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(54) LUBRICANT COMPOSITION

(57) Provided is a lubricant composition that, even when the viscosity thereof has decreased, can suppress abrasion of bearings, etc. and scoring of gear tooth surfaces, etc. A lubricant composition that contains a lubricant base oil and a sulfur-based extreme pressure agent. The lubricant composition is characterized in that the amount of active sulfur in the extreme pressure agent is 5-30 mass% and in that the extreme pressure agent content of the lubricant composition is 5-15 mass% with respect to the mass of the whole composition.

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Description

FIELD

[0001] The present invention relates to a lubricant composition. In particular, the present invention relates to an automobile lubricant composition having a decreased viscosity, which can be applied to differential gears.

BACKGROUND

[0002] Lubricant compositions are used in a wide range of applications such as automobile and machinery applications. In recent years, there is a demand to decrease viscosity levels of automobile lubricant compositions in view of fuel cost saving. Meanwhile, decreasing viscosity of a lubricant composition may affect oil film formation ability. Decreasing viscosity of a lubricant may cause the occurrence of wear in a bearing or the like or the occurrence of scoring on a gear tooth surface or the like especially in the field of automobile gear oils and further especially in the field of lubricants used for differential gears, which makes it difficult to deal with the issue of decreasing viscosity. Therefore, the development of an automobile gear oil composition and especially a differential gear oil composition, which can suppress wear in a bearing or the like under conditions that make it difficult to form an oil film at high temperatures even for low viscosity oils, has been awaited.

[0003] The present inventors previously found that it is possible to decrease viscosity of a lubricant using a low viscosity base oil and a high viscosity base oil in combination, thereby simultaneously achieving bearing fatigue life characteristics and fuel cost saving, which are particularly influenced by oil film formation ability. This led to the completion of the invention disclosed in Japanese Unexamined Patent Publication (Kokai) No. 2007-039480. However, the lubricant composition disclosed in Japanese Unexamined Patent Publication (Kokai) No. 2007-039480 is insufficient in terms of ability to prevent wear in a bearing or the like and scoring characteristics on a gear tooth surface or the like.

[0004] Japanese Unexamined Patent Publication (Kokai) No. 2014-012855 discloses a lubricant composition comprising a specific acidic phosphoric acid alkyl ester, a dialkyl amine, and/or a trialkyl amine, a specific sulfur compound lacking a polysulfide bond of -S-S-S- or more sulfur atoms, and if needed, a specific thiophosphoric acid trihydrocarbyl ester. However, the lubricant composition disclosed in Japanese Unexamined Patent Publication (Kokai) No. 2014-012855 relates to a speed-up gear oil composition for wind-power generation, which needs to have resistance to baking and fatigue resistance, and thus, it is not described in terms of scoring.

[CITATION LIST]

[PATENT LITERATURE]

[0005]

Patent Literature 1: Japanese Unexamined Patent Publication (Kokai) No. 2007-039480
Patent Literature 2: Japanese Unexamined Patent Publication (Kokai) No. 2014-012855

SUMMARY

[TECHNICAL PROBLEM]

[0006] Therefore, the present inventors have an objective to provide a lubricant composition, which can suppress wear in a bearing or the like and scoring on a gear tooth surface or the like even having a decreased viscosity.

[SOLUTION TO PROBLEM]

[0007] The present inventors found that the above-described objective can be achieved by blending an extreme pressure agent containing a specific amount of active sulfur with a lubricant composition. This has led to the completion of the present invention.

[0008] In other words, a lubricant composition comprising a lubricant base oil and a sulfur-based extreme pressure agent, wherein the amount of active sulfur in the extreme pressure agent is from 5% to 30% by weight, and the content of the extreme pressure agent in the composition is from 5% to 15% by weight based on the total weight of the lubricant composition, is provided according to the present invention.

[0009] A preferred embodiment of the present invention further has at least one of the following features (1) to (7).

(1) The sulfur-based extreme pressure agent is a sulfurized olefin.
(2) The lubricant composition has a kinetic viscosity at 100°C of 5 to 15 mm^2/s.
(3) At least a part of the lubricant base oil is a Fischer-Tropsch-derived base oil.
(4) At least a part of the lubricant base oil is a poly-α-olefin (PAO) base oil.
(5) The lubricant base oil has a kinetic viscosity at 100°C of 5 to 15 mm^2/s.
(6) The lubricant composition is a lubricant composition for transmissions.
(7) The lubricant composition is a lubricant composition for differential gears.

[ADVANTAGEOUS EFFECTS OF THE INVENTION]

[0010] The lubricant composition of the present invention can suppress wear in a bearing or the like and scoring on a gear tooth surface or the like even when having a decreased viscosity. The lubricant composition of the present invention can be suitably used as an automobile lubricant and further suitable for a transmission gear oil and a differential gear oil.

DESCRIPTION OF EMBODIMENTS

[0011] The present invention will be further described in detail below.

(A) Lubricant base oil

[0012] A lubricant base oil in the present invention is not particularly limited and a conventionally known lubricant base oil can be used. Examples of a lubricant base oil include mineral oil-based base oils, synthetic base oils, and mixed base oils thereof.

[0013] A method of producing a mineral oil-based base oil is not limited. A mineral oil-based base oil is preferably a highly refined paraffinic mineral oil (mineral oil-based lubricant base oil having a high viscosity index) prepared by treating a hydrorefined oil, a catalytically isomerized oil, or the like through solvent dewaxing, hydrodewaxing, or the like. In addition, examples of a mineral oil-based base oil other than the above include raffinate obtained by treating a lubricant raw material through solvent purification using an aromatic extraction solvent such as phenol or furfural and hydrotreated oils obtained by hydrotreatment using hydrotreatment catalysts such as cobalt and molybdenum with silica-alumina carriers. For example, 100 neutral oil, 150 neutral oil, and 500 neutral oil can be exemplified.

[0014] Examples of a synthetic base oil include a base oil (i.e., Fischer-Tropsch-derived base oil) obtained by hydrocracking and hydroisomerization of a raw material of wax or the like obtained via Fischer-Tropsch synthesis from a natural gas such as methane, poly-α-olefin base oil (PAO), polybutene, alkylbenzene, polyol ester, polyglycol ester, dibasic acid ester, phosphoric acid ester, and silicone oil. Of these, a Fischer-Tropsch-derived base oil and a poly-α-olefin (PAO) base oil are preferable.

[0015] One type of lubricant base oil may be used singly or two or more types of lubricant base oils may be used in combination as long as lubricant oils are selected from mineral oil-based base oils and synthetic base oils described above or any combination thereof. When two or more types of lubricant base oils are used, a combination of mineral oil-based base oils, a combination of synthetic base oils, or a combination of a mineral oil-based base oil and a synthetic base oil may be used. Embodiments of such combination are not limited. A combination of a mineral oil-based base oil and a synthetic base oil is particularly preferable.

[0016] When a mineral oil-based base oil and a synthetic base oil are used in combination, it is preferable to use, as a synthetic base oil, at least one selected from a Fischer-Tropsch-derived base oil and a poly-α-olefin (PAO) base oil. Suitable embodiments of the combination include:

(1) a combination of a mineral oil-based base oil and a Fischer-Tropsch-derived base oil;
(2) a combination of a mineral oil-based base oil and a poly-α-olefin (PAO) base oil;
(3) a combination of a mineral oil-based base oil, a Fischer-Tropsch-derived base oil, and a poly-α-olefin (PAO) base oil; and
(4) a combination of a Fischer-Tropsch-derived base oil and a poly-α-olefin (PAO) base oil.

[0017] Of these, (3) a combination of a mineral oil-based base oil, a Fischer-Tropsch-derived base oil, and a poly-α-olefin (PAO) base oil is particularly preferable.

[0018] A mineral oil-based base oil is not limited to one produced by the above-described production method. However, it has a kinetic viscosity of preferably 2 to 35 mm^2/s, more preferably 2 to 20 mm^2/s, and still more preferably 3 to 10 mm^2/s at 100°C.

[0019] A Fischer-Tropsch-derived base oil has a kinetic viscosity of preferably, but not limited to, 2 to 40 mm^2/s, more preferably 2 to 20 mm^2/s, still more preferably 2 to 10 mm^2/s at 100°C.

[0020] Examples of a poly-α-olefin (PAO) base oil include, but is not limited to. 1-octene oligomer, 1-decene oligomer, ethylene-α-olefin oligomer, ethylene-propylene oligomer, isobutene oligomer, and hydrogenated products thereof. A poly-α-olefin (PAO) base oil has a kinetic viscosity of preferably 2 to 100 mm^2/s, more preferably 2 to 50 mm^2/s, and still more preferably 10 to 50 mm^2/s at 100°C.

[0021] Kinetic viscosity of a lubricant base oil is not limited unless subject matter of the present invention is impaired. In particular, in order to obtain a low viscosity lubricant composition, a lubricant base oil as a whole has a kinetic viscosity at 100°C of preferably 3 to 40 mm^2/s, more preferably 4 to 20 mm^2/s, still more preferably 5 to 15 mm^2/s, and particularly preferably 8 to 15 mm^2/s. When kinetic viscosity at 100°C of a lubricant base oil is above the upper limit, it makes it difficult to decrease viscosity of a lubricant composition, which may be an obstacle to achievement of fuel cost saving. In addition, when the kinetic viscosity at 100°C is below the lower limit, it might make it difficult to ensure wear prevention performance or scoring prevention performance, although fuel cost saving could be achieved.

(B) Sulfur-based extreme pressure agent

[0022] The lubricant composition of the present invention comprises a sulfur-based extreme pressure agent as an essential component. A sulfur-based extreme pressure agent used in the present invention needs to have an amount of active sulfur of 5% to 30% by weight, which is preferably 5% to 20% by weight, more preferably 5% to 18% by weight, still more preferably 5% to 15% by weight, and particularly preferably 8% to 12% by weight. When the amount of active sulfur is above the upper limit, it may cause metallic corrosion and make it difficult to ensure wear prevention performance or scoring prevention performance. Although the lower limit of the amount of active sulfur is not particularly limited, the above-described lower limit is preferable for ensuring extreme pressure performance.

[0023] Here, the amount of active sulfur is measured by the method stipulated by ASTM D1662. More specifically, the amount of active sulfur in accordance with ASTM D1662 can be measured by the following procedures.

1. Mix 50 g of a sample and 5 g of a copper powder (having a purity of 99% or more and a particle size of 75 μm or less) in a 200-mL beaker and heat the mixture to 150°C while stirring it by a stirrer (500 rpm).
2. Once the temperature reaches 150°C, further add 5 g of a copper powder and stir the mixture for 30 minutes.
3. Stop stirring, place a copper plate prepared in compliance with ASTM D130 in the beaker and immerse the copper plate therein for 10 minutes. Then, once the copper plate becomes discolored, further add 5 g of a copper powder and stir the mixture for 30 minutes (continue this operation until discoloration of the copper plate stops).
4. Once discoloration of the copper plate stops, filter the copper powder added to the sample for separation and measure the amount of sulfur contained in the filtrate.

[0024] The amount of active sulfur is calculated as follows.

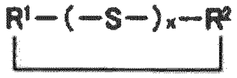
Amount of active sulfur (% by weight) = Amount of sulfur before reacted with copper powder (% by weight) - Amount of sulfur after reacted with copper powder (% by weight)

[0025] A sulfur-based extreme pressure agent in the present invention needs to have a specific amount of active sulfur as described above. It can be selected from known sulfur-based extreme pressure agents. It is preferably at least one selected from sulfide compounds represented by sulfurized olefin and sulfurized esters represented by sulfurized oil and fat and particularly preferably sulfurized olefin.

[0026] A sulfur-based extreme pressure agent used in the present invention is expressed by, for example, following formula (1).

$$R^1\text{-}(\text{-S-})_x\text{-}R^2 \qquad (1)$$

[0027] In formula (1), R^1 and R^2 are each independently a monovalent substituent and contain at least one element selected from carbon, hydrogen, oxygen, and sulfur. Specifically, R^1 and R^2 may be, for example, a saturated or unsaturated hydrocarbon group having a linear or branched structure containing 1 to 40 carbon atoms, which may be an aliphatic, aromatic, or aromatic aliphatic hydrocarbon group. In addition, such group may contain an oxygen and/or sulfur atom. R^1 and R^2 may be bound to each other. When they form a single bond, they are expressed by, for example, following formula (2).



$$R^1-(-S-)_x-R^2 \quad (2)$$

[0028] In formulae (1) and (2) above, x is an integer of 1 or more and preferably an integer of 1 to 12. When x is small, extreme pressure performance declines, while on the other hand, when x is excessively large, thermal oxidation stability tends to decline. In order to attain both extreme pressure performance and thermal oxidation stability, x is preferably an integer of 1 to 10, more preferably an integer of 1 to 8, and particularly preferably an integer of 2 to 5. For a sulfur-based extreme pressure agent expressed by formulae (1) and (2), it is considered that x is not a single substance but a mixture of substances having different numbers of sulfur atoms, and a compound having a specific number of sulfur atoms selected therefrom can function as active sulfur.

[0029] Examples of a sulfur-based extreme pressure agent will be further described below.

[0030] Sulfurized olefins are obtained by sulfurizing olefins. They are collectively referred to as sulfide compounds including those obtained by sulfurizing hydrocarbon materials other than olefins.

[0031] Sulfurized olefins may be obtained by, for example, sulfurizing olefins such as polyisobutylenes and terpenes with sulfur or other sulfurizing agents.

[0032] Examples of sulfide compounds other than sulfurized olefins include diisobutyl disulfide, dioctyl polysulfide, di-tert-butyl polysulfide, diisobutyl polysulfide, dihexyl polysulfide, di-tert-nonyl polysulfide, didecyl polysulfide, didodecyl polysulfide, di-isobutylene polysulfide, dioctenyl polysulfide, and dibenzyl polysulfide.

[0033] Sulfurized oil or fat is a reaction product of oil or fat and sulfur. It can be obtained by a sulfurization reaction with the use of animal or vegetable oil or fat such as lard, beef tallow, whale oil, palm oil, coconut oil, or rapeseed oil. The reaction product is not of a single species but a mixture of various substances, and the chemical structure itself is not always clear.

[0034] In addition to the above-described sulfurized oils and fats, examples of sulfurized esters may be obtained by sulfurizing ester compounds obtained through reaction between various organic acids (e.g., saturated fatty acid, unsaturated fatty acid, dicarboxylic acid, and aromatic carboxylic acid) and various alcohols with sulfur and other sulfurizing agents. As with sulfurized oil or fat, the chemical structures themselves are not always clear.

[0035] The content of the above-described sulfur-based extreme pressure agent in the lubricant composition of the present invention is from 5% by weight to 15% by weight and preferably from 6% by weight to 12% by weight based on the total weight of the lubricant composition. The present invention is also characterized in that the content of a sulfur-based extreme pressure agent is greater when compared with conventional lubricant compositions. When the content is above the upper limit, it tends to cause reduction of thermal oxidation stability and generation of sludge, and further tends to cause metallic corrosion, which is not preferable. In addition, when the content is below the lower limit, scoring prevention performance declines, which is not preferable.

(C) Phosphorus-based extreme pressure agent and sulfur-containing phosphorus-based extreme pressure agent

[0036] The lubricant composition of the present invention may further contain, as an optional component, a phosphorus-based extreme pressure agent and/or a sulfur-containing phosphorus-based extreme pressure agent. Note that a sulfur element contained in the sulfur-containing phosphorus-based extreme pressure agent specified herein is not sulfur measured in accordance with ASTM D1662 (active sulfur), and therefore, the extreme pressure agent is distinguished from the above-mentioned sulfur-based extreme pressure agent.

[0037] A phosphorus-based extreme pressure agent and a sulfur-containing phosphorus-based extreme pressure agent are not particularly limited, and thus, they may be conventionally known products. For example, they are each preferably at least one selected from phosphoric acid esters, acidic phosphoric acid esters, phosphorous acid esters, acidic phosphorous acid esters, thiophosphoric acid esters, acidic thiophosphoric acid esters, thiophosphorous acid esters, acidic thiophosphorous acid esters, amine salts of acidic phosphoric acid esters, amine salts of acidic phosphorous acid esters, amine salts of acidic thiophosphoric acid esters, amine salts of acidic thiophosphorous acid esters, phosphoric acid, and phosphorous acid.

[0038] Phosphoric acid esters and acidic phosphoric acid esters are represented by $(R^1O)_aP(=O)(OH)_{3-a}$. a is 0, 1, 2, or 3. R^1 is independently a monovalent hydrocarbon group having 4 to 30 carbon atoms. Here, when a = 0, it means phosphoric acid, and when a = 1 or 2, it means an acidic phosphoric acid ester.

[0039] Phosphorous acid esters and acidic phosphorous acid esters are represented by $(R^2O)_bP(=O)(OH)_{2-b}H$. b is 0, 1, or 2. R^2 is independently a monovalent hydrocarbon group having 4 to 30 carbon atoms. Here, when b = 0, it means phosphorous acid, and when b = 1, it means an acidic phosphorous acid ester.

[0040] Thiophosphoric acid esters and acidic thiophosphoric acid esters are represented by $(R^3X^1)(R^4X^2)(R^5X^3)P(=X^4)$. R^3, R^4, and R^5 are hydrogen atoms or monovalent hydrocarbon groups having 4 to 30 carbon atoms. Here, when one or two of R^3, R^4, and R^5 are each a hydrogen atom, it means an acidic thiophosphoric acid ester. X^1, X^2, X^3, and X^4 are each independently an oxygen atom or a sulfur atom. Note that at least one of X^1, X^2, X^3, and X^4 is a sulfur atom.

[0041] Thiophosphorous acid esters are represented by $(R^6X^5)(R^7X^6)P(=X^7)H$. R^6 and R^7 are each independently a hydrogen atom or a monovalent hydrocarbon group having 4 to 30 carbon atoms. Here, when one of R^6 and R^7 is a hydrogen atom, it means an acidic thiophosphoric acid ester. X^5, X^6, and X^7 are each independently an oxygen atom or a sulfur atom. Note that at least one of X^5 , X^6, and X^7 is a sulfur atom.

[0042] Phosphoric acid esters and acidic phosphoric acid esters are, but are not limited to, preferably phosphoric acid monoalkyl esters, phosphoric acid dialkyl esters, and phosphoric acid trialkyl esters.

[0043] Phosphorous acid esters and acidic phosphorous acid esters are preferably, but not limited to, phosphorous acid monoalkyl esters and phosphorous acid dialkyl esters.

[0044] Thiophosphoric acid esters and acidic thiophosphoric acid esters are preferably, but not limited to, thiophosphoric acid monoalkyl esters, thiophosphoric acid dialkyl esters, and thiophosphoric acid trialkyl esters.

[0045] Thiophosphorous acid esters are preferably, but not limited to, thiophosphorous acid monoalkyl esters and thiophosphorous acid dialkyl esters.

[0046] More specifically, examples of phosphoric acid esters, phosphorous acid esters, thiophosphoric acid esters, and thiophosphorous acid esters include, but are not limited to, monooctyl phosphate, dioctyl phosphate, trioctyl phosphate, monooctyl phosphite, dioctyl phosphite, monooctyl thiophosphate, dioctyl thiophosphate, trioctyl thiophosphate, monooctyl thiophosphite, dioctyl thiophosphite, monododecyl phosphate, didodecyl phosphate, tridodecyl phosphate, monododecyl phosphite, didodecyl phosphite, monododecyl thiophosphate, didodecyl thiophosphate, tridodecyl thiophosphate, monododecyl thiophosphite, didodecyl thiophosphite, monooctadecenyl phosphate, dioctadecenyl phosphate, trioctadecenyl phosphate, monooctadecenyl phosphite, dioctadecenyl phosphite, monooctadecenyl thiophosphate, dioctadecenyl thiophosphate, trioctadecenyl thiophosphate, monooctadecenyl thiophosphite, and dioctadecenyl thiophosphite.

[0047] Further, alkylamine salts and alkenyl amine salts of those selected from the above compounds which are partially esterified may also be suitably used. In other words, amine salts of acidic phosphoric acid esters, amine salts of acidic phosphorous acid esters, amine salts of acidic thiophosphoric acid esters, and amine salts of acidic thiophosphorous acid esters can be used while the present invention is not limited thereto.

[0048] More specifically, examples thereof include amine salts of monooctyl phosphate, amine salts of dioctyl phosphate, amine salts of monooctyl phosphite, amine salts of monooctyl thiophosphate, amine salts of dioctyl thiophosphate, amine salts of monooctyl thiophosphite, amine salts of monododecyl phosphate, amine salts of didodecyl phosphate, amine salts of monododecyl phosphite, amine salts of monododecyl thiophosphate, amine salts of didodecyl phosphate, amine salts of monooctadecenyl phosphate, amine salts of dioctadecenyl phosphate, amine salts of monooctadecenyl phosphite, amine salts of monooctadecenyl thiophosphate, amine salts of dioctadecenyl thiophosphate, and amine salts of monooctadecenyl thiophosphite.

[0049] Incidentally, amine in an amine salt is represented by $R^8R^9R^{10}N$. R^8, R^9, and R^{10} are each independently hydrogen or a saturated or unsaturated aliphatic hydrocarbon group having a linear or branched structure containing 1 to 20 carbon atoms. More specifically, examples thereof include a methyl group, an ethyl group, a propyl group, a butyl group, a nonyl group, a dodecyl group, a propenyl group, a butenyl group, and an oleyl group.

[0050] The above-described phosphorus-based extreme pressure agents and sulfur-containing phosphorus-based extreme pressure agents can be used singly or two or more thereof can be used in combination. When they are used in combination, they can be used in, for example, the following embodiments but are not limited thereto.

(1) A combination of an amine salt of a thiophosphoric acid ester and an amine salt of a phosphoric acid ester, which is especially a combination of an amine salt of a thiophosphoric acid ester having an alkyl group and an amine salt of a phosphoric acid ester having an alkyl group
(2) A combination of an amine salt of a thiophosphoric acid ester and a phosphoric acid ester, which is especially a combination of an amine salt of a thiophosphoric acid ester having an alkyl group and a phosphoric acid ester having an alkyl group
(3) A combination of an amine salt of a phosphoric acid ester and a thiophosphoric acid ester, which is especially a combination of an amine salt of a phosphoric acid ester having an alkyl group and a thiophosphoric acid ester having an alkyl group
(4) A combination of a thiophosphoric acid ester and a phosphoric acid ester, which is especially a combination of a thiophosphoric acid ester having an alkyl group and a phosphoric acid ester having an alkyl group

[0051] The amounts of the above-described phosphorus-based extreme pressure agents and sulfur-containing phosphorus-based extreme pressure agents to be added are not limited and can be appropriately adjusted. For example, the amount of such extreme pressure agent is preferably 10% by weight or less, more preferably from 1% to 8% by weight, and still more preferably from 2% to 6% by weight based on the total weight of the lubricant composition. When the content is above the upper limit, it may exacerbate scoring prevention performance on a tooth surface or the like, which is not preferable. When the content is not less than the lower limit based on the total weight of the lubricant composition, it further contributes to wear prevention performance.

(D) Ashless dispersant

[0052] The lubricant composition of the present invention may further comprise an ashless dispersant. Conventionally known ashless dispersants can be used without particular limitations. Examples thereof include a nitrogen-containing compound which has in its molecule at least one alkyl group or alkenyl group having a linear or branched structure containing 40-400 carbon atoms, and derivatives thereof, and a modified alkenyl succinimide. One type of ashless dispersant may be used singly or two or more types of ashless dispersants may be used in combination. It is also possible to use a boronated ashless dispersant. A boronated ashless dispersant are obtained by boronating any ashless dispersant used in lubricants. In general, boronation is carried out by allowing boric acid to act on an imide compound, thereby neutralizing a part or all of remaining amino and/or imino groups remain.

[0053] The above-described alkyl group or alkenyl group has preferably 40 to 400 carbon atoms and more preferably 60 to 350 carbon atoms. When the numbers of carbon atoms of alkyl and alkenyl groups are below the lower limit, solubility of the compound in a lubricant base oil tends to decline. In addition, when the numbers of carbon atoms of alkyl and alkenyl groups are above the upper limit, low-temperature fluidity of the lubricant composition tends to deteriorate. The alkyl and alkenyl groups each may have a linear or branched structure. Preferable examples thereof include a branched alkyl or alkenyl group derived from oligomer of olefin such as propylene, 1-butene, or isobutylene, and cooligomer of ethylene and propylene.

[0054] One type of alkenyl succinimide is so-called mono-type succinimide which is a reaction product of one end of polyamine and succinic anhydride and another type of alkenyl succinimide is a so-called bis-type succinimide which is a reaction product of both ends of polyamine and succinic anhydride. The lubricant composition of the present invention may comprise either or both of mono-type and bis-type succinimides.

[0055] The above-described modified alkenyl succinimide is obtained by, for example, modifying alkenyl succinimide with a boron compound (hereinafter sometimes referred to as "boronated succinimide"). Modifying with a boron compound means boronation. Boronated succinimide may be used singly or in combination of two or more thereof. In the case of combination use, two or more types of boronated succinimide may be used in combination. In addition, both of mono-type and bis-type succinimides may be contained. Mono-type or bis-type succinimides may be used in combination. Alternatively, boronated succinimide and non-boronated succinimide may be used in combination.

[0056] Examples of a method of producing boronated succinimide include methods disclosed in Japanese Examined Patent Publication (Kokoku) Nos. S42-8013 and S42-8014, and Japanese Unexamined Patent Publication (Kokai) Nos. S51-52381 and S51-130408. Specifically, it is possible to obtain boronated succinimide by, for example, mixing polyamine, polyalkenyl succinic acid (anhydride), and a boronated compound such as boric acid, boric acid ester, or borate with an organic solvent such as alcohol, hexane, or xylene, a light lubricant base oil, and the like, and heat-treating the mixture under appropriate conditions. The boron content in boronated succinimide obtained in such manner can be usually set to 0.1% to 4% by weight. In the present invention, a boron-modified compound of alkenyl succinimide (boronated succinimide) is particularly preferable because it is excellent in terms of heat resistance, oxidation resistance, and wear prevention performance.

[0057] The content of boron in a boronated ashless dispersant is usually, but not limited to, from 0.1% to 3% by weight based on the weight of the ashless dispersant. In one embodiment of the present invention, the content of boron in the ashless dispersant is preferably not less than 0.2% by weight, more preferably not less than 0.4% by weight, while it is preferably not more than 2.5% by weight, more preferably not more than 2.3% by weight, and still more preferably not more than 2.0% by weight. Such boronated ashless dispersant is preferably boronated succinimide and particularly preferably boronated bis-succinimide.

[0058] The boronated ashless dispersant has a boron/nitrogen weight ratio (B/N ratio) of not less than 0.1 and preferably not less than 0.2 while it is preferably less than 1.0 and more preferably not more than 0.8.

[0059] The content of the ashless dispersant in the composition may be appropriately adjusted. For example, it is preferably from 0.01% to 20% by weight and more preferably from 0.1% to 10% by weight based on the total weight of the lubricant composition. When the content of the ashless dispersant is below the lower limit, sludge dispersibility may become insufficient. In addition, when the content is above the upper limit, it may cause deterioration of a specific rubber material or low-temperature fluidity.

(E) Other additives

[0060] The lubricant composition of the present invention may comprise, as additives other than above components (A) to (D), a viscosity index improver, an antioxidant, a metallic cleaner, a friction modifier, a corrosion inhibitor, a rust inhibitor, a demulsifier, a metal deactivator, a defoamer, and a pour point depressant. However, as the lubricant composition of the present invention is not a grease, it does not comprise any thickening agent. The thickening agent is, for example, a metal soap or metal salt.

[0061] Examples of a viscosity index improver include a so-called non-dispersant viscosity index improver such as a polymer or copolymer of one type or two or more types of monomers selected from various methacrylic acid esters or a hydrogenated product thereof, a so-called dispersant viscosity index improver obtained by copolymerizing various methacrylic acid esters containing nitrogen compounds, a non-dispersant or dispersant ethylene-α-olefin copolymer (e.g., propylene, 1-butene, or 1-pentene as α-olefin) or a hydrogenated product thereof, polyisobutylene or a hydrogenated product thereof, a hydrogenated product of a styrene-diene copolymer, a styrene-maleic anhydride ester copolymer, and polyalkyl styrene.

[0062] The molecular weight of a viscosity index improver needs to be selected in consideration of shear stability of the lubricant composition. For example, the weight-average molecular weight of a viscosity index improver that can be used is usually from 5,000 to 1,000,000 and preferably from 100,000 to 900,000 for dispersant or non-dispersant polymethacrylate, it is usually from 800 to 5,000 and preferably from 1,000 to 4,000 for polyisobutylene or a hydrogenated product thereof, it is usually from 800 to 500,000 and preferably from 3,000 to 200,000 for an ethylene-α-olefin copolymer or a hydrogenated product thereof.

[0063] Of the above viscosity index improvers, when an ethylene-α-olefin copolymer or a hydrogenated product thereof is used, a lubricant composition which has particularly excellent shear stability can be obtained. One type or two or more types of compounds selected from the above-described viscosity index improvers in arbitrary amounts can be mixed. The content of a viscosity index improver in the lubricant composition is from 0.01% to 20% by weight, preferably from 0.02% to 10% by weight, and more preferably from 0.05% to 5% by weight based on the total amount of the composition.

[0064] Antioxidants may be those usually used in lubricants, which are, for example, ashless antioxidants such as phenolic antioxidants and amine antioxidants and organometallic antioxidants. It is possible to increase oxidation stability of the lubricant composition with the addition of an antioxidant.

[0065] Examples of a metallic cleaner include those containing compounds selected from sulfonate, phenate, salicylate, or carboxylate of calcium, magnesium, barium, or the like. It is possible to arbitrarily select and use overbased salts, basic salts, neutral salts, and the like having different base values. The content of a metallic cleaner blended in the lubricant composition is usually from 0.01% to 1% by weight in terms of an amount of metal.

[0066] Examples of a friction modifier include organomolybdenum compounds, fatty acids, fatty acid esters, fats and oils, alcohols, amines, and amides. A friction modifier is usually blended in an amount of 0.01% to 5% by weight in the lubricant composition.

[0067] Examples of a corrosion inhibitor include benzotriazole, tolyltriazole, thiadiazole and imidazole compounds. An antioxidant is usually blended in an amount of 0.1% to 5% by weight in the lubricant composition.

[0068] Examples of a rust inhibitor include petroleum sulfonates, alkyl sulfonates, fatty acids, fatty acid soaps, fatty acid amines, alkyl polyoxyalkylenes, alkenyl succinic acid esters, and polyhydric alcohol fatty acid esters. A rust inhibitor is usually blended in an amount of 0.01% to 5% by weight in the lubricant composition.

[0069] Examples of a demulsifier include polyalkylene glycol-based nonionic surfactants such as polyoxyethylene alkyl ethers, polyoxyethylene alkyl phenyl ethers, and polyoxyethylene alkyl naphthyl ethers. A demulsifier is usually blended in an amount of 0.01% to 5% by weight in the lubricant composition.

[0070] Examples of a metal deactivator include pyrroles, imidazoles, pyrazoles, pyrazines, pyrimidines, pyridazines, triazines, triazoles, thiazoles, and thiadiazoles. A metal deactivator is usually blended in an amount of 0.01% to 3% by weight in the lubricant composition.

[0071] Examples of a defoamer include dimethyl polysiloxanes and fluorinated derivatives thereof, polyacrylates and fluorinated derivatives thereof, and perfluoropolyethers. A defoamer is usually blended in an amount of 0.001% to 1% by weight in the lubricant composition.

[0072] As a pour point depressant, for example, a polymethacrylate-based polymer or the like, which is suitable for a lubricant base oil to be used, can be used. A pour point depressant is usually blended in an amount of 0.01% to 3% by weight in the lubricant composition.

[0073] Kinetic viscosity at 40°C of the lubricant composition of the present invention is preferably from 20 to 120 mm^2/s, more preferably from 40 to 100 mm^2/s, and still more preferably from 50 to 80 mm^2/s.

[0074] Kinetic viscosity at 100°C of the lubricant composition of the present invention is preferably from 3 to 40 mm^2/s, more preferably from 4 to 20 mm^2/s, still more preferably from 5 to 15 mm^2/s, and particularly preferably from 8 to 15 mm^2/s.

EXAMPLES

[0075] Hereinafter, the present invention will be described in more detail with reference to the Examples and Comparative Examples. However, the present invention is not limited to the Examples described below.

[0076] Components used in the Examples and Comparative Examples are as follows. Components described below are mixed with the compositions listed in Table 1 to prepare lubricant compositions. In the following description, KV40 represents kinetic viscosity at 40°C, KV100 represents kinetic viscosity at 100°C, and VI represents viscosity index.

(A) Lubricant base oil

[0077]

- Mineral oil-based base oil 1: KV40 = 19.0 mm^2/s, KV100 = 4 mm^2/s
- Synthetic base oil 1: Fischer-Tropsch-derived base oil, KV100 = 8 mm^2/s
- Synthetic base oil 2: Ethylene-α-olefin base oil, KV100 = 40 mm^2/s

(B) Sulfur-based extreme pressure agent

[0078] The following amounts of active sulfur were measured by the method in accordance with ASTM D1662 as the amounts of active sulfur in a sulfur-based extreme pressure agent.

- Sulfur-based extreme pressure agent 1: Sulfurized olefin (the amount of active sulfur = 11% by weight)
- Sulfur-based extreme pressure agent 2: Sulfurized olefin (the amount of active sulfur = 32% by weight)

(C) Phosphorus-based extreme pressure agent

[0079]

- Phosphorus-based extreme pressure agent 1: Amine salt of acidic phosphoric acid ester (C8-C18 alkyl)
- Phosphorus-based extreme pressure agent 2: Amine salt of acidic thiophosphoric acid ester (C8-C18 alkyl)

(D) Ashless dispersant

[0080]

- Boronated polybutenyl succinimide (bis-imide type): Molecular weight of polybutenyl group = 1,400, boron = 1.8% by weight, nitrogen = 2.4% by weight

(E) Other additives

[0081] Defoamer, pour point depressant, rust inhibitor

Table 1

	(% by weight)	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3
(A)	Mineral oil-based base oil 1	10.0	10.2	9.5	9.7	10.5	9.1	10.0
	Synthetic base oil 1	52.8	54.1	50.5	51.0	55.2	48.0	52.8
	Synthetic base oil 2	24.8	25.3	23.6	24.0	25.9	22.5	24.8
	Kinetic viscosity of base oil KV100*1	12	12	12	12	12	12	12
(B)	Sulfur-based extreme pressure agent 1	8.3	6.3	12.3	8.3	4.3	16.3	
	Sulfur-based extreme pressure agent 2							8.3
(C)	Phosphorus-based extreme pressure agent 1	1.8	1.8	1.8	3.6	1.8	1.8	1.8
	Phosphorus-based extreme pressure agent 2	1.1	1.1	1.1	2.2	1.1	1.1	1.1
(D)	Ashless dispersant	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Other additives	0.7	0.7	0.7	0.7	0.7	0.7	0.7
*1: Unit is mm^2/s								

[0082] Various properties were determined for each lubricant composition according to the method described below. Table 2 lists the results.

(1) Kinetic viscosity at 40°C (KV40)

[0083] Measurement was conducted in accordance with ASTM D445.

(2) Kinetic viscosity at 100°C (KV100)

[0084] Measurement was conducted in accordance with ASTM D445.

(3) Viscosity index

[0085] Measurement was conducted in accordance with ASTM D2270.

(4) Evaluation of wear performance

[0086] Testing was conducted in accordance with ASTM D2714 under the following conditions to evaluate the width of wear generated on a block sample piece after testing: oil temperature: 120°C; load: 20 1bf; number of revolutions: 1000 rpm; time: 1h. A wear width (mm) of not more than 0.5 was determined to be acceptable.

(5) Evaluation of scoring performance

[0087] Testing was conducted using a four-ball wear test machine stipulated by ASTM D4172 under the following conditions. The number of revolutions when seizure occurred was recorded: oil temperature: room temperature; load: 100 kgf; number of revolutions: increased by 100 rpm every 30 seconds. A number of revolutions (rpm) of more than 1000 was determined to be acceptable.

(6) Oxidation stability

[0088] Testing was conducted in accordance with JIS K2514-1 under the following conditions: oil temperature: 135°C; time: 96h. The content of pentane insolubles in tested sample oils after the testing was measured in accordance with ASTM D893 (B method). A content of pentane insolubles (% by weight) of not more than 2.0 was determined to be acceptable.

Table 2

Evaluation results	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3
Kinetic viscosity (KV40)	74	75	71	75	74	69	71
Kinetic viscosity (KV100)	11	12	11	11	11	11	11
Viscosity index (VI)	146	146	145	144	146	145	146
Wear prevention performance Wear width (mm)	0.37	0.38	0.39	0.40	-	-	0.63

(continued)

Evaluation results	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3
Scoring prevention performance Number of revolutions upon seizure (rpm)	1250	1113	1500	1138	1000	-	-
Oxidation stability Pentane insolubles (% by weight)	0.4	0.2	1.2	0.9	-	2.5	-

[0089] As is apparent from Table 2, it is understood that the lubricant composition of the present invention has excellent wear prevention performance, scoring prevention performance, and oxidation stability.

[0090] Meanwhile, in the case of Comparative Example 1 where the content of the sulfur-based extreme pressure agent was small, scoring prevention performance was insufficient, and in the case of Comparative Example 2 where the content of the sulfur-based extreme pressure agent was excessively large, oxidation stability was poor. In the case of Comparative Example 3 where the sulfur-based extreme pressure agent having a large amount of active sulfur was used, wear prevention performance was insufficient.

INDUSTRIAL APPLICABILITY

[0091] The lubricant composition of the present invention can suppress wear in a bearing or the like and scoring on a gear tooth surface or the like even when having a decreased viscosity. The lubricant composition of the present invention can be preferably used for automobile lubricants and particularly preferable for transmission gear oil and differential gear oils.

Claims

1. A lubricant composition comprising a lubricant base oil and a sulfur-based extreme pressure agent, wherein the amount of active sulfur in the extreme pressure agent is from 5% to 30% by weight, and the content of the extreme pressure agent in the composition is from 5% to 15% by weight based on the total weight of the lubricant composition.

2. The lubricant composition according to claim 1, wherein the sulfur-based extreme pressure agent is a sulfurized olefin.

3. The lubricant composition according to claim 1 or 2, wherein the lubricant composition has a kinetic viscosity at 100°C of 5 to 15 mm^2/s.

4. The lubricant composition according to any one of claims 1 to 3, wherein at least a part of the lubricant base oil is a Fischer-Tropsch-derived base oil.

5. The lubricant composition according to any one of claims 1 to 4, wherein at least a part of the lubricant base oil is a poly-α-olefin (PAO) base oil.

6. The lubricant composition according to any one of claims 1 to 5, wherein the lubricant base oil has a kinetic viscosity at 100°C of 5 to 15 mm^2/s.

7. The lubricant composition according to any one of claims 1 to 6, which is used for transmissions.

8. The lubricant composition according to any one of claims 1 to 6, which is used for differential gears.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/002825

A. CLASSIFICATION OF SUBJECT MATTER

C10M169/04(2006.01)i, *C10M105/04*(2006.01)i, *C10M107/02*(2006.01)i, *C10M135/04*(2006.01)i, *C10N20/02*(2006.01)n, *C10N30/00*(2006.01)n, *C10N30/06*(2006.01)n, *C10N40/04*(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10M169/04, C10M105/04, C10M107/02, C10M135/04, C10N20/02, C10N30/00, C10N30/06, C10N40/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

JSTPlus/JMEDPlus/JST7580(JDreamIII) keyword: GIYAYU, KYOKUATSUZAI, KASSEI IO (in Japanese) and related terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2007-326921 A (Sugimura Chemical Industrial Co., Ltd.), 20 December 2007 (20.12.2007), claims; paragraphs [0001], [0021] to [0022], [0036] to [0041]; table 1; examples 6 to 7, 10 (Family: none)	1-2,5 3-4,6-8
X Y	JP 2002-3879 A (Nippon Steel Corp.), 09 January 2002 (09.01.2002), claims; paragraphs [0052], [0064] to [0070]; examples 3, 7, 13 to 17, 19 to 21 (Family: none)	1-3,5-6 4

☒ Further documents are listed in the continuation of Box C.　　☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 16 March 2017 (16.03.17)	Date of mailing of the international search report 04 April 2017 (04.04.17)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2009/110452 A1 (Idemitsu Kosan Co., Ltd.), 11 September 2009 (11.09.2009), claims; paragraphs [0020] to [0021], [0026] to [0031]; table 1-1; examples 1, 7 to 9 & JP 2009-209325 A & CN 101965393 A & TW 200946672 A	1-3,5-6 4
X Y	JP 2003-253287 A (Yushiro Chemical Industry Co., Ltd.), 10 September 2003 (10.09.2003), claims; paragraphs [0012], [0016] to [0018]; table 1; example 4 (Family: none)	1-3,5-6 4
X Y	US 2005/0245403 A1 (HARRIS, Charles P. et al.), 03 November 2005 (03.11.2005), claims; paragraphs [0047] to [0049], [0064] to [0066]; tables 1 to 2; examples 2, 7 & DE 102005020663 A & CN 1749378 A	1-6 4
X	WO 2015/046008 A1 (DIC Corp.), 02 April 2015 (02.04.2015), paragraphs [0111] to [0120]; comparative examples 1 to 2 & US 2016/0215231 A1 paragraphs [0120] to [0128]; comparative examples 1 to 2 & JP 5896087 B2 & EP 3034492 A1 & CN 105579435 A & TW 201522295 A	1-2
Y	JP 2004-217797 A (Ethyl Japan Corp.), 05 August 2004 (05.08.2004), claims; paragraphs [0001] to [0004], [0014] to [0062] & US 2004/0147410 A1 claims; paragraphs [0001] to [0004], [0019] to [0065] & EP 1439216 A1 & KR 10-0583218 B1 & CN 1519302 A & SG 115584 A	3-4,6-8
P,X	WO 2016/022773 A1 (THE LUBRIZOL CORP.), 11 February 2016 (11.02.2016), claims; paragraphs [0066] to [0091]; table 1; examples 5 to 6 (Family: none)	1-6

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2007039480 A **[0003] [0005]**
- JP 2014012855 A **[0004] [0005]**
- JP S428013 B **[0056]**
- JP S428014 B **[0056]**
- JP S5152381 B **[0056]**
- JP S51130408 B **[0056]**