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(54) LUBRICANT OIL COMPOSITION, METHOD FOR PRODUCING LUBRICANT OIL COMPOSITION, AND METHOD FOR LUBRICATING TRANSMISSION GEAR OR REDUCTION GEAR

(57) To provide a lubricating oil composition which can achieve a good wear resistance even in a high temperature range where oil film is difficult to retain.

A lubricating oil composition containing a base oil (A), at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D), the base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein.

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Description

Technical Field

[0001] The present invention relates to a lubricating oil composition, a method for producing a lubricating oil composition, and a method for lubricating a transmission or a speed reducer.

Background Art

[0002] In recent years, from the viewpoint of reduction in carbon dioxide emission and in fossil fuel consumption, fuel saving in automobiles has been strongly demanded. For example, lubricating oil compositions for a transmission or a speed reducer of automobiles have been increasingly reduced in viscosity.

[0003] However, with reduction in viscosity of lubricating oil compositions, there arises a concern about decrease in wear resistance against fretting wear and the like.

[0004] In addition, in design of a transmission or a speed reducer, the size and weight thereof are being decreased. By decreasing the size and weight, the mechanical load on a lubricated site increases, and thus a lubricating oil composition to be filled is required to further increase in the wear resistance.

[0005] A typical example of a means for improving wear resistance of a lubricating oil composition is a technique of adding an anti-wear agent, such as zinc dialkylthiophosphate (PTLs 1 to 2).

Citation List

Patent Literature

[0006]

PTL 1: JP 2019-73572 A
PTL 2: JP 2018-21107 A

Summary of Invention

Technical Problem

[0007] However, the lubricating oil compositions of PTLs 1 to 2 were insufficient in improvement of the wear resistance in a high temperature range where oil film is difficult to retain.

Solution to Problem

[0008] The present invention has an object to provide a lubricating oil composition that can ensure a low viscosity thereof and that can achieve a good wear resistance even in a high temperature range where oil film is difficult to retain.

[0009] Specifically, the present invention provides the following [1] to [3].

[1] A lubricating oil composition containing a base oil (A), at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D), the base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein.

[2] A method for producing a lubricating oil composition, the method including a step of mixing a base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein, at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D).

[3] A method for lubricating a transmission or a speed reducer, the method including adding the lubricating oil composition according to the above [1] to a sliding part of the transmission or speed reducer.

Advantageous Effects of Invention

[0010] According to the present invention, it is possible to provide a lubricating oil composition that can ensure a low viscosity thereof and can achieve a good wear resistance even in a high temperature range where oil film is difficult to retain. Description of Embodiments

[Lubricating oil composition]

[0011] A lubricating oil composition of this embodiment contains a base oil (A), at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D), the base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein.

<Base oil (A)>

[0012] As the base oil (A) used in this embodiment, one or two or more selected from mineral oils and synthetic oils can be used.

[0013] The high viscosity in the high-viscosity base oil (A1) in the present invention means a 100°C kinematic viscosity of at least 25 mm^2/s or higher. The base oil (A) used in this embodiment has the high-viscosity base oil (A1) blended therein. As the high-viscosity base oil (A1), one or two or more selected from mineral oils and synthetic oils can be used.

[0014] When the high-viscosity base oil (A1) is not blended in the base oil (A), a good wear resistance cannot be achieved in a high temperature range where oil film is difficult to retain.

[0015] The high-viscosity base oil (A1) preferably has a 100°C kinematic viscosity of 25 to 300 mm^2/s, more preferably 27 to 250 mm^2/s, and further preferably 30 to 230 mm^2/s. Note that, in this description, the following (i) to (iv) are mentioned as an embodiment of a numerical range of the 100°C kinematic viscosity of the high-viscosity base oil (A1), but any of the upper limits of (i) to (iv) and any of the lower limits thereof can be combined. For example, the range of the 100°C kinematic viscosity of the high-viscosity base oil (A1) may be 25 to 250 mm^2/s. The same applies to numerical ranges in other components of this description. That is, when multiple embodiments are mentioned for a numerical range in another component of this description, any of the upper limits and any of the lower limits of the numerical ranges can be combined.

(i) a 100°C kinematic viscosity of 25 mm^2/s or higher
(ii) a 100°C kinematic viscosity of 25 to 300 mm^2/s
(iii) a 100°C kinematic viscosity of 27 to 250 mm^2/s
(iv) a 100°C kinematic viscosity of 30 to 230 mm^2/s

[0016] Note that, in this description, the kinematic viscosity and the viscosity index mean values measured or calculated according to JIS K2283:2003.

[0017] The high-viscosity base oil (A1) preferably has a 40°C kinematic viscosity of 200 to 3000 mm^2/s, more preferably 300 to 2500 mm^2/s, and further preferably 350 to 2200 mm^2/s.

[0018] The amount of the high-viscosity base oil (A1) blended is preferably 2.0 to 15.0% by mass, more preferably 3.0 to 10.0% by mass, and further preferably 4.0 to 8.0% by mass, based on the total amount of the base oil (A).

[0019] With an amount of the high-viscosity base oil (A1) blended of 2.0% by mass or more, a good wear resistance in a high temperature range where oil film is difficult to retain can be easily achieved. With an amount of the high-viscosity base oil (A1) blended of 15.0% by mass or less, an increase in kinematic viscosity of the lubricating oil composition can be suppressed, thus ensuring flowability of the lubricating oil composition at low temperature.

[0020] From the viewpoint of lowering the kinematic viscosity of the lubricating oil composition as a whole, the base oil (A) used in this embodiment preferably has a low viscosity base oil (A2) that has a 100°C kinematic viscosity of 2 to 12 mm^2/s blended therein in addition to the high-viscosity base oil (A1) having a 100°C kinematic viscosity of 25 mm^2/s or higher.

[0021] The low viscosity base oil (A2) preferably has a 100°C kinematic viscosity of 2.5 to 10 mm^2/s, and further preferably 3 to 8 mm^2/s.

[0022] The low viscosity base oil (A2) preferably has a 40°C kinematic viscosity of 10 to 40 mm^2/s, more preferably 15 to 37 mm^2/s, and further preferably 18 to 35 mm^2/s.

[0023] The amount of the low viscosity base oil (A2) blended is preferably 85.0 to 98.0% by mass, more preferably 90.0 to 97.0% by mass, and further preferably 92.0 to 96.0% by mass, based on the total amount of the base oil (A).

[0024] With an amount of the low viscosity base oil (A2) blended of 85.0% by mass or more, a low kinematic viscosity of the lubricating oil composition can be easily achieved. With an amount of the low viscosity base oil (A2) blended of 98.0% by mass or less, a too low kinematic viscosity of the lubricating oil composition can be easily inhibited.

[0025] An example of the mineral oil as the base oil (A), such as the high-viscosity base oil (A1) or the low viscosity base oil (A2), is a refined oil obtained by refining a distillate obtained by subjecting an atmospheric distillation residual oil (oil remaining after subjecting a crude oil, such as paraffin crude oil, intermediate base crude oil, and naphthene crude oil to atmospheric distillation to extract gas, gasoline, kerosene, and the like) to reduced-pressure distillation.

[0026] Examples of a refining method for obtaining the refined oil include hydroforming treatment, solvent extraction

treatment, solvent dewaxing treatment, hydroisomerization dewaxing treatment, hydrofinishing treatment, and clay treatment.

[0027] Examples of the synthetic oil as the base oil (A), such as the high-viscosity base oil (A1) or the low viscosity base oil (A2), include a hydrocarbon oil, an aromatic oil, an ester oil, and an ether oil. Another example thereof is a synthetic oil obtained by isomerizing a wax produced by Fischer-Tropsch process or the like (GTL wax).

[0028] Examples of the hydrocarbon oil include n-paraffin, isoparaffin, a poly-α-olefine (PAO), such as polybutene, polyisobutylene, 1-decene oligomer, cooligomer of 1-decene and ethylene, and a hydrogenated product thereof.

[0029] Examples of the aromatic oil include an alkylbenzene, such as a monoalkylbenzene or a dialkylbenzene; and an alkylnaphthalene, such as a monoalkylnaphthalene, a dialkylnaphthalene, and a polyalkylnaphthalene.

[0030] Examples of the ester oil include a diester oil, such as dibutyl sebacate, di-2-ethylhexyl sebacate, dioctyl adipate, diisodecyl adipate, ditridecyl adipate, ditridecyl glutarate, or methylacetyl ricinolate; an aromatic ester oil, such as trioctyl trimellitate, tridecyl trimellitate, or tetraoctyl pyromellitate; a polyol ester oil, such as trimethylolpropane caprylate, trimethylolpropane pelargonate, pentaerythrytol-2-ethylhexanoate, or pentaerythritol pelargonate; and a complex ester oil, such as an oligo ester of a polyhydric alcohol and a mixed fatty acid of a dibasic acid and a monobasic acid.

[0031] Examples of the ether oil include a polyglycol, such as polyethylene glycol, polypropylene glycol, polyethylene glycol monoether, and polypropylene glycol monoether; a phenyl ether oil, such as a monoalkyl triphenyl ether, an alkyldiphenyl ether, a dialkyldiphenyl ether, pentaphenyl ether, tetraphenyl ether, a monoalkyl tetraphenyl ether, or a dialkyl tetraphenyl ether.

[0032] The content of the base oil (A) is preferably 80.0 to 98.0% by mass, more preferably 85.0 to 96.0% by mass, and further preferably 87.0 to 95.0% by mass, based on the total amount of the lubricating oil composition.

[0033] The base oil (A) preferably has a 100°C kinematic viscosity of 4.0 to 8.0 mm^2/s, more preferably 4.3 to 7.0 mm^2/s, and further preferably 4.5 to 6.5mm^2/s.

[0034] The base oil (A) preferably has a 40°C kinematic viscosity of 15 to 45 mm^2/s, more preferably 18 to 40 mm^2/s, and further preferably 20 to 38 mm^2/s.

<Compound (B)>

[0035] The lubricating oil composition of this embodiment is required to contain at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2). When the compound (B) is not contained, a good wear resistance cannot be achieved in a high temperature range where oil film is difficult to retain.

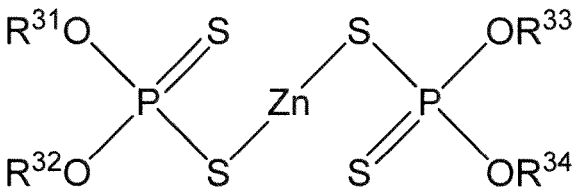
[0036] Note that, for achieving a good wear resistance in a high temperature range where oil film is difficult to retain, it is not enough that the lubricating oil composition contains the compound (B), and the lubricating oil composition is required to further contain the sarcosine compound (C) and the thiophosphate ester or an amine salt thereof (D) which are described later.

[0037] As the compound (B), at least one compound selected from the zinc dithiophosphate (B1) and the sulfurized olefin (B2) is contained.

<<Zinc dithiophosphate (B1)>>

[0038] A preferred example of the zinc dithiophosphate (B1) is a compound represented by the following general formula (III).

[Chem. 1]



(III)

[0039] In the general formula (I), R^{31} to R^{31} each independently represent a hydrocarbon group.

[0040] The hydrocarbon group as R^{31} to R^{34} is not particularly limited as long as it is a monovalent hydrocarbon group, and preferred examples thereof include an alkyl group, an alkenyl group, a cycloalkyl group, and an aryl group. An alkyl group and an aryl group are more preferred and an alkyl group is further preferred. Specifically, the zinc dithiophosphate used in this embodiment is preferably a zinc dialkyldithiophosphate or a zinc diaryldithiophosphate, and further preferably

a zinc dialkyldithiophosphate.

[0041] The alkyl group and alkenyl group as R^{31} to R^{34} may be either linear or branched.

[0042] When R^{31} to R^{34} are an alkyl group, taking into account the tendencies of a primary alkyl group which is superior in oxidation stability in a high temperature range and a secondary alkyl group which is superior in wear resistance, it is preferred to select either of the zinc dialkyldithiophosphate in which R^{31} to R^{34} are a primary alkyl group (a primary zinc dialkyldithiophosphate) or the zinc dialkyldithiophosphate in which R^{31} to R^{34} are a secondary alkyl group (a secondary zinc dialkyldithiophosphate), or to appropriately mix a primary zinc dialkyldithiophosphate and a secondary zinc dialkyldithiophosphate, depending on the property regarded to be important.

[0043] In an embodiment, it is preferred to mix a primary zinc dialkyldithiophosphate and a secondary zinc dialkyldithiophosphate at a mass ratio of 3:7 to 7:3 and more preferably at 4:6 to 6:4, from the viewpoint of the balance between oxidation stability and wear resistance.

[0044] The cycloalkyl group and the aryl group as R^{31} to R^{34} may be, for example, a polycyclic group, such as a decalyl group or a naphthyl group.

[0045] The monovalent hydrocarbon group as R^{31} to R^{34} may have a substituent containing an oxygen atom and/or a nitrogen atom, such as a hydroxy group, a carboxy group, an amino group, an amide group, a nitro group, or a cyano group, or may be partially substituted with a nitrogen atom, an oxygen atom, a halogen atom, or the like.

[0046] The number of carbon atoms in the hydrocarbon group as R^{31} to R^{34}, when the monovalent hydrocarbon group is an alkyl group, is preferably 1 or more, more preferably 2 or more, and further preferably 3 or more, and the upper limit thereof is preferably 24 or less, more preferably 18 or less, and further preferably 12 or less. When the monovalent hydrocarbon is an alkenyl group, the number of carbon atoms is preferably 2 or more and more preferably 3 or more, and the upper limit thereof is preferably 24 or less, more preferably 18 or less, and further preferably 12 or less. When the monovalent hydrocarbon is a cycloalkyl group, the number of carbon atoms is preferably 5 or more and the upper limit thereof is preferably 20 or less. When the monovalent hydrocarbon is an aryl group, the number of carbon atoms is preferably 6 or more and the upper limit thereof is preferably 20 or less.

<<Sulfurized olefin (B2)>>

[0047] An example of the sulfurized olefin (B2) is a compound represented by the following general formula (IV).

$$R^{41}\text{-Sa-}R^{42} \qquad \text{(IV)}$$

[0048] R^{41} and R^{42} each independently represent a monovalent substituent, and contain at least one element of carbon, hydrogen, oxygen, and sulfur. Specifically, an example of R^{41} and R^{12} is a saturated or unsaturated hydrocarbon group of a linear structure or a branched structure having 1 to 40 carbon atoms, and R^{41} and R^{42} may be an aliphatic hydrocarbon group having an aliphatic, aromatic, or aromatic group. In addition, an oxygen and or a sulfur atom may be contained therein. Note that R^{41} and R^{42} may bind to each other.

[0049] R^{41} is preferably an alkenyl group having 2 to 15 carbon atoms, and R^{42} is preferably an alkyl group or alkenyl group having 2 to 15 carbon atoms. a is an integer of 1 or larger, and preferably 1 to 12, more preferably 1 to 6.

[0050] The compound represented by the general formula (IV) can be obtained, for example, by reacting an olefin having 2 to 15 carbon atoms or a dimer to tetramer thereof and a sulfurizing agent, such as sulfur or sulfur chloride. As the olefin having 2 to 15 carbon atoms, propylene, isobutene, and diisobutene are preferred. A specific example of the sulfurized olefin is sulfurized isobutylene.

[0051] The compound (B) may contain only either one of the zinc dithiophosphate (B1) and the sulfurized olefin (B2) or may contain both.

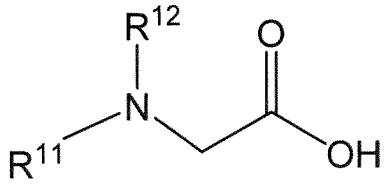
[0052] The content of the compound (B) is preferably 0.5 to 5.5% by mass, more preferably 1.0 to 5.0% by mass, and further preferably 1.5 to 4.5% by mass, based on the total amount of the lubricating oil composition. With a content of the compound (B) of 0.5% by mass or more, a good wear resistance in a high temperature range where oil film is difficult to retain can be easily achieved by synergistic effects with the component (C) and the component (D) described later. With a content of the compound (B) of 5.5% by mass or less, corrosion of cupper can be easily inhibited (an effect mainly of reduction of Bl), or occurrence of damage due to the fatigue life of a lubricated site can be easily inhibited (an effect mainly of reduction of B2).

<Sarcosine compound (C)>

[0053] The lubricating oil composition of this embodiment is required to contain the sarcosine compound (C). When the lubricating oil composition does not contain the sarcosine compound (C), even if it contains the compound (B), a good wear resistance can not be achieved in a high temperature range where oil film is difficult to retain.

[0054] An example of the sarcosine compound (C) is a compound represented by the following general formula (I).

[Chem. 2]



(I)

[In the formula (I), R^{11} represents a hydrocarbon group having 2 to 30 carbon atoms and R^{12} represents a hydrogen atom or a methyl group.]

[0055] The hydrocarbon group as R^{11} is not particularly limited as long as it is a monovalent hydrocarbon group, examples thereof include an alkyl group having 2 to 30 carbon atoms, a cycloalkyl group having 3 to 30 carbon atoms, and an alkenyl group having 3 to 30 carbon atoms. The monovalent hydrocarbon group may have a substituent containing an oxygen atom and/or nitrogen atom, such as a hydroxy group, a carboxy group, an amino group, an amide group, a nitro group, or a cyano group, or may be partially substituted with a nitrogen atom, an oxygen atom, a halogen atom, or the like.

[0056] The number of carbon atoms in the hydrocarbon group as R^{11} is preferably 8 to 26, more preferably 12 to 24, and further preferably 16 to 20. R^{11} is preferably an alkyl group or an alkenyl group which may have a substituent, and more preferably an alkenyl group which may have a substituent.

[0057] Examples of the alkyl group which may have a substituent that can be selected as R^{11} include an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, a hexadecyl group, an octadecyl group, a tetracosyl group, and a hexacosyl group. Note that the alkyl group may be a linear alkyl group or a branched alkyl group.

[0058] Examples of the cycloalkyl group which may have a substituent that can be selected as R^{11} include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, and an adamantyl group. Note that the cycloalkyl group may be substituted with an alkyl group having 1 to 10 (preferably 1 to 4) carbon atoms.

[0059] Examples of the alkenyl group which may have a substituent that can be selected as R^{11} include a propenyl group, a butenyl group, a pentenyl group, a hexenyl group, a heptenyl group, an octenyl group, a nonenyl group, a decenyl group, an undecenyl group, a dodecenyl group, a tridecenyl group, a tetradecenyl group, a hexadecenyl group, an octadecenyl group, a tetracosenyl group, and a hexacosenyl group. Note that the alkenyl group may be a linear alkenyl group or a branched alkenyl group. A specific example of the compound represented by the general formula (I) in which R^{11} is an alkenyl group which may have a substituent is N-oleoyl sarcosine (R^{11} has a carboxy group as a substituent and has 18 carbon atoms. R^{12} is a methyl group.).

[0060] The content of the sarcosine compound (C) is preferably 0.10 to 1.00% by mass, more preferably 0.12 to 0.80% by mass, and further preferably 0.15 to 0.60% by mass, based on the total amount of the lubricating oil composition.

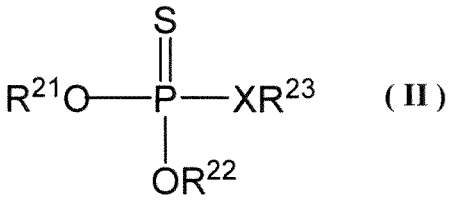
[0061] With a content of the sarcosine compound (C) of 0.10% by mass or more, a good wear resistance in a high temperature range where oil film is difficult to retain can be easily achieved by synergistic effects with the compound (B) and the thiophosphate ester or an amine salt thereof (D). With a content of the sarcosine compound (C) of 1.00% by mass or less, reduction in seize resistance can be easily suppressed.

<Thiophosphate ester or amine salt thereof (D)>

[0062] The lubricating oil composition of this embodiment is required to contain the thiophosphate ester or an amine salt thereof (D). When the lubricating oil composition does not contain the thiophosphate ester or an amine salt thereof (D), even if the compound (B) and the sarcosine compound (C) are contained, a good wear resistance cannot be achieved in a high temperature range where oil film is difficult to retain.

[0063] An example of the thiophosphate ester is a compound represented by the following general formula (II).

[Chem. 3]



(II)

[In the formula (II), R^{21} and R^{22} represent a hydrocarbon group having 1 to 20 carbon atoms and R^{21} and R^{22} may be the same as or different from each other. In the formula (II), X represents an oxygen atom or a sulfur atom. In the formula (II), R^{23} represents a hydrogen atom or a hydrocarbon group having 1 to 10 carbon atoms.]

[0064] The number of carbon atoms in the hydrocarbon group as R^{21} and R^{22} is preferably 1 to 16, more preferably 1 to 8, and further preferably 3 to 4.

[0065] Examples of the hydrocarbon group as R^{21} and R^{22} include an alkyl group, a cycloalkyl group, an alkylcycloalkyl group, an aryl group, and an alkylaryl group. More specific examples thereof include an n-butyl group, an isobutyl group, a tert-butyl group, a cyclopentyl group, a cyclohexyl group, a methylcyclopentyl group, a phenyl group, a benzyl group, a tolyl group (cresyl group), and a xylenyl group. The hydrocarbon group may be saturated or unsaturated, and may be linear or branched. Among them, a saturated hydrocarbon group is preferred and an alkyl group is particularly preferred.

[0066] The number of carbon atoms in the hydrocarbon group as R^{23} is preferably 1 to 8, more preferably 1 to 6, and further preferably 1 to 4.

[0067] Examples of the hydrocarbon group as R^{23} include an alkyl group, a cycloalkyl group, and an alkylcycloalkyl group. More specific examples include a methyl group and an ethyl group. The hydrocarbon group may be saturated or unsaturated, and may be linear or branched. Among them, a saturated hydrocarbon group is preferred and an alkyl group is particularly preferred.

[0068] A preferred example of the amine salt of the thiophosphate ester is an amine salt formed from a thiophosphate ester and an amine.

[0069] An example of the thiophosphate ester used for forming the amine salt is a compound represented by the general formula (II) in which XR^{23} is OH or SH.

[0070] Examples of the amine used for forming the amine salt include a primary amine, a secondary amine, and a tertiary amine which are represented by the general formula NR_3, and a polyalkyleneamine.

[0071] The primary to tertiary amines represented by the general formula NR_3 are preferably an amine in which one to three of R's are an aliphatic hydrocarbon group and the remaining R(s) is/are a hydrogen atom. Here, the aliphatic hydrocarbon group is preferably an alkyl group or an unsaturated hydrocarbon group having one to two unsaturated bonds, and the alkyl group and the unsaturated hydrocarbon group may each be any of linear, branched, or cyclic, but preferably linear.

[0072] Examples of the primary to tertiary amines represented by the general formula NR_3 include oleylamine, dilaurylamine, dimyristylamine, distearylamine, dioleylamine, trilaurylamine, trimyristylamine, tristearylamine, trioleylamine, and tallow alkyl amine.

[0073] Examples of the polyalkyleneamine include ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenehexamine, hexaethyleneheptamine, heptaethyleneoctamine, tetrapropylenepentamine, and hexabutyleneheptamine.

[0074] The content of the thiophosphate ester or an amine salt thereof (D) is preferably 0.05 to 1.00% by mass, more preferably 0.06 to 0.50% by mass, and further preferably 0.07 to 0.30% by mass, based on the total amount of the lubricating oil composition.

[0075] With a content of the thiophosphate ester or an amine salt thereof (D) of 0.05% by mass or more, a good wear resistance in a high temperature range where oil film is difficult to retain can be easily achieved by synergistic effects with the compound (B) and the sarcosine compound (C). With the content of the thiophosphate ester or an amine salt thereof (D) of 1.00% by mass or less, the wear due to the excess amount of the component (D) can be easily inhibited.

<Ratio of component (B), component (C), and component (D) blended>

[0076] In an embodiment of the lubricating oil composition, with the content of the compound (B) based on the total amount of the lubricating oil composition defined as W_B and the content of the sarcosine compound (C) based on the total amount of the lubricating oil composition defined as W_C, W_C/W_B is preferably 0.02 to 1.00, more preferably 0.03 to 0.50, further preferably 0.04 to 0.20, and furthermore preferably 0.05 to 0.15.

[0077] With W_C/W_B in the above range, the synergistic effect of the compound (B) and the sarcosine compound (C)

can be easily exhibited.

[0078] In an embodiment of the lubricating oil composition, with the content of the compound (B) based on the total amount of the lubricating oil composition defined as W_B and the content of the thiophosphate ester or an amine salt thereof (D) based on the total amount of the lubricating oil composition defined as W_D), W_D/W_B is preferably 0.01 to 1.00, more preferably 0.02 to 0.30, and further preferably 0.03 to 0.10.

[0079] With W_D/W_B in the above range, the synergistic effect of the compound (B) and the thiophosphate ester or an amine salt thereof (D) can be easily exhibited.

[0080] In an embodiment of the lubricating oil composition, with the content of the compound (B) based on the total amount of the lubricating oil composition defined as W_B, the content of the sarcosine compound (C) based on the total amount of the lubricating oil composition defined as W_C, and the content of the thiophosphate ester or an amine salt thereof (D) based on the total amount of the lubricating oil composition defined as W_D, $(W_C+W_D)/W_B$ is preferably 0.04 to 1.50, more preferably 0.05 to 0.75, further preferably 0.06 to 0.30, and furthermore preferably 0.07 to 0.20.

[0081] With $(W_C+W_D)/W_B$ in the above range, the synergistic effects of the compound (B) with the sarcosine compound (C) and the thiophosphate ester or an amine salt thereof (D) can be easily exhibited.

<Additives>

[0082] The lubricating oil composition of this embodiment can contain an additive other than the components (A) to (D) to the extent that the effect of the present invention is not impaired.

[0083] Examples of the additive include an ash-free dispersant, a metal-based detergent, an antioxidant, a metal deactivator, a viscosity index improver, a pour point depressant, and an anti-foaming agent. The amount of each additive blended is preferably 10% by mass or less, more preferably 7.5% by mass or less, and further preferably 5.0% by mass or less., based on the total amount of the lubricating oil composition

<Physical properties of lubricating oil composition>

[0084] In an embodiment of the lubricating oil composition, the lubricating oil composition preferably has a 100°C kinematic viscosity of 4.0 to 8.0 mm^2/s, more preferably 4.5 to 7.5 mm^2/s, and further preferably 4.7 to 7.2 mm^2/s.

[0085] When the lubricating oil composition has a 100°C kinematic viscosity of 4.0 mm^2/s or higher, reduction in oil film strength in a high temperature range can be easily suppressed. When the lubricating oil composition has a 100°C kinematic viscosity of 8.0 mm^2/s or less, a good fuel efficiency can be easily achieved.

[0086] In an embodiment of the lubricating oil composition, the lubricating oil composition preferably has a 40°C kinematic viscosity of 20 to 40 mm^2/s, more preferably 22 to 37 mm^2/s, and further preferably 23 to 35 mm^2/s.

<Application>

[0087] The lubricating oil composition of this embodiment can be suitably used in an application to a transmission or a speed reducer. Among transmissions, a manual transmission is useful. Note that the lubricating oil composition of this embodiment is also useful in an application to a speed-increaser.

[0088] In addition, this embodiment can provide a transmission, a speed reducer, and a speed increaser with the lubricating oil composition filled therein.

[Method for producing a lubricating oil composition]

[0089] The method for producing a lubricating oil composition of this embodiment includes a step of mixing a base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein, at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D).

[0090] According to the method for producing a lubricating oil composition of this embodiment, it is possible to produce in a simple manner a lubricating oil composition which ensure a low viscosity and can achieve a good wear resistance even in a high temperature range where oil film is difficult to retain.

[Lubrication method]

[0091] The method for lubricating a transmission or a speed reducer of this embodiment includes adding the lubricating oil composition of this embodiment described above to a sliding part of the transmission or speed reducer.

[0092] Note that a method for lubricating a speed increaser including adding the lubricating oil composition of this embodiment described above to a sliding part of the speed increaser is also useful.

Examples

[0093] Next, this embodiment is more specifically described with reference to examples but this embodiment is in no way limited by the examples.

1. Measurements and evaluations

1-1. Kinematic viscosity

[0094] A kinematic viscosity at each temperature was measured according to JIS K 2283:2000.

1-2. Wear resistance

[0095] Using a reciprocating dynamic friction tester (SRV Friction Tester manufactured by Optimol) described in DIN51834, a ball was placed as an upper test piece and a disk was placed as a lower test piece, a friction test was performed under the following conditions to measure a friction depth (unit: μm) generated in the disk after 60 minutes of the start of the test. The shallower the friction depth is, the better the wear resistance is.

<Test conditions>

[0096]

- Ball: diameter 10 mm, material AISI52100
- Disk: diameter 24 mm, thickness 7.8 mm, material AISI52100
- Frequency of vibration: 50 Hz
- Amplitude: 0.1 mm
- Load: 50 N
- Temperature: 120°C
- Test time: 60 minutes

2. Preparation of lubricating oil composition

[0097] The components shown in Table 1 were formulated to prepare each lubricating oil composition of Examples and Comparative Examples. Note that the details of the components are described later.

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Formulation	Base oil (A)	A1.1	7.0	-	-	-	7.0	7.0	7.0	-
		A1-2	-	-	4.0	-	-	-	-	-
		A1-3	-	7.0	-	-	-	-	-	-
		A1-4	-	-	-	-	-	-	-	-
		A2-1	86.6	86.6	89.6	89.6	-	86.7	86.8	88.1	93.6
		A2-2		-	-	-	85.6	-	-	-	-
	Compound (B)	B1-1	1.0	1.0	1.0	1.0	-	1.0	1.0	-	1.0
		B1-2	0.8	0.8	0.8	0.8	-	0.8	0.8	-	0.8
		B2	-	-	-	-	4.0	-	-	-	-
	Sarcosine compound (C)		0.2	0.2	0.2	0.2	0.2	0.2	-	0.2	0.2
	Amine salt of thiophosphate ester (D)		0.1	0.1	0.1	0.1	0.1	-	0.1	0.1	0.1
	Additive	Pour point depressant	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Ash-free dispersant	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Metal-based detergent	1.5	1.5	1.5	1.5	-	1.5	1.5	1.5	1.5
		Antioxidant	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
		Metal deactivator	0.1	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1
		Phosphorus compound	0.1	0.1	0.1	0.1	0.5	0.1	0.1	0.1	0.1
		Anti-foaming agent	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

(continued)

			Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Properties	Kinematic viscosity of base oil (A) [mm^2/s]	100°C	4.77	4.76	4.91	4.73	6.43	4.77	4.77	4.77	4.36
		40°C	23.3	23.3	23.2	22.9	36.0	23.3	23.3	23.3	20.1
	Kinematic viscosity of lubricating oil composition [$mm^2/.s$]	100°C	5.11	4.95	4.96	4.96	7	5.10	5.15	5.23	4.52
		40°C	25.3	24.4	24.5	24.5	35	25.3	25.35	25.41	21.5
Evaluation	Wear resistance [μm]		0.1	0.1	0.2	0.1	0.1	1.2	0.7	1.5	0.8

[0098] The details of the components in Table 1 are as follows.

<Base oil (A)>

<<High -viscosity base oil (A1)>>

[0099]

A1-1: mineral oil (bright stock, 100°C kinematic viscosity: 32 mm^2/s, 40°C kinematic viscosity: 500 mm^2/s)
A1-2: synthetic oil (PAO, 100°C kinematic viscosity: 150 mm^2/s, 40°C kinematic viscosity: 1600 mm^2/s)
A1-3: synthetic oil (polyisobutylene, 100°C kinematic viscosity: 30 mm^2/s, 40°C kinematic viscosity: 400 mm^2/s)
A1-4: synthetic oil (polyisobutylene, 100°C kinematic viscosity: 200 mm^2/s, 40°C kinematic viscosity: 2000 mm^2/s)

<<Low viscosity base oil (A2)>>

[0100]

A2-1: 100 N mineral oil (100°C kinematic viscosity: 4 mm^2/s, 40°C kinematic viscosity: 20 mm^2/s)
A2-2: 150 N mineral oil (100°C kinematic viscosity: 6 mm^2/s, 40°C kinematic viscosity: 33 mm^2/s)

<Compound (B)>

<<Zinc dithiophosphate (B1)>>

[0101]

B1-1: primary zinc alkyldithiophosphate (number of carbon atoms of alkyl group: 2 to 8)
B1-2: secondary zinc alkyldithiophosphate (number of carbon atoms of alkyl group: 2 to 8)

<<Sulfurized olefin (B2)>>

[0102] B2: sulfurized isobutylene

<Sarcosine compound (C)>

[0103] N-Oleoyl sarcosine

<Amine salt of thiophosphate ester(D)>

[0104] Amine salt of dibutyl thiophosphate and oleylamine

<Additives>

[0105]

- Pour point depressant (polymethacrylate, weight average molecular weight: 50000)
- Ash-free dispersant (polybutenyl succinimide)
- Metal-based detergent (calcium sulfonate, total base number: 300 mgKOH/g)
- Antioxidant (phenol-based antioxidant)
- Metal deactivator (thiadiazol compound)
- Phosphorus compound (ethyl-3-[[bis(1-methylethoxy)phosphinothioyl]thio]propionate)
- Anti-foaming agent (silicone compound)

[0106] As can be seen from the results in Table 1, the lubricating oil compositions of Examples can achieve a quite good wear resistance even in a high temperature range where oil film is difficult to retain (120°C) while retaining a low viscosity.

Industrial Applicability

[0107] The lubricating oil composition of the present invention is industrially extremely useful in that it can simultaneously achieve "low viscosity" and "wear resistance in a high temperature range" which have conventionally been difficult to simultaneously achieve.

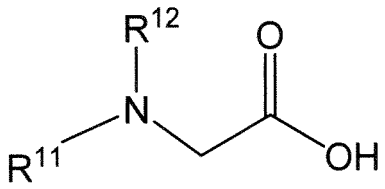
Claims

1. A lubricating oil composition comprising a base oil (A), at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D), the base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein.

2. The lubricating oil composition according to Claim 1, wherein the compound (B) is contained in an amount of 0.5 to 5.0% by mass based on the total amount of the lubricating oil composition.

3. The lubricating oil composition according to Claim 1 or 2, wherein the sarcosine compound (C) is a compound represented by the following general formula (I):

[Chem. 1]



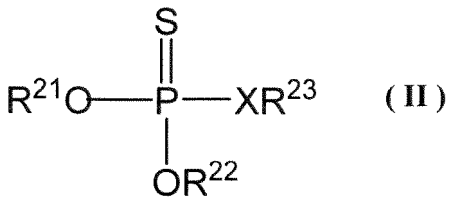
(I)

wherein R^{11} represents a hydrocarbon group having 2 to 30 carbon atoms and R^{12} represents a hydrogen atom or a methyl group.

4. The lubricating oil composition according to any one of claims 1 to 3, wherein the sarcosine compound (C) is contained in an amount of 0.10 to 1.00% by mass based on the total amount of the lubricating oil composition.

5. The lubricating oil composition according to any one of claims 1 to 4, wherein the thiophosphate ester is a compound represented by the following general formula (II):

[Chem. 2]



(II)

wherein R^{21} and R^{22} represent a hydrocarbon group having 1 to 20 carbon atoms and may be the same as or different from each other, X represents an oxygen atom or a sulfur atom, and R^{23} represents a hydrogen atom or a hydrocarbon group having 1 to 10 carbon atoms.

6. The lubricating oil composition according to any one of claims 1 to 5, wherein the thiophosphate ester or an amine salt thereof (D) is contained in an amount of 0.05 to 1.00% by mass based on the total amount of the lubricating oil composition.

7. The lubricating oil composition according to any one of claims 1 to 6, wherein, with the content of the compound

(B) based on the total amount of the lubricating oil composition defined as W_B and the content of the sarcosine compound (C) based on the total amount of the lubricating oil composition defined as W_C, W_C/W_B is 0.02 to 1.00.

8. The lubricating oil composition according to any one of claims 1 to 7, wherein, with the content of the compound (B) based on the total amount of the lubricating oil composition defined as W_B and the content of the thiophosphate ester or an amine salt thereof (D) based on the total amount of the lubricating oil composition defined as W_D, W_D/W_B is 0.01 to 1.00.

9. The lubricating oil composition according to any one of claims 1 to 8, wherein, with the content of the compound (B) based on the total amount of the lubricating oil composition defined as W_B, the content of the sarcosine compound (C) based on the total amount of the lubricating oil composition defined as W_C, and the content of the thiophosphate ester or an amine salt thereof (D) based on the total amount of the lubricating oil composition defined as W_D, $(W_C+W_D)/W_B$ is 0.04 to 1.50.

10. The lubricating oil composition according to any one of claims 1 to 9, wherein the lubricating oil composition has a 100°C kinematic viscosity of 4.0 to 8.0 mm^2/s.

11. The lubricating oil composition according to any one of claims 1 to 10, wherein the lubricating oil composition is for a transmission or a speed reducer.

12. A method for producing a lubricating oil composition, the method comprising a step of mixing a base oil (A) having a high-viscosity base oil (A1) that has a 100°C kinematic viscosity of 25 mm^2/s or higher blended therein, at least one compound (B) selected from a zinc dithiophosphate (B1) and a sulfurized olefin (B2), a sarcosine compound (C), and a thiophosphate ester or an amine salt thereof (D).

13. A method for lubricating a transmission or a speed reducer, the method comprising adding the lubricating oil composition according to any one of claims 1 to 10 to a sliding part of the transmission or speed reducer.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/026602

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. C10M169/04(2006.01)i, C10N20/02(2006.01)n, C10N30/06(2006.01)n, C10N40/04(2006.01)n, C10M133/16(2006.01)i, C10M135/04(2006.01)i, C10M137/10(2006.01)i
FI: C10M169/04, C10M137/10 A, C10M135/04, C10M133/16, C10M137/10 Z, C10N20:02, C10N40:04, C10N30:06

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)
Int. Cl. C10M169/04, C10N20/02, C10N30/06, C10N40/04, C10M133/16, C10M135/04, C10M137/10

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 10-306292 A (IDEMITSU KOSAN CO., LTD.) 17 November 1998, claims, examples 1-6	1-13
A	JP 9-263782 A (IDEMITSU KOSAN CO., LTD.) 07 October 1997, claims, examples 1-3	1-13
A	WO 2017/170811 A1 (IDEMITSU KOSAN CO., LTD.) 05 October 2017, claims, examples 1-28	1-13
A	JP 2014-129523 A (AFTON CHEMICAL CORP.) 10 July 2014, claims, examples 1-17	1-13
A	JP 2017-78138 A (JX ENERGY CORPORATION) 27 April 2017, claims, examples 1-8	1-13

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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
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"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09.09.2020	24.09.2020
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/026602

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2002/097017 A1 (NISSAN MOTOR CO., LTD.) 05 December 2002, claims, examples 1-26	1-13
A	JP 2000-001687 A (JAPAN ENERGY CORP.) 07 January 2000, claims, examples 1-3	1-13

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/026602

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 10-306292 A	17.11.1998	(Family: none)	
JP 9-263782 A	07.10.1997	US 6051536 A claims, examples 1-3 EP 798367 A2	
WO 2017/170811 A1	05.10.2017	CN 108884406 A TW 201807180 A	
JP 2014-129523 A	10.07.2014	US 2014/0179576 A1 claims, examples 1-17 EP 2746371 A1 CN 103881791 A KR 10-2014-0081748 A BR 102013033017 A SG 2013094826 A CA 2836635 A1	
JP 2017-78138 A	27.04.2017	(Family: none)	
WO 2002/097017 A1	05.12.2002	US 2004/0209786 A1 claims, examples 1-26 EP 1405897 A1 CN 1535307 A	
JP 2000-001687 A	07.01.2000	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2018021107 A **[0006]**