and 8 cSt.

[0011] The claimed invention, therefore, solves the problem of providing good or improved bearing life or reduced bearing wear, for instance, in needle bearings, particularly when using very low viscosity lubricant fluids.

SUMMARY

[0012] In a first aspect, the claimed invention provides a lubricant composition comprising: (a) an oil having a kinematic viscosity at 100 °C of 2.2 to 3.7 mm²/s; (b) at least one borate ester having an alkyl group of 4 to 18 carbon atoms in an amount to provide 25 to 300, or 30 to 150, or 50 to 100, parts per million by weight boron to the composition; (c) at least one phosphorus ester in an amount to provide 150 to 650 parts per million by weight phosphorus to the composition; (d) a viscosity index modifier comprising a linear polymer viscosity modifier having dispersant functionality, wherein the linear polymer has a weight average molecular weight of 5,000 to 25,000, and wherein said linear polymer is present in an amount of 0.1 to 4 weight percent; and (e) a borated succinimide dispersant to provide 180 to 270 ppm boron to the lubricant composition; wherein the kinematic viscosity at 100 °C of the lubricant composition is less than or equal to 4.7 mm²/s.

[0013] In a second aspect, the claimed invention provides a lubricant composition comprising: (a) 50 to 98 percent by weight of an oil having a kinematic viscosity at 100 °C of 2.2 to 3.7 mm²/s; (b) at least one borate ester having an alkyl group of 4 to 18 carbon atoms, wherein the borate ester comprises: (b-1) 0.1 to 1.0 percent by weight of a borate ester containing a C4 to C12 alkyl group; (b-2) 0.15 to 0.40 percent by weight of a borate ester containing a C14 to a C18 alkyl group; (c) at least one phosphorus ester in an amount to provide 150 to 650 parts per million by weight phosphorus to the composition; (e) a borated succinimide dispersant in an amount to provide 180 to 270 ppm boron to the lubricant composition, wherein the borated succinimide dispersant comprises: (e-1) 1.0 to 4.0 percent by weight of a borated succinimide dispersant not treated with a dimercaptothiadiazole; and (e-2) 0.1 to 1.5 percent by weight of a borated succinimide dispersant that is treated with a dimercaptothiadiazole; wherein the amount of boron provided by components (b-1), (b-2), (e-1) and (e-2) is at least 180 parts per million by weight of the composition; and wherein the kinematic viscosity at 100 °C of the lubricant composition is less than or equal to 4.7 mm²/s.

[0014] In a third aspect, the claimed invention provides a method of lubricating an automatic transmission comprising supplying thereto the lubricant composition defined herein, wherein the automatic transmission optionally contains a bearing that is lubricated by said lubricant composition..

DETAILED DESCRIPTION

[0015] Various preferred features and embodiments will be described below by way of non-limiting illustration.

[0016] One component of the disclosed technology is an **oil of lubricating viscosity**, also referred to as a base oil. The base oil may be selected from any of the base oils in Groups I-V of the American Petroleum Institute (API) Base Oil Interchangeability Guidelines (2011), namely

Base Oil Category	Sulfur (%)	Saturates(%)	Viscosity Index
Group I	>0.03 and/or	<90	80 to less than 120
Group II	≤0.03 and	≥90	80 to less than 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		

[0017] Groups I, II and III are mineral oil base stocks. Other generally recognized categories of base oils may be used, even if not officially identified by the API: Group II+, referring to materials of Group II having a viscosity index of 110-119 and lower volatility than other Group II oils; and Group III+, referring to materials of Group III having a viscosity index greater than or equal to 130. The oil of lubricating viscosity can include natural or synthetic oils and mixtures thereof. Mixture of mineral oil and synthetic oils, e.g., polyalphaolefin oils and/or polyester oils, may be used. In one embodiment the oil of lubricating viscosity comprises an API group II or Group III oil or mixtures thereof.

[0018] The oil of lubricating viscosity (or mixture of such oils) will be a relatively low viscosity oil, having a kinematic viscosity at 100 °C of 2.2 to 3.7 mm²/s, or 2.5 to 3.5 mm²/s, or 2.8 to 3.3 mm²/s. The use of oil of this viscosity range permits preparation of a lubricant composition having a kinematic viscosity at 100 °C of less than or equal to 4.7 mm²/s, such as 3.0 to 4.6 or 3.3 to 4.3 or 3.6 to 4.1 mm²/s

The amount of the oil of lubricating viscosity may be 70 to 94, or 80 to 93, or 85 to 92 percent by weight. The amount

may be calculated so as to include the amount of diluent oil conventionally supplied with such additive components as detergents, dispersants, and viscosity modifiers.

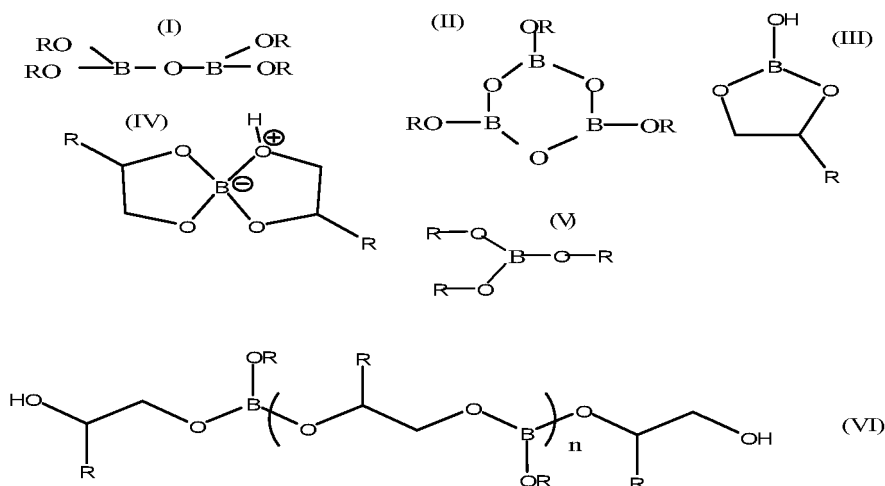
[0019] Another component of the disclosed lubricant composition is at least one **borate ester** having an alkyl group of 4 to 18 carbon atoms. In certain embodiments there are two alkyl groups, one having 4 to 12 or 4 to 10 or 6 to 10 carbon atoms and another having 14 to 18 carbon atoms. Borate ester may be seen generically an ester from boric acid or an equivalent thereof with an alcohol, although they need not be formed by an esterification (condensation) reaction. In one embodiment, the borate ester may be what is referred to as a borated epoxide.

[0020] In one embodiment the boron-containing compound may be described as a borate ester or a borate alcohol. The borate ester or borate alcohol compounds are substantially the same except the borate alcohol has at least one hydroxyl group that is not esterified, and the latter may also be a borated epoxide. Therefore, as used herein the term "borate ester" is used to refer to either borate ester or borate alcohol.

[0021] The borate ester may be prepared by the reaction of a boron compound and at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds, alcohols and mixtures thereof. The alcohols include dihydric alcohols, trihydric alcohols or higher alcohols, with the proviso for one embodiment that hydroxyl groups are on adjacent carbon atoms, i.e., vicinal. Hereinafter "epoxy compounds" is used when referring to epoxy compounds, halohydrin compounds, epihalohydrin compounds, or mixtures thereof.

[0022] Boron compounds suitable for preparing the borate ester include the various forms such as boric acid (including metaboric acid, HBO_2 , orthoboric acid, H_3BO_3 , and tetraboric acid, $\text{H}_2\text{B}_4\text{O}_7$), boric oxide, boron trioxide and alkyl borates. The borate ester may also be prepared from boron halides.

[0023] In one embodiment the borate ester is formed by the reaction of a boron compound with an epoxy compound, dihydric alcohols, trihydric alcohols or higher alcohols. The borate ester may be represented by at least one of formulae (I) to (VI):



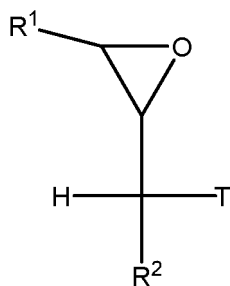
wherein each R may be hydrogen or a hydrocarbyl groups, provided that the borate ester is oil soluble.

[0024] In one embodiment at least two of the R groups per the above formulas are hydrocarbyl groups. The hydrocarbyl groups may be alkyl, aryl or cycloalkyl, wherein when any two adjacent R groups are connected in a ring. When R is alkyl, the group may be saturated or unsaturated. In one embodiment the hydrocarbyl group is an unsaturated alkyl. In one embodiment the hydrocarbyl group is cyclic. In one embodiment the hydrocarbyl groups are mixtures of alkyl and cycloalkyl.

[0025] The number of carbon atoms present in each R may be 4 to 18 or 6 to 12. In certain embodiments the total number of carbon atoms on the R groups typically may be 9 or more, or 10 or more, or 12 or more, or 14 or more.

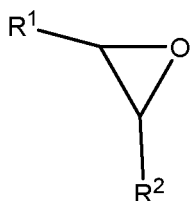
[0026] Examples of R groups include isopropyl, n-butyl, isobutyl, amyl, 2-pentenyl, 4-methyl-2-pentyl, 2-ethylhexyl, heptyl, isoctyl, nonyl, decyl, undecyl, dodecenyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, and octadecyl groups.

[0027] The epoxy compounds useful for preparing borate esters (that is, for preparing the materials also referred to as borated epoxides) may be represented by the formulas (VIIa) or (VIIb):



(VIIa)

or



(VIIb)

wherein

R¹ is independently H or an alkyl chain containing 1 to 4, or 1 to 2 carbon atoms;

R² is an alkyl chain containing 4 to 18, or 6 to 16, or 8 to 14 carbon atoms; and

T is independently hydrogen or a halogen such as chlorine, bromine, iodine or fluorine or mixtures thereof. In one embodiment T is chlorine; in another T is hydrogen.

[0028] In one embodiment the epoxy compounds of the invention include commercial mixtures of C₁₄-C₁₆ epoxides or C₁₄-C₁₈ epoxides. In one embodiment, the epoxy compounds of the invention have been purified. Examples of suitable purified epoxy compounds may include 1,2-epoxydecane, 1,2-epoxyundecane, 1,2-epoxydodecane, 1,2-epoxytridecane, 1,2-epoxybutadecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane, 1,2-epoxyheptadecane, and 1,2-epoxyoctadecane. In one embodiment purified epoxy compounds include 1,2-epoxyhexadecane. In one embodiment a borated ester comprises a borated epoxide having 12 to 18 or 14 to 18 carbon atoms.

[0029] The alcohols employed for esterification of an alcohol with a borating agent may include monohydric alcohols, dihydric alcohols, trihydric alcohols or higher alcohols. The alcohol may contain 4 to 18 carbon atoms or 6 to 16 or 6 to 12 carbon atoms.

[0030] The borate ester may be prepared by blending the boron compound and the epoxy compounds or alcohols described above and heating them at a suitable temperature, such as at 80 °C to 250 °C, 90 °C to 240 °C, or 100 °C to 230 °C, until the desired reaction has occurred. The molar ratio of the boron compounds to the epoxy compounds may be 4:1 to 1:4, or 1:1 to 1:3, or 1:2. An inert liquid may be used in performing the reaction, such as toluene, xylene, chlorobenzene, dimethylformamide, or mixtures thereof. Water is typically formed and is distilled off during a condensation reaction. Alkaline reagents may be used to catalyze the reaction.

[0031] In one embodiment suitable borate ester compounds include tripropyl borate, tributyl borate, tripentyl borate, trihexyl borate, triheptyl borate, trioctyl borate, trinonyl borate, and tridecyl borate. In one embodiment the borate ester compounds include tributyl borate, tri-2-ethylhexyl borate or mixtures thereof.

[0032] In certain embodiments the lubricant composition may comprise borate ester containing an alkyl group of 4 to 12 carbon atoms and a borate ester containing an alkyl group of 12 to 18 or 14 to 18 carbon atoms. In other embodiments that borate ester component may comprise the reaction product of boric acid with an alcohol of 6 to 12 carbon atoms. In yet other embodiments the borate ester component may comprise a borated epoxide having 12 to 18 carbon atoms.

[0033] The amount of the borate ester in the lubricant may be 0.1 to 1.1 percent by weight or 0.05 to 1.1 or 0.15 to 0.7 or 0.10 or 0.90 percent by weight, or 0.2 to 1.0 percent or 0.25 to 0.75 percent. If there are two borate esters present, one with a C₄ to C₁₂ alkyl group and one with a C₁₄ to C₁₈ alkyl group, the amount of the C₄-C₁₂ ester may be 0.05 to 1.0 percent by weight or 0.1 to 1, or 0.15 to 0.7 or 0.2 to 0.6 percent; and the C₁₄ to C₁₈ ester may be 0.05 to 1 percent by weight, or 0.075 to 0.7, or 0.15 to 0.4 percent by weight. The borate ester or esters will contribute to the amount of boron in the lubricant, a portion of which may come from other sources such as a borated dispersant (discussed below). The amount contributed by the borate ester may be 25 to 300, or 30 to 150, or 50 to 100, or 70 to 100 parts per million by weight. The balance of the boron may be provided by other sources such as borated dispersants, described

below.

[0034] The lubricant of the disclosed technology will also contain at least one **phosphorus ester** in an amount to provide 150 to 650, or 150 to 350, or 180 to 250 parts per million by weight phosphorus to the composition. The amount of the at least one phosphorus ester will be 0.05 to 0.4 percent by weight, or 0.1 to 0.35 percent.

[0035] The phosphorus ester may comprise a C4 to C8 or C4 to C6 alkyl phosphite, such as dioctyl phosphite, or, alternatively, an oligomeric phosphite which is the reaction product of a monomeric phosphorous acid or ester with an alkylene diol.

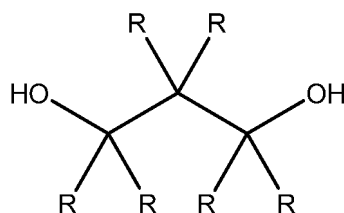
[0036] The C4 to C6 alkyl phosphite may include dialkyl phosphites such as dibutyl phosphites, dihexyl phosphite, and dicyclohexyl phosphite. Such materials are readily commercially available.

[0037] The oligomeric phosphites are described in greater detail in PCT publication WO 2016/089565, Abraham et al. (Lubrizol), June 9, 2016. In brief they may be described as a reaction product of (a) a monomeric phosphorous acid or an ester thereof with (b) at least two alkylene diols. The first alkylene diol (i) will have two hydroxy groups in a 1,4 or 1,5 or 1,6 relationship on the carbon chain, and the second alkylene diol (ii) will be an alkyl-substituted 1,3-propylene diol with one or more of the alkyl substituents on one or more of the carbon atoms of the propylene unit. The total number of carbon atoms in the alkyl-substituted 1,3-propylene diol will be 5 to 12. In the oligomeric phosphite, the relative molar amounts of monomeric phosphorous acid or ester thereof (a) and the total of the alkylene diols (b) will typically be in a ratio of 0.9:1.1 to 1.1:0.9. Moreover, the relative molar amounts of the first alkylene diol (i) and the alkyl-substituted 1,3-propylene diol (ii) will typically be in a ratio of 30:70 to 65:35, or alternatively 35:54 to 60:40 or 50:60 to 50:50, or 40:60 to 45:55.

[0038] The first alkylene diol may be branched (e.g., alkyl-substituted) or unbranched and in one embodiment is unbranched. Unbranched, that is, linear diols (α,ω -diols) include 1,4-butanediol, 1,5-pentane diol, and 1,6-hexanediol. Branched or substituted diols include 1,4-pentanediol, 2-methyl-1,5-pentanediol, 3-methyl-1,5-pentanediol, 3,3-dimethyl-1,5-pentanediol, 1,5-hexanediol, 2,5-hexanediol, and 2,5-dimethyl-2,5-hexanediol. For purposes of the disclosed technology, a diol having one or more secondary hydroxy groups (such as 2,5-hexanediol) may be referred to as a branched or substituted diol, even though the carbon chain itself may be linear. The location of the hydroxy groups in the 1,4-, 1,5-, or 1,6- positions (that is, either positions relative to each other or literal positions) may be helpful to promote oligomerization with the phosphorous species rather than formation of cyclic structures (which would be sterically disfavored). In certain embodiments the first alkylene diol may be 1,6-hexanediol.

[0039] The first alkylene dihydroxy compound (diol) may, if desired, have additional hydroxy groups, that is, more than two per molecule, or there may be exactly two. In one embodiment, there are exactly two hydroxy groups per molecule. If there are more than two hydroxy groups, care should be taken to assure that there is no excessive cyclization such as might interfere with the polymerization reaction, if there are fewer than 4 atoms separating any of the hydroxy groups. Also, care should be taken to avoid excessive branching or crosslinking in the product, which could lead to undesirable gel formation. Such problems may be avoided by careful control of reaction conditions such as control of the ratio of reagents and the order of their addition, performing the reaction under suitably dilute conditions, and reacting under low acid conditions. These conditions can be determined by the person skilled in the art with only routine experimentation.

[0040] The second alkylene diol is an alkyl-substituted 1,3-propylene diol with one or more of the alkyl substituents thereof being on one or more of the carbon atoms of the propylene unit, the total number of carbon atoms in the alkyl-substituted 1,3-propylene diol being 5 to 12 or 6 to 12 or 7 to 11 or 8 to 18 or, in certain embodiments, 9. That is, the alkyl-substituted 1,3-propylene diol may be represented by the general formula



where the various R groups may be the same or different and may be hydrogen or an alkyl group, provided that at least one R is an alkyl group and that the total number of carbon atoms in the R groups is 2 to 9 or 3 to 9, so that the total carbon atoms in the diol will be 5 to 12 or 6 to 12, respectively, and likewise for the other ranges of total carbons. By analogy with the above-described, 1,4-, 1,5-, or 1,6-diols, reference here to 1,3-diols means that the two hydroxy groups are in a 1,3 relationship to each other, that is, separated by a chain of 3 carbon atoms. A 1,3-diol may thus also be named as a 2,4- or 3,5-diol. If the 1,3-diol has one or more secondary hydroxy groups, such a molecule will be considered to be a substituted diol. In one embodiment the number of alkyl substituents is 2 and the total number of carbon atoms in the molecule is 9. Suitable substituents may include, for instance, methyl, ethyl, propyl, and butyl (in their various possible isomers).

5 [0041] Examples of the second alkylene diol may include 2,2-dimethyl-1,3-propanediol, 2-ethyl-2-butylpropane-1,3-diol, 2-ethylhexane-1,3-diol, 2,2-dibutylpropane-1,3-diol, 2,2-diisobutylpropane-1,3-diol, 2-methyl-2-propylpropane-1,3-diol, 2-propyl-propane-1,3-diol, 2-butylpropane-1,3-diol, 2-pentylpropane-1,3-diol, 2-methyl-2-propylpropane-1,3-diol, 2,2-diethylpropane-1,3-diol, 2,2,4-trimethylpentane-1,3-diol, 2-methylpentane-2,4-diol, 2,4,-dimethyl-2,4-pentanediol, and 2,4-hexanediol. It should be noted that some of the foregoing nomenclature emphasizes the propane-1,3-diol structure of the molecules, for clarity. For instance, 2-pentylpropane-1,3-diol might also be named 2-hydroxymethylheptan-1-ol, but the latter nomenclature does not so clearly illustrate the 1,3-nature of the diol.

10 [0042] While the one or more phosphorus esters will provide the amount of phosphorus to the lubricant composition as indicated above, the total amount of phosphorus in the lubricant may be in a higher range, such as 150 to 1000, or 200 to 800, parts per million by weight. The additional phosphorus may be provided by a different phosphorus-containing species, such as an inorganic phosphorus acid, such as phosphoric acid or phosphorous acid. Phosphoric acid may be commercially provided as an 85 percent by weight composition with 15 percent water, and appropriate amounts thereof may be employed. Other phosphorus sources may include phosphorus-treated (phosphorus-containing) dispersants such as post-treated succinimide dispersants, described below.

15 [0043] The lubricant composition of the claimed invention further comprises a **viscosity modifier** as defined in claim 1, also referred to as a viscosity index modifier or a viscosity index improver. Viscosity modifiers (VMs) and dispersant viscosity modifiers (DVMs) are well known. Examples of VMs and DVMs may include polymethacrylates, polyacrylates, polyolefins, hydrogenated vinyl aromatic-diene copolymers (e.g., styrene-butadiene, styrene-isoprene), styrene-maleic ester copolymers, and similar polymeric substances including homopolymers, copolymers, and graft copolymers, including polymers having linear, branched, or star-like structures. The DVM may comprise a nitrogen-containing methacrylate polymer or nitrogen-containing olefin polymer, such as a poly(meth)acrylate containing a nitrogen-containing dispersant monomer; for example, a nitrogen-containing methacrylate polymer derived from methyl methacrylate and dimethylaminopropyl amine. The DVM may alternatively comprise a copolymer with units derived from an α -olefin and units derived from a carboxylic acid or anhydride, such as maleic anhydride, in part esterified with a branched primary alcohol and in part reacted with an amine-containing compound.

20 [0044] Examples of commercially available VMs, DVMs and their chemical types may include the following: polyisobutylenes (such as Indopol™ from BP Amoco or Parapol™ from ExxonMobil); olefin copolymers (such as Lubrizol® 7060, 7065, and 7067, and Lucant® HC-2000L, HC-1100, and HC-600 from Lubrizol); hydrogenated styrene-diene copolymers (such as Shellvis™ 40 and 50, from Shell and LZ® 7308, and 7318 from Lubrizol); styrene/maleate copolymers, which are dispersant copolymers (such as LZ® 3702 and 3715 from Lubrizol); polymethacrylates, some of which have dispersant properties (such as those in the Viscoplex™ series from RohMax, the Hitec™ series of viscosity index improvers from Afton, and LZ® 7702, LZ® 7727, LZ® 7725 and LZ® 7720C from Lubrizol); olefin-graft-polymethacrylate polymers (such as Viscoplex™ 2-500 and 2-600 from RohMax); and hydrogenated polyisoprene star polymers (such as Shellvis™ 200 and 260, from Shell).

25 [0045] The VM or DVM may have a weight average molecular weight of 5,000 to 25,000, or 10,000 to 20,000, or 12,000 to 18,000. The number average molecular weight will be proportionally lower, such as 3,000 to 15,000, or 6,000 to 12,000. The materials in question typically have a relatively low molecular weight compared to VMs and DVMs that may be commonly used in other applications such as lubricants for internal combustion engines.

30 [0046] In accordance with the claimed invention, the viscosity index modifier comprises a linear polymer viscosity modifier having dispersant functionality, wherein the linear polymer has a weight average molecular weight of 5,000 to 25,000 or 10,000 to 20,000, and wherein said linear polymer is present in an amount of 0.1 to 4 weight percent. In one embodiment the viscosity index modifier may comprise a linear polymer as described herein and a polymer with star architecture, e.g., (meth)acrylic type star polymers, as disclosed in WO 2007/127660, Lubrizol, November 8, 2007.

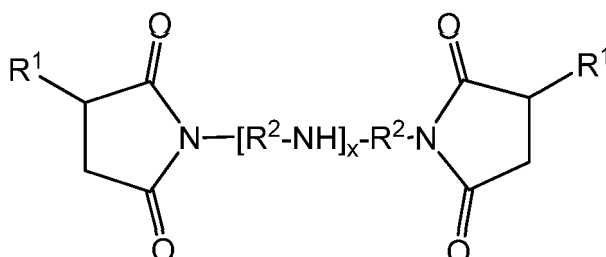
35 [0047] Viscosity modifiers that may be used are described in U.S. patents 5,157,088, 5,256,752 and 5,395,539. The VMs and/or DVMs may be used in the functional fluid at a concentration of up to 50% or to 20% by weight, depending on the application. Concentrations of 0.1 to 20%, or 0.5 to 20%, or 1 to 20%, or 1 to 12%, or 3 to 10%, or 0.1 to 4%, or 1 to 4%, or alternatively 20 to 40%, or 20 to 30% by weight in the lubricant composition may be used. The selection of the amount of viscosity modifier is within the abilities of the person of ordinary skill, and will be in an amount which, in combination with the viscosity of the base oil, will provide a lubricant composition with a kinematic viscosity at 100 °C of less than or equal to 4.7 mm²/s, such as 2.7 to 4.7, or 2.8 to 4.7, or 3.4 to 4.0, or 3.5 to 3.9 mm²/s.

40 [0048] The lubricant composition of the claimed invention also includes one or more **dispersants**, including a borated succinimide dispersant, which provides additional boron content to the lubricant composition. Succinimide dispersants are sometimes referred to ashless dispersants are so-called because, as supplied, they do not contain metal and thus do not normally contribute to sulfated ash when added to a lubricant (although the boron component which borated detergents contain may contribute to sulfated ash). However, ashless dispersants may, of course, interact with ambient metals once they are added to a lubricant which includes metal-containing species. Ashless 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, having a variety of chemical structures including typically the simplified

structure

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Here each R¹ is independently an alkyl group, frequently a polyisobutylene group with a molecular weight (M_n) of 500-5000 based on the polyisobutylene precursor, and R² are alkylene groups, commonly ethylene (C₂H₄) groups. Such molecules are commonly derived from reaction of an alkenyl acylating agent with a polyamine. A wide variety of linkages between the two moieties is possible beside the simple imide structure shown above, including a variety of amides and quaternary ammonium salts. Likewise, a variety of structures of the polyamine component are known to be possible, including various cyclic structures. Moreover, in the above structure, the amine portion is shown as an alkylene polyamine, although other aliphatic and aromatic mono- and polyamines may also be used. Also, a variety of modes of linkage of the R¹ groups onto the imide structure are possible, including various cyclic linkages. The ratio of the carbonyl groups of the acylating agent to the nitrogen atoms of the amine may be 1:0.5 to 1:3, and in other instances 1: 1 to 1:2.75 or 1: 1.5 to 1:2.5. Succinimide dispersants are more fully described in U.S. Patents 4,234,435 and 3,172,892 and in EP 0355895.

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[0049] Dispersants can also be post-treated by reaction with any of a variety of agents. Among these are urea, thiourea, dimercaptothiadiazoles, carbon disulfide, aldehydes, ketones, carboxylic acids, hydrocarbon-substituted succinic anhydrides, nitriles, epoxides, boron compounds, and phosphorus compounds. References detailing such treatment are listed in U.S. Patent 4,654,403.

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[0050] The borated succinimide dispersants as used in the claimed invention contain boron and supply boron to the lubricant formulation. Borated dispersants may be prepared by borating using a variety of agents such as any of the various forms of boric acid (including metaboric acid, HBO₂, orthoboric acid, H₃BO₃, and tetraboric acid, H₂B₄O₇), boric oxide, boron trioxide, and alkyl borates. In one embodiment the borating agent is boric acid which may be used alone or in combination with other borating agents.

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[0051] The borated dispersant may be prepared by blending the boron compound and a succinimide dispersant and heating them at a suitable temperature, typically 80 °C to 250 °C, 90 °C to 230 °C, or 100 °C to 210 °C, until the desired reaction has occurred. An inert liquid may be used in performing the reaction. The liquid may include toluene, xylene, chlorobenzene, dimethylformamide, or mixtures thereof. The boron-containing succinimide dispersant may have a boron content of 0.5 to 1.0 weight percent, or 0.6 to 0.9, or 0.54 to 0.85, or 0.56 to 0.83 weight percent.

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[0052] The borated succinimide dispersant may also be a product containing additional functionality by post treating, for instance, prepared by heating together:

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- (i) a succinimide dispersant;
- (ii) a borating agent; and
- (iii) optionally 2,5-dimercapto-1,3,4-thiadiazole or a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole ("DMTD"), or oligomers thereof;
- (iv) optionally a dicarboxylic acid of an aromatic compound selected from the group consisting of 1,3 diacids and 1,4 diacids; and
- (v) optionally a phosphorus acid compound,

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said heating being sufficient to provide a product of (i), (ii), and optionally (iii), (iv) and/or (v), the product being which is soluble in an oil of lubricating viscosity. In one embodiment the borated succinimide dispersant is further treated with a dimercaptothiadiazole.

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[0053] The dispersant component may also comprise a mixture of separate dispersant species, including an untreated (non-borated) succinimide dispersant, a borated succinimide dispersant, a DMTD-treated dispersant, and a terephthalic acid-treated dispersant. Alternatively, some or all of the post treatments may be applied to some or all of the succinimide dispersant species. In one embodiment, for example, some or all of the succinimide dispersant may be borated and treated with a dimercaptothiadiazole and optionally further with terephthalic acid. In one embodiment there may be a mixture of a borated succinimide dispersant and a borated and DMTD-treated dispersant. In certain embodiments the dispersant component may comprise 1 to 4 percent by weight of a borated succinimide dispersant that is not treated

with a dimercaptothiadiazole and 0.1 to 1.5 percent weight of a borated succinimide dispersant that is treated with a dimercaptothiadiazole.

5 [0054] The components to prepare the post-treated succinimide dispersant may be combined and reacted in any order. In particular, the borating agent may be a pretreatment process or a post-treatment process. Thus, for instance, boric acid (and optionally also phosphoric acid) may be reacted with a dispersant substrate in one step, and thereafter the intermediate borated dispersant may be reacted with the mercaptothiadiazole and the dicarboxylic acid of an aromatic compound. Alternatively, the dispersant substrate, dicarboxylic acid of an aromatic compound and mercaptothiadiazole may be first reacted, and then the product treated with a borating agent (and optionally with phosphoric acid, a phosphorus acid). In yet another variation, a phosphorylated succinimide dispersant may be prepared by reacting a phosphorus acid with a hydrocarbyl-substituted succinic anhydride to prepare a mixed anhydride-acid precursor, and then reacting the precursor with a polyamine to form a phosphorus-containing dispersant. The phosphorus-containing dispersant may thereafter be reacted with the dicarboxylic acid of an aromatic compound and mercaptothiadiazole; and with the borating agent.

10 [0055] The components are typically reacted by heating the borating agent and optionally the other agents with the dispersant substrate at a sufficient time and temperature to assure solubility of resulting product, typically 80-200°C, or 90-180°C, or 120-170°C, or 150-170°C. The time of reaction is typically at least 0.5 hours, for instance, 1-24 hours, 2-12 hours, 4-10 hours, or 6-8 hours.

15 [0056] The amount of the succinimide dispersant component (or alternatively of specifically the boron-containing succinimide dispersant) in a fully formulated lubricant of the present technology, if it is present, may be at least 0.1% of the lubricant composition, or at least 0.3% or 0.5% or 1% or 1.5%, and in certain embodiments at most 9% or 8% or 6% or 4% or 3% or 2% by weight, such as 1.1 to 5.5 or 1.0 to 3.5 percent by weight. The amount of boron provided to the lubricant formulation by the borated succinimide dispersant component in accordance with the invention is 180 to 270 parts per million by weight, . In certain embodiments the succinimide dispersant component may provide 10 to 250 parts per million by weight, or 20 to 200, or 50 to 150 ppm, sulfur to the composition by means of the presence of a dimer-
20 captothiadiazole moiety present therewith.

25 [0057] The lubricant compositions of the disclosed technology may also include one or more **foam inhibitors**. Anti-foam agents used to reduce or prevent the formation of stable foam include silicones, fluorosilicones, or organic polymers such as acrylate polymers, fluoroacrylate polymers, or fluoromethacrylate polymers. Examples of these and additional anti-foam compositions are described in "Foam Control Agents," by Henry T. Kerner (Noyes Data Corporation, 1976), pages 125-162. They may typically be present in amounts of 20 to 250 or 50 to 200 parts per million (excluding diluent). Various combinations of antifoam agents may be used: for example, a first anti-foam agent, being derived from a first anti-foam composition comprising a polydimethyl siloxane dispersed or dissolved in an aromatic oil or a naphthenic hydrocarbon solvent, the first anti-foam composition having a kinetic viscosity at 25 °C (absent solvent) in the range from 10,000 to 50,000 mm²/s; a second anti-foam agent being comprising a polydimethyl siloxane dispersed or dissolved in an aromatic oil or a naphthenic hydrocarbon solvent and having a kinetic viscosity at 25 °C (absent solvent) in the range from 80,000 to 120,000 mm²/s; and a third anti-foam agent comprising a fluorinated polysiloxane dispersed or dissolved in an aliphatic solvent or a solvent comprising a ketone (e.g., aliphatic ketone) having 5 to 16 carbon atoms and having a kinematic viscosity at 25 °C (absent solvent) in the range from 50 to 500 mm²/s. Such a mixture of antifoam agents is disclosed in U.S. Patent 9.3309,480, Loop et al., April 12, 2016.

30 [0058] Other conventional additives may also optionally be present in amounts conventionally used for automatic transmission lubricants. They include friction modifiers, antioxidants, detergents, corrosion inhibitors, extreme pressure/antiwear agents, and seal swell agents.

35 [0059] **Friction modifiers**, in the context of automatic transmission lubricants, are materials designed to provide a high, stable coefficient of friction to lubricated clutch plates, typically comprising mating plates of metal (iron) and a non-metal composition such as a cellulosic surface. Friction modifiers are well known to those skilled in the art. A list of friction modifiers that may be used is included in U.S. Patents 4,792,410, 5,395,539, 5,484,543 and 6,660,695. U.S. Patent 5,110,488 discloses metal salts of fatty acids and especially zinc salts, useful as friction modifiers. A list of friction modifiers that may be used may include borated alkoxylated fatty amines; fatty acid amides; metal salts of fatty acids; fatty epoxides; sulfurized olefins; fatty imidazolines; fatty amines; condensation products of carboxylic acids and poly-alkylene-polyamines; glycerol esters; metal salts of alkyl salicylates; borated glycerol esters; amine salts of alkylphosphoric acids; alkoxylated fatty amines; ethoxylated alcohols; oxazolines; imidazolines; hydroxyalkyl amides; polyhydroxy tertiary amines; and mixtures of two or more thereof.

40 [0060] Non-borated fatty epoxides may also be useful as supplemental friction modifiers.

45 [0061] Borated amines that may be used are disclosed in U.S. Patent 4,622,158. Borated amine friction modifiers (including borated alkoxylated fatty amines) may be prepared by the reaction of a boron compounds, as described above, with the corresponding amines, including simple fatty amines and hydroxy containing tertiary amines. The amines useful for preparing the borated amines may include commercial alkoxylated fatty amines known by the trademark "ETHOMEEN" and available from Akzo Nobel, such as bis[2-hydroxyethyl]-cocoamine, polyoxyethylene[10]cocoamine, bis[2-hydrox-

yethyl]soyamine, bis[2-hydroxyethyl]-tallowamine, polyoxyethylene-[5]tallowamine, bis[2-hydroxyethyl]oleylamine, bis[2-hydroxyethyl]octadecylamine, and polyoxyethylene[15]octadecylamine. Such amines are described in U.S. Patent 4,741,848.

5 **[0062]** Alkoxylated fatty amines and fatty amines themselves (such as oleylamine) may be useful as friction modifiers. These amines are commercially available.

[0063] Both borated and unborated fatty acid esters of glycerol may be used as friction modifiers. Borated fatty acid esters of glycerol may be prepared by borating a fatty acid ester of glycerol with a boron source such as boric acid. Fatty acid esters of glycerol themselves may be prepared by a variety of methods well known in the art. Many of these esters, such as glycerol monooleate and glycerol tallowate, are manufactured on a commercial scale. Commercial glycerol

10 **[0064]** Fatty acids may be used in preparing the above glycerol esters; they may also be used in preparing their metal salts, amides, and imidazolines, any of which may also be used as friction modifiers. The fatty acids may contain 6 to 24 carbon atoms, or 8 to 18 carbon atoms. A useful acid may be oleic acid.

15 **[0065]** The amides of fatty acids may be those prepared by condensation with ammonia or with primary or secondary amines such as diethylamine and diethanolamine. Fatty imidazolines may include the cyclic condensation product of an acid with a diamine or polyamine such as a polyethylenepolyamine. In one embodiment, the friction modifier may be the condensation product of a C8 to C24 fatty acid with a polyalkylene polyamine, for example, the product of isostearic acid with tetraethylenepentamine. The condensation products of carboxylic acids and polyalkyleneamines may be imidazolines or amides.

20 **[0066]** The fatty acid may also be present as its metal salt, e.g., a zinc salt. These zinc salts may be acidic, neutral, or basic (overbased). These salts may be prepared from the reaction of a zinc containing reagent with a carboxylic acid or salt thereof. A useful method of preparation of these salts is to react zinc oxide with a carboxylic acid. Useful carboxylic acids are those described hereinabove. Suitable carboxylic acids include those of the formula RCOOH where R is an aliphatic or alicyclic hydrocarbon radical. Among these are those wherein R is a fatty group, e.g., stearyl, oleyl, linoleyl, or palmyl. Also suitable are the zinc salts wherein zinc is present in a stoichiometric excess over the amount needed to prepare a neutral salt. Salts wherein the zinc is present from 1.1 to 1.8 times the stoichiometric amount, e.g., 1.3 to 1.6 times the stoichiometric amount of zinc, may be used. These zinc carboxylates are known in the art and are described in U.S. Patent 3,367,869. Metal salts may also include calcium salts. Examples may include overbased calcium salts.

25 **[0067]** Sulfurized olefins are also well known commercial materials used as friction modifiers. A suitable sulfurized olefin is one which is prepared in accordance with the detailed teachings of U.S. Patents 4,957,651 and 4,959,168. Described therein is a cosulfurized mixture of 2 or more reactants selected from the group consisting of at least one fatty acid ester of a polyhydric alcohol, at least one fatty acid, at least one olefin, and at least one fatty acid ester of a monohydric alcohol. The olefin component may be an aliphatic olefin, which usually will contain 4 to 40 carbon atoms. Mixtures of these olefins are commercially available. The sulfurizing agents useful in the process of the present invention

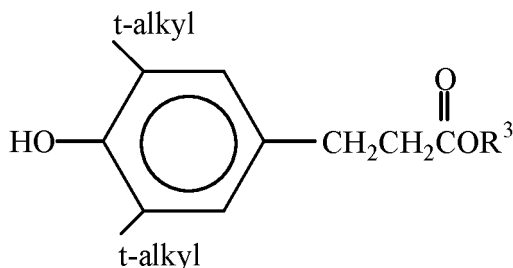
30 **[0068]** Metal salts of alkyl salicylates include calcium and other salts of long chain (e.g. C12 to C16) alkyl-substituted salicylic acids.

35 **[0069]** Amine salts of alkylphosphoric acids include salts of oleyl and other long chain esters of phosphoric acid, with amines such as tertiary-aliphatic primary amines, sold under the tradename Primene™.

[0070] Eighty-five percent phosphoric acid is a suitable material for addition to the fully-formulated compositions to increase frictional properties and can be included at a level of 0.01-0.3 weight percent based on the weight of the composition, such as 0.03 to 0.2 or to 0.1 percent.

40 **[0071]** The amount of supplemental friction modifier, if it is present, may be 0.01 to 10 or 5 percent by weight of the lubricating composition, 0.1 to 2.5 percent by weight of the lubricating composition, such as 0.1 to 2.0, 0.2 to 1.75, 0.3 to 1.5 or 0.4 to 1 percent. In some embodiments, however, the amount of friction modifier is present at less than 0.2 percent or less than 0.1 percent by weight, for example, 0.01 to 0.1 percent.

45 **[0072]** Antioxidants encompass phenolic antioxidants, which may be hindered phenolic antioxidants, one or both ortho positions on a phenolic ring being occupied by bulky groups such as t-butyl. The para position may also be occupied by a hydrocarbyl group or a group bridging two aromatic rings. In certain embodiments the para position is occupied by an ester-containing group, such as, for example, an antioxidant of the formula



wherein R³ is a hydrocarbyl group such as an alkyl group containing, e.g., 1 to 18 or 2 to 12 or 2 to 8 or 2 to 6 carbon atoms; and t-alkyl can be t-butyl. Such antioxidants are described in greater detail in U.S. Patent 6,559,105.

[0073] Antioxidants also include aromatic amines. In one embodiment, an aromatic amine antioxidant can comprise an alkylated diphenylamine such as nonylated diphenylamine or a mixture of a di-nonylated and a mono-nonylated diphenylamine.

[0074] Antioxidants also include sulfurized olefins such as mono- or disulfides or mixtures thereof. These materials generally have sulfide linkages of 1 to 10 sulfur atoms, e.g., 1 to 4, or 1 or 2. Materials which can be sulfurized to form the sulfurized organic compositions of the present invention include oils, fatty acids and esters, olefins and polyolefins made thereof, terpenes, or Diels-Alder adducts. Details of methods of preparing some such sulfurized materials can be found in U.S. Pat. Nos. 3,471,404 and 4,191,659.

[0075] Molybdenum compounds can also serve as antioxidants, and these materials can also serve in various other functions, such as antiwear agents or friction modifiers. U.S. Patent 4,285,822 discloses lubricating oil compositions containing a molybdenum- and sulfur-containing composition prepared by combining a polar solvent, an acidic molybdenum compound and an oil-soluble basic nitrogen compound to form a molybdenum-containing complex and contacting the complex with carbon disulfide to form the molybdenum- and sulfur-containing composition.

[0076] Typical amounts of antioxidants will, of course, depend on the specific antioxidant and its individual effectiveness, but illustrative total amounts can be 0.01 to 5 percent by weight or 0.15 to 4.5 percent or 0.2 to 4 percent.

[0077] Detergents are typically overbased materials, otherwise referred to as overbased or superbased salts, which are generally homogeneous Newtonian systems having by a metal content in excess of that which would be present for neutralization according to the stoichiometry of the metal and the detergent anion. The amount of excess metal is commonly expressed in terms of metal ratio, that is, the ratio of the total equivalents of the metal to the equivalents of the acidic organic compound. Overbased materials are prepared by reacting an acidic material (such as carbon dioxide) with an acidic organic compound, an inert reaction medium (e.g., mineral oil), a stoichiometric excess of a metal base, and a promoter such as a phenol or alcohol. The acidic organic material will normally have a sufficient number of carbon atoms, to provide oil-solubility.

[0078] Overbased detergents may be characterized by Total Base Number (TBN, ASTM D2896), the amount of strong acid needed to neutralize all of the material's basicity, expressed as mg KOH per gram of sample. Since overbased detergents are commonly provided in a form which contains diluent oil, for the purpose of this document, TBN is to be recalculated to an oil-free basis by dividing by the fraction of the detergent (as supplied) that is not oil. Some useful detergents may have a TBN of 100 to 800, or 150 to 750, or, 400 to 700.

[0079] The metal compounds useful in making the basic metal salts are generally any Group 1 or Group 2 metal compounds (CAS version of the Periodic Table of the Elements). Examples include alkali metals such as sodium, potassium, lithium, copper, magnesium, calcium, barium, zinc, and cadmium. In one embodiment the metals are sodium, magnesium, or calcium. The anionic portion of the salt can be hydroxide, oxide, carbonate, borate, or nitrate.

[0080] In one embodiment the lubricant can contain an overbased sulfonate detergent. Suitable sulfonic acids include sulfonic and thiosulfonic acids, including mono- or polynuclear aromatic or cycloaliphatic compounds. Certain oil-soluble sulfonates can be represented by R²-T-(SO₃⁻)_a or R³-(SO₃⁻)_b, where a and b are each at least one; T is a cyclic nucleus such as benzene or toluene; R² is an aliphatic group such as alkyl, alkenyl, alkoxy, or alkoxyalkyl; (R²)-T typically contains a total of at least 15 carbon atoms; and R³ is an aliphatic hydrocarbyl group typically containing at least 15 carbon atoms. The groups T, R², and R³ can also contain other inorganic or organic substituents. In one embodiment the sulfonate detergent may be a predominantly linear alkylbenzenesulfonate detergent having a metal ratio of at least 8 as described in paragraphs [0026] to [0037] of US Patent Application 2005065045.

[0081] Another overbased material is an overbased phenate detergent. The phenols useful in making phenate detergents can be represented by (R¹)_a-Ar-(OH)_b, where R¹ is an aliphatic hydrocarbyl group of 4 to 400 or 6 to 80 or 6 to 30 or 8 to 25 or 8 to 15 carbon atoms; Ar is an aromatic group such as benzene, toluene or naphthalene; a and b are each at least one, the sum of a and b being up to the number of displaceable hydrogens on the aromatic nucleus of Ar, such as 1 to 4 or 1 to 2. Phenate detergents are also sometimes provided as sulfur-bridged species.

[0082] In one embodiment, the overbased material is an overbased saligenin detergent. Overbased saligenin deter-

gents are commonly overbased magnesium salts which are based on saligenin derivatives. Saligenin detergents are disclosed in greater detail in U.S. Patent 6,310,009, with special reference to their methods of synthesis (Column 8 and Example 1).

[0083] Salixarate derivatives and methods of their preparation are described in greater detail in U.S. patent number 6,200,936 and PCT Publication WO 01/56968. It is believed that the salixarate derivatives have a predominantly linear, rather than macrocyclic, structure, although both structures are intended to be encompassed by the term "salixarate." Overbased glyoxylic detergents and their methods of preparation are disclosed in greater detail in U.S. Patent 6,310,011 and references cited therein. The overbased detergent can also be an overbased salicylate, e.g., an alkali metal or alkaline earth metal salt of a substituted salicylic acid. Overbased salicylate detergents and their methods of preparation are disclosed in U.S. Patents 4,719,023 and 3,372,116. Other overbased detergents can include overbased detergents having a Mannich base structure, as disclosed in U.S. Patent 6,569,818.

[0084] In certain embodiments, the hydrocarbyl substituents on hydroxy-substituted aromatic rings in the above detergents (e.g., phenate, saligenin, salixarate, glyoxylate, or salicylate) are free of or substantially free of C₁₂ aliphatic hydrocarbyl groups (e.g., less than 1%, 0.1%, or 0.01% by weight of the substituents are C₁₂ aliphatic hydrocarbyl groups). In some embodiments such hydrocarbyl substituents contain at least 14 or at least 18 carbon atoms.

[0085] The amount of the overbased detergent, in the formulations of the present technology, if it is present, may typically be at least 0.6 weight percent on an oil-free basis, or 0.7 to 5 weight percent or 1 to 3 weight percent or 0.05 to 0.55 weight percent. Either a single detergent or multiple detergents can be present. As alternatively expressed, the amount of overbased calcium detergent may be an amount suitable to deliver 110 to 550 parts per million by weight, or 175 or 400 or 175 to 300 ppm.

[0086] Corrosion inhibitors often refer to copper (or "yellow metal") corrosion inhibitors. Such materials include triazole compounds such as tolyltriazole, derivatives of tolyltriazole, imidazoline compounds, thiadiazoles, carboxylic acids and their salts or esters, and alkanolamines.

[0087] Antiwear agents may also be included, in addition to or supplemental to the phosphorus esters described in detail above. Examples include phosphorus-containing antiwear/extreme pressure agents such as phosphoric acid esters and salts thereof, phosphorus-containing carboxylic acids, esters, ethers, and amides; and phosphites. In certain embodiments a phosphorus antiwear agent may be present in an amount to deliver 0.01 to 0.2 or 0.015 to 0.15 or 0.02 to 0.1 or 0.025 to 0.08 percent phosphorus. Non-phosphorus-containing anti-wear agents include borate esters (including borated epoxides), dithiocarbamate compounds, molybdenum-containing compounds, and sulfurized olefins.

[0088] Extreme pressure (EP) agents include some of the materials listed elsewhere herein as well as other sulfur- and chlorosulfur-containing EP agents, chlorinated hydrocarbon EP agents, and phosphorus EP agents. Examples of such EP agents include chlorinated wax; sulfurized olefins (such as sulfurized isobutylene), organic sulfides and polysulfides such as dibenzyl disulfide, bis-(chlorobenzyl)disulfide, dibutyl tetrasulfide, sulfurized methyl ester of oleic acid, sulfurized alkylphenol, sulfurized dipentene, sulfurized terpene, and sulfurized Diels-Alder adducts; phosphorus sulfurized hydrocarbons such as the reaction product of phosphorus sulfide with turpentine or methyl oleate; phosphorus esters such as the dihydrocarbon and trihydrocarbon phosphites, e.g., dibutyl phosphite, diheptyl phosphite, dicyclohexyl phosphite, pentylphenyl phosphite; dipentylphenyl phosphite, tridecyl phosphite, distearyl phosphite and polypropylene-substituted phenol phosphite; metal thiocarbamates such as zinc dioctyldithiocarbamate; amine salts of alkyl and dialkylphosphoric acids or derivatives including, for example, the amine salt of a reaction product of a dialkyldithiophosphoric acid with propylene oxide and subsequently followed by a further reaction with P₂O₅; and mixtures thereof (as described in U.S. Patent 3,197,405).

[0089] Seal swell agents include oil-soluble esters and oil-soluble sulfones, sulfolanes, such as isodecyl sulfolane, benzyl esters, lactones, nitriles, phenolic materials, or phthalate esters.

[0090] As used herein, the term "condensation product" is intended to encompass esters, amides, imides and other such materials that may be prepared by a condensation reaction of an acid or a reactive equivalent of an acid (e.g., an acid halide, anhydride, or ester) with an alcohol or amine, irrespective of whether a condensation reaction is actually performed to lead directly to the product. Thus, for example, a particular ester may be prepared by a transesterification reaction rather than directly by a condensation reaction. The resulting product is still considered a condensation product.

[0091] The amount of each chemical component described is presented exclusive of any solvent or diluent oil, which may be customarily present in the commercial material, that is, on an active chemical basis, unless otherwise indicated. However, unless otherwise indicated, each chemical or composition referred to herein should be interpreted as being a commercial grade material which may contain the isomers, byproducts, derivatives, and other such materials which are normally understood to be present in the commercial grade.

[0092] As used herein, the term "hydrocarbyl substituent" or "hydrocarbyl group" 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 the molecule and having predominantly hydrocarbon character. Examples of hydrocarbyl groups include:

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 a ring); substituted hydrocarbon substituents, that is, substituents containing non-hydrocarbon groups which, in the context of this invention, do not alter the predominantly hydrocarbon nature of the substituent (e.g., halo (especially chloro and fluoro), hydroxy, alkoxy, mercapto, alkylmercapto, nitro, nitroso, and sulfoxy); hetero substituents, that is, substituents which, while having a predominantly hydrocarbon character, in the context of this invention, contain other than carbon in a ring or chain otherwise composed of carbon atoms and encompass substituents as pyridyl, furyl, thienyl and imidazolyl. Heteroatoms include sulfur, oxygen, and nitrogen. In general, no more than two, or no more than one, non-hydrocarbon substituent will be present for every ten carbon atoms in the hydrocarbyl group; alternatively, there may be no non-hydrocarbon substituents in the hydrocarbyl group.

[0093] It is known that some of the materials described above may interact in the final formulation, so that the components of the final formulation may be different from those that are initially added. For instance, metal ions (of, e.g., a detergent) can migrate to other acidic or anionic sites of other molecules. The products formed thereby, including the products formed upon employing the composition of the present invention in its intended use, may not be susceptible of easy description. Nevertheless, all such modifications and reaction products are included within the scope of the present invention; the present invention encompasses the composition prepared by admixing the components described above.

[0094] Needle bearings, or needle roller bearings, are a species of roller bearing in which the rollers have a high length-to-diameter ratio, such as at least 3:1 or 4:1 and up to, for instance, 10:1. The rollers may be used in a compression bearing, and the rollers may be oriented radially with respect to the axis of rotation of the bearing. Needle bearings may have a higher load capacity than other roller bearings.

[0095] The invention herein is useful for lubricating a transmission such as an automatic transmission; the method of which comprises supplying thereto the lubricant composition as described herein. It may be particularly useful wherein the automatic transmission contains a bearing, such as a needle bearing, that is lubricated by the lubricant composition. The advantages and uses of the disclosed technology may be better understood with reference to the following examples.

[0096] EXAMPLES. The following lubricant formulations are prepared and tested. All amounts reported are oil-free basis and are reported as weight percent, except as noted.

[0097] Example 1. (outside scope of claimed invention) A mineral oil-based formulation, containing:

0.13% of a borated epoxide (a borate ester of 14 to 16 carbons) containing 2.1% B (thus contributing 27 parts per million boron to the lubricant)
 3.1% of borated succinimide dispersants containing 0.82% B (thus contributing 253 ppm boron to the lubricant [this is my calculation from 116.31 + 116.32])
 0.23% dibutyl phosphite containing 15.5% P (thus contributing 357 ppm phosphorus to the lubricant)
 0.08% phosphoric acid ester of a C18 alcohol, containing 5.25% P (thus contributing 42 ppm phosphorus to the lubricant)
 0.9% acrylic-based viscosity modifier with star architecture
 0.16% overbased calcium sulfonate detergents

Plus conventional friction modifiers, antioxidants, corrosion inhibitors and other additives characteristic of an automatic transmission lubricant. For Example 1, the example has the following properties: FINISH BLEND KV100 = 4.27cSt, KV40cSt = 17.7cSt; BOV = 3.15cSt; B = 368ppm, Ca = 322ppm, P = 736ppm, S = 1763ppm.

[0098] Example 2. A mineral oil-based formulation, containing:

0.15% of a borated epoxide (a borate ester of 14 to 16 carbons) containing 2.1% B (thus contributing 32 ppm boron to the lubricant)
 0.1% of a borate ester based on an alcohol of 8 carbons, containing 2.7% B (thus contributing 20 ppm boron to the lubricant)
 3.2% of borated succinimide dispersants containing 0.82% B (thus contributing 262 ppm boron to the lubricant)
 0.2% of an oligomeric phosphite containing 15.4%P (thus contributing 306 ppm phosphorus to the lubricant)
 0.12% phosphoric acid ester of a C18 alcohol, containing 5.25% P (thus contributing 63 ppm phosphorus to the lubricant)
 0.87% acrylic-based viscosity modifiers with various architectures 0.28% overbased calcium sulfonate detergents

Plus conventional friction modifiers, antioxidants, corrosion inhibitors and other additives characteristic of an automatic transmission lubricant.

For Example 2, the example has the following properties: FINISH BLEND KV100 = 3.84cSt, KV40cSt = 15.7cSt; BOV

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= 2.98cSt and B = 328ppm, Ca = 298ppm, P = 586ppm, S = 1617ppm.

[0099] Example 3. (outside scope of claimed invention) A mineral oil-based formulation, containing:

- 0.15% of a borated epoxide (a borate ester of 14 to 16 carbons) containing 2.1% B (thus contributing 32 ppm boron to the lubricant)
- 0.1% of a borate ester based on an alcohol of 8 carbons, containing 2.7% B (thus contributing 20 ppm boron to the lubricant)
- 2.8% of borated succinimide dispersants containing 0.4% B (thus contributing 128 ppm boron to the lubricant)
- 0.5% of a mixture of DMTD containing dispersants
- 0.12% phosphoric acid ester of a C18 alcohol, containing 5.25% P (thus contributing 63 ppm phosphorus to the lubricant)
- 0.23% alkyl phosphite antiwear, containing 15.5% P (thus contributing 357 ppm phosphorus to the lubricant)
- 0.28% overbased calcium sulfonate detergents

Plus conventional friction modifiers, antioxidants, corrosion inhibitors and other additives characteristic of an automatic transmission lubricant.

For Example 3, the example has the following properties: FINISH BLEND KV100 = 3.82cSt, KV40cSt = 15.5cSt; BOV = 2.98cSt and B = 344ppm, Ca = 303ppm, P = 607ppm, S = 1755ppm.

[0100] Example 4. (outside scope of claimed invention) A mineral oil-based formulation, containing:

- 0.15% of a borated epoxide (a borate ester of 14 to 16 carbons) containing 2.1% B (thus contributing 32 ppm boron to the lubricant)
- 0.15% of a borate ester based on an alcohol of 8 carbons, containing 2.7% B (thus contributing 41 ppm boron to the lubricant)
- 2.6% of a non-borated succinimide dispersants
- 0.7% of borated succinimide dispersants containing 0.4% B (thus contributing 127 ppm boron to the lubricant)
- 0.65% of a mixture of DMTD containing dispersants
- 0.12% phosphoric acid ester of a C18 alcohol, containing 5.25% P (thus contributing 79 ppm phosphorus to the lubricant)
- 0.25% alkyl phosphite antiwear, containing 15.5% P (thus contributing 388 ppm phosphorus to the lubricant)
- 0.28% overbased calcium sulfonate detergents

Plus conventional friction modifiers, antioxidants, corrosion inhibitors and other additives characteristic of an automatic transmission lubricant.

For Example 4, the example has the following properties: FINISH BLEND KV100 = 3.84cSt, KV40cSt = 15.8cSt; BOV = 2.98cSt and B = 298ppm, Ca = 301ppm, P = 570ppm, S = 1615ppm

[0101] Example 5 is a commercially available sample of automatic transmission fluid included for comparison. It is a sample of Shell™ ATF134FE, a high performance automatic transmission fluid commercially available from Shell. For Example 5, the example has the following properties: FINISH BLEND KV100 = 5.3cSt, KV40 = 23.8cSt. The BOV of Toyota WS is approximately KV100 = 3.3cSt (BOV). B = 70ppm, Ca = 130ppm, P = 271ppm, S = 729ppm.

[0102] Example 6 is also a commercially available sample of automatic transmission fluid included for comparison. It is Toyota WS (World Standard) automatic transmission fluid used commercially by Toyota™. For Example 6, the example has the following properties: FINISH BLEND KV100 = 4.35cSt and KV40 = 18.1cSt. The BOV of Shell ATF134 is approximately KV100 = 3.0cSt (BOV). B = 136ppm, Ca = 236ppm, P = 343ppm, S = 1669ppm.

[0103] The formulations of examples 1 to 4 are subjected to needle bearing testing on a Unisteel™ bearing rig. A 100 mL sample of each lubricant is evaluated using a bearing with 12 thrust needle rollers, running 6 tests per sample, with an applied load of 10,000 N, at a speed of 1.1-1.5 m/s (which corresponds to 12,250 rpm needle revolutions and a shaft speed of about 700 rpm), at 120 °C, with a maximum pressure of 2.6 GPa. The test results are presented in terms of L10 and L50, fitting data to a Weibull analysis. L10 indicates the number of revolutions with a 10 percent probability of failure of the bearing (as determined by pit formation, typically detected as vibration), and L50 indicates the number of revolutions with a 50 percent probability of failure. The results, reported in terms of revolutions (cycles) are shown in the following table:

	L10	L50	KV100 (cSt)	KV40 (cSt)
Ex 1	285,000	920,000	4.27	17.7
Ex 2	592,000	2,100,000	3.84	15.7

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(continued)

	L10	L50	KV100 (cSt)	KV40 (cSt)
Ex 3	700,000	2,000,000	3.82	15.5
Ex 4	163,000	610,000	3.84	15.8
Ex 5	42,000	255,000	5.30	23.8
Ex 6	148,000	500,000	4.35	18.1

[0104] The formulations of Inventive example Ex2 provides good bearing life.

[0105] The mention of any document is not an admission that such document qualifies as prior art or constitutes the general knowledge of the skilled person in any jurisdiction.

[0106] As used herein, the transitional term "comprising," which is synonymous with "including," "containing," or "characterized by," is inclusive or open-ended and does not exclude additional, un-recited elements or method steps. However, in each recitation of "comprising" herein, it is intended that the term also encompass, as alternative embodiments, the phrases "consisting essentially of" and "consisting of," where "consisting of" excludes any element or step not specified and "consisting essentially of" permits the inclusion of additional un-recited elements or steps that do not materially affect the essential or basic and novel characteristics of the composition or method under consideration. The expression "consisting of" or "consisting essentially of," when applied to an element of a claim, is intended to restrict all species of the type represented by that element, notwithstanding the presence of "comprising" elsewhere in the claim.

[0107] While certain representative embodiments and details have been shown for the purpose of illustrating the subject invention, it will be apparent to those skilled in this art that various changes and modifications can be made therein without departing from the scope of the subject invention. In this regard, the scope of the invention is to be limited only by the following claims.

Claims

1. A lubricant composition comprising:

- (a) an oil having a kinematic viscosity at 100 °C of 2.2 to 3.7 mm²/s;
- (b) at least one borate ester having an alkyl group of 4 to 18 carbon atoms in an amount to provide 25 to 300, or 30 to 150, or 50 to 100, parts per million by weight boron to the composition;
- (c) at least one phosphorus ester in an amount to provide 150 to 650 parts per million by weight phosphorus to the composition;
- (d) a viscosity index modifier comprising a linear polymer viscosity modifier having dispersant functionality, wherein the linear polymer has a weight average molecular weight of 5,000 to 25,000, and wherein said linear polymer is present in an amount of 0.1 to 4 weight percent; and
- (e) a borated succinimide dispersant to provide 180 to 270 ppm boron to the lubricant composition;

wherein the kinematic viscosity at 100 °C of the lubricant composition is less than or equal to 4.7 mm²/s.

2. The lubricant composition of claim 1 wherein:

the amount of the at least one borate ester (b) is 0.1 to 1.1 percent by weight, or 0.15 to 0.7 percent by weight; and the amount of the at least one phosphorus ester (c) is 0.05 to 0.40 percent by weight.

3. The lubricant composition of claim 1 wherein the oil of component (a) comprises an API Group II or Group III oil or mixtures thereof.

4. The lubricant composition of any one of claims 1 through 3 wherein (b) the at least one borate ester component comprises a borate ester containing an alkyl group of 4 to 12 carbon atoms and a borate ester containing an alkyl group of 14 to 18 carbon atoms.

5. The lubricant composition of any one of claims 1 through 3 wherein (b) the at least one borate ester component comprises a borated epoxide having 12 to 18 carbon atoms.

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6. The lubricant composition of any one of claims 1 through 4 wherein (b) the at least one borate ester component comprises the reaction product of boric acid with an alcohol of 6 to 12 carbon atoms.
7. The lubricant composition of any one of claims 1 through 6 wherein (c) the phosphorus ester comprises a C4 to C6 alkyl phosphite such as dibutylphosphite or an oligomeric phosphite which is the reaction product of a monomeric phosphorous acid or ester with an alkylene diol.
8. The lubricant composition of any one of claims 1 through 7 wherein (d) the viscosity index modifier comprises a poly(meth)acrylate containing a nitrogen-containing dispersant monomer.
9. The lubricant composition of any one of claims 1 through 8 wherein (e) the succinimide dispersant is further treated with a dimercaptothiadiazole.
10. The composition of any one of claims 1 through 9 wherein the amount of (e) the boron-containing succinimide dispersant is 1.0 to 3.5 percent by weight.
11. The lubricant composition of any one of claims 1 through 10 wherein (e) the boron-containing succinimide dispersant component provides 10 to 250 parts per million by weight sulfur to the composition by means of the presence of a dimercaptothiadiazole moiety present therewith.
12. The lubricant composition of any one of claims 1 through 11 wherein (e) the boron-containing succinimide dispersant has a boron content of 0.6 to 0.9 weight percent, or 0.54 to 0.85, or 0.56 to 0.83 weight percent.
13. A lubricant composition comprising:
- (a) 50 to 98 percent by weight of an oil having a kinematic viscosity at 100 °C of 2.2 to 3.7 mm²/s;
 - (b) at least one borate ester having an alkyl group of 4 to 18 carbon atoms, wherein the borate ester comprises:
 - (b-1) 0.1 to 1.0 percent by weight of a borate ester containing a C4 to C12 alkyl group;
 - (b-2) 0.15 to 0.40 percent by weight of a borate ester containing a C14 to a C18 alkyl group;
 - (c) at least one phosphorus ester in an amount to provide 150 to 650 parts per million by weight phosphorus to the composition;
 - (e) a borated succinimide dispersant in an amount to provide 180 to 270 ppm boron to the lubricant composition, wherein the borated succinimide dispersant comprises:
 - (e-1) 1.0 to 4.0 percent by weight of a borated succinimide dispersant not treated with a dimercaptothiadiazole; and
 - (e-2) 0.1 to 1.5 percent by weight of a borated succinimide dispersant that is treated with a dimercaptothiadiazole;wherein the amount of boron provided by components (b-1), (b-2), (e-1) and (e-2) is at least 180 parts per million by weight of the composition; and wherein the kinematic viscosity at 100 °C of the lubricant composition is less than or equal to 4.7 mm²/s.
14. A method of lubricating an automatic transmission comprising supplying thereto the lubricant composition of any one of claims 1 through 13, wherein the automatic transmission optionally contains a bearing that is lubricated by said lubricant composition.

Patentansprüche

1. Schmiermittelzusammensetzung, umfassend:
- (a) ein Öl, das eine kinematische Viskosität bei 100 °C von 2,2 bis 3,7 mm²/s aufweist;
 - (b) mindestens einen Boratester, der eine Alkylgruppe von 4 bis 18 Kohlenstoffatomen in einer Menge aufweist, um 25 bis 300 oder 30 bis 150 oder 50 bis 100 Teile pro Million nach Gewicht Bor für die Zusammensetzung bereitzustellen;
 - (c) mindestens einen Phosphorester in einer Menge, um 150 bis 650 Teile pro Million nach Gewicht Phosphor

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für die Zusammensetzung bereitzustellen;

(d) einen Viskositätsindexmodifikator, umfassend einen linearen Polymerviskositätsmodifikator, der eine Dispergiermittelfunktionalität aufweist, wobei das lineare Polymer ein gewichtsmittleres Molekulargewicht von 5.000 bis 25.000 aufweist, und wobei das lineare Polymer in einer Menge zu 0,1 bis 4 Gewichtsprozent vorhanden ist; und

(e) ein boriertes Succinimid-Dispergiermittel, um 180 bis 270 ppm Bor für die Schmiermittelzusammensetzung bereitzustellen;

wobei die kinematische Viskosität bei 100 °C der Schmiermittelzusammensetzung kleiner als oder gleich 4,7 mm²/s ist.

2. Schmiermittelzusammensetzung nach Anspruch 1, wobei:

die Menge des mindestens einen Boratesters (b) 0,1 bis 1,1 Gewichtsprozent oder 0,15 bis 0,7 Gewichtsprozent ist; und

die Menge des mindestens einen Phosphoresters (c) 0,05 bis 0,40 Gewichtsprozent ist.

3. Schmiermittelzusammensetzung nach Anspruch 1, wobei das Öl von Komponente (a) ein Öl von API-Gruppe II oder -Gruppe III oder Mischungen davon umfasst.

4. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 3, wobei (b) die mindestens eine Boratesterkomponente einen Boratester, der eine Alkylgruppe von 4 bis 12 Kohlenstoffatomen enthält, und einen Boratester umfasst, der eine Alkylgruppe von 14 bis 18 Kohlenstoffatomen enthält.

5. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 3, wobei (b) die mindestens eine Boratesterkomponente ein boriertes Epoxid umfasst, das 12 bis 18 Kohlenstoffatome aufweist.

6. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 4, wobei (b) die mindestens eine Boratesterkomponente das Reaktionsprodukt von Borsäure mit einem Alkohol von 6 bis 12 Kohlenstoffatomen umfasst.

7. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 6, wobei (c) der Phosphorester ein C4 bis C6-Alkylphosphit wie Dibutylphosphit oder ein oligomeres Phosphit umfasst, das das Reaktionsprodukt einer monomeren Phosphorsäure oder eines Esters mit einem Alkylendiol ist.

8. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 7, wobei (d) der Viskositätsindexmodifikator ein Poly(meth)acrylat umfasst, das ein stickstoffhaltiges Dispergiermittelmonomer enthält.

9. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 8, wobei (e) das Succinimid-Dispergiermittel ferner mit einem Dimercaptiothiadiazol behandelt ist.

10. Zusammensetzung nach einem der Ansprüche 1 bis einschließlich 9, wobei die Menge (e) des borhaltigen Succinimid-Dispergiermittels 1,0 bis 3,5 Gewichtsprozent ist.

11. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 10, wobei (e) die borhaltige Succinimid-Dispergiermittelkomponente 10 bis 250 Teile pro Million nach Gewicht Schwefel für die Zusammensetzung mittels des Vorhandenseins eines damit vorhandenen Dimercaptiothiadiazolrests bereitstellt.

12. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 11, wobei (e) das borhaltige Succinimid-Dispergiermittel einen Borgehalt von 0,6 bis 0,9 Gewichtsprozent oder 0,54 bis 0,85 oder 0,56 bis 0,83 Gewichtsprozent aufweist.

13. Schmiermittelzusammensetzung, umfassend:

(a) zu 50 bis 98 Gewichtsprozent ein Öl, das eine kinematische Viskosität bei 100 °C von 2,2 bis 3,7 mm²/s aufweist;

(b) mindestens einen Boratester, der eine Alkylgruppe von 4 bis 18 Kohlenstoffatomen aufweist, wobei der Boratester umfasst:

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- (b-1) zu 0,1 bis 1,0 Gewichtsprozent einen Boratester, der eine C4 bis C12-Alkylgruppe enthält;
(b-2) zu 0,15 bis 0,40 Gewichtsprozent einen Boratester, der eine C14 bis eine C18-Alkylgruppe enthält;

(c) mindestens einen Phosphorester in einer Menge, um 150 bis 650 Teile pro Million nach Gewicht Phosphor für die Zusammensetzung bereitzustellen;

(e) ein boriertes Succinimid-Dispergiermittel in einer Menge, um 180 bis 270 ppm Bor für die Schmiermittelzusammensetzung bereitzustellen, wobei das borierte Succinimid-Dispergiermittel umfasst:

(e-1) zu 1,0 bis 4,0 Gewichtsprozent ein boriertes Succinimid-Dispergiermittel, das nicht mit einem Dimer-captiothiadiazol behandelt ist; und

(e-2) zu 0,1 bis 1,5 Gewichtsprozent ein boriertes Succinimid-Dispergiermittel, das mit einem Dimercaptothiadiazol behandelt ist;

wobei die Menge von Bor, die durch Komponenten (b-1), (b-2), (e-1) und (e-2) bereitgestellt ist, mindestens 180 Teile pro Million nach Gewicht der Zusammensetzung ist; und wobei die kinematische Viskosität bei 100 °C der Schmiermittelzusammensetzung kleiner als oder gleich 4,7 mm²/s ist.

14. Verfahren zum Schmieren eines automatischen Getriebes, umfassend ein Zuführen dazu der Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis einschließlich 13, wobei das automatische Getriebe optional ein Lager enthält, das durch die Schmiermittelzusammensetzung geschmiert ist.

Revendications

1. Composition lubrifiante comprenant :

(a) une huile ayant une viscosité cinématique à 100 °C de 2,2 à 3,7 mm²/s ;

(b) au moins un ester de borate ayant un groupe alkyle de 4 à 18 atomes de carbone en une quantité pour fournir 25 à 300, ou 30 à 150, ou 50 à 100, parties par million en poids de bore à la composition ;

(c) au moins un ester de phosphore en une quantité pour fournir 150 à 650 parties par million en poids de phosphore à la composition ;

(d) un modificateur d'indice de viscosité comprenant un modificateur de viscosité polymère linéaire ayant une fonctionnalité de dispersant, dans laquelle le polymère linéaire a une masse moléculaire moyenne en poids de 5 000 à 25 000, et dans laquelle ledit polymère linéaire est présent en une quantité de 0,1 à 4 pour cent en poids ; et

(e) un dispersant succinimide boré pour fournir 180 à 270 ppm de bore à la composition lubrifiante ; dans laquelle la viscosité cinématique à 100 °C de la composition lubrifiante est inférieure ou égale à 4,7 mm²/s.

2. Composition lubrifiante selon la revendication 1, dans laquelle :

la quantité de l'au moins un ester de borate (b) est de 0,1 à 1,1 pour cent en poids, ou 0,15 à 0,7 pour cent en poids ; et

la quantité de l'au moins un ester de phosphore (c) est de 0,05 à 0,40 pour cent en poids.

3. Composition lubrifiante selon la revendication 1, dans laquelle l'huile du composant (a) comprend une huile du groupe II ou du groupe III de l'API ou des mélanges de celles-ci.

4. Composition lubrifiante selon l'une quelconque des revendications 1 à 3, dans laquelle (b) l'au moins un composant ester de borate comprend un ester de borate contenant un groupe alkyle de 4 à 12 atomes de carbone et un ester de borate contenant un groupe alkyle de 14 à 18 atomes de carbone.

5. Composition lubrifiante selon l'une quelconque des revendications 1 à 3, dans laquelle (b) l'au moins un composant ester de borate comprend un époxyde boré ayant 12 à 18 atomes de carbone.

6. Composition lubrifiante selon l'une quelconque des revendications 1 à 4, dans laquelle (b) l'au moins un composant ester de borate comprend le produit de réaction d'acide borique avec un alcool de 6 à 12 atomes de carbone.

7. Composition lubrifiante selon l'une quelconque des revendications 1 à 6, dans laquelle (c) l'ester de phosphore comprend un phosphite d'alkyle en C4 à C6 tel que le dibutylphosphite ou un phosphite oligomère qui est le produit de réaction d'un acide ou ester de phosphore monomère avec un alkylène-diol.

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8. Composition lubrifiante selon l'une quelconque des revendications 1 à 7 dans laquelle (d) le modificateur d'indice de viscosité comprend un poly(méth)acrylate contenant un monomère dispersant contenant de l'azote.
- 5 9. Composition lubrifiante selon l'une quelconque des revendications 1 à 8, dans laquelle (e) le dispersant succinimide est en outre traité avec un dimercaptiothiadiazole.
10. Composition selon l'une quelconque des revendications 1 à 9, dans laquelle la quantité de (e) le dispersant succinimide contenant du bore est de 1,0 à 3,5 pour cent en poids.
- 10 11. Composition lubrifiante selon l'une quelconque des revendications 1 à 10, dans laquelle (e) le composant dispersant succinimide contenant du bore fournit 10 à 250 parties par million en poids de soufre à la composition au moyen de la présence d'un fragment dimercaptiothiadiazole présent avec celui-ci.
- 15 12. Composition lubrifiante selon l'une quelconque des revendications 1 à 11, dans laquelle (e) le dispersant succinimide contenant du bore a une teneur en bore de 0,6 à 0,9 pour cent en poids, ou 0,54 à 0,85, ou 0,56 à 0,83 pour cent en poids.
13. Composition lubrifiante comprenant :
- 20 (a) 50 à 98 pour cent en poids d'une huile ayant une viscosité cinématique à 100 °C de 2,2 à 3,7 mm²/s ;
(b) au moins un ester de borate ayant un groupe alkyle de 4 à 18 atomes de carbone, dans laquelle l'ester de borate comprend :
- 25 (b-1) 0,1 à 1,0 pour cent en poids d'un ester de borate contenant un groupe alkyle en C4 à C12 ;
(b-2) 0,15 à 0,40 pour cent en poids d'un ester de borate contenant un groupe alkyle en C14 à C18 ;
- (c) au moins un ester de phosphore en une quantité pour fournir 150 à 650 parties par million en poids de phosphore à la composition ;
- 30 (e) un dispersant succinimide boré en une quantité pour fournir 180 à 270 ppm de bore à la composition lubrifiante, dans laquelle le dispersant succinimide boré comprend :
- (e-1) 1,0 à 4,0 pour cent en poids d'un dispersant succinimide boré non traité avec un dimercaptiothiadiazole ;
et
- 35 (e-2) 0,1 à 1,5 pour cent en poids d'un dispersant succinimide boré qui est traité avec un dimercaptiothiadiazole ;
dans laquelle la quantité de bore fournie par les composants (b-1), (b-2), (e-1) et (e-2) est d'au moins 180 parties par million en poids de la composition ; et dans laquelle la viscosité cinématique à 100 °C de la composition lubrifiante est inférieure ou égale à 4,7 mm²/s.
- 40 14. Procédé de lubrification d'une transmission automatique comprenant la fourniture à celle-ci de la composition lubrifiante selon l'une quelconque des revendications 1 à 13, dans lequel la transmission automatique contient facultativement un palier qui est lubrifié par ladite composition lubrifiante.
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REFERENCES CITED IN THE DESCRIPTION

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