(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 506 438 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
12.02.2025 Bulletin 2025/07

(21) Application number: **23779780.8**

(22) Date of filing: **17.03.2023**

(51) International Patent Classification (IPC):
C10M 169/04 *(2006.01)* ***C10M 129/76*** *(2006.01)*
C10M 133/12 *(2006.01)* ***C10M 137/12*** *(2006.01)*
C10N 20/00 *(2006.01)* ***C10N 20/02*** *(2006.01)*
C10N 30/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
C10M 169/04; C10M 129/76; C10M 133/12; C10M 137/12

(86) International application number:
PCT/JP2023/010722

(87) International publication number:
WO 2023/189764 (05.10.2023 Gazette 2023/40)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **30.03.2022 JP 2022057701**

(71) Applicant: **Idemitsu Kosan Co.,Ltd.**
Tokyo 100-8321 (JP)

(72) Inventor: **SATO, Tokue**
Tokyo 100-8321 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) LUBRICATING OIL COMPOSITION, FLASH POINT IMPROVER, AND FLASH POINT IMPROVING METHOD

(57) Provided is a lubricating oil composition, containing: a lubricant base oil (X); a diphenylamine-based antioxidant (A); a naphthylamine-based antioxidant (B); and a phosphorus-containing phenol-based antioxidant (C), in which the lubricant base oil (X) satisfies requirements (1) to (4) below: - requirement (1): having a viscosity index of 120 or more, - requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more, - requirement (3): having a density at 15°C of 0.835 g/cm^3 or less, - requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more, a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

EP 4 506 438 A1

Description

Technical Field

[0001] The present invention relates to a lubricating oil composition, a flash point improver, and a method for improving a flash point. More specifically, the present invention relates to a lubricating oil composition, a flash point improver of a lubricant base oil, and a method for improving a flash point of a lubricant base oil.

Background Art

[0002] From the viewpoint of safety improvement, various methods for improving flash points of oils have been conventionally proposed.

[0003] For example, PTL 1 proposes a method of mixing an ester oil having a flash point of 220°C or more and an antioxidant having a molecular weight of 300 or more to improve the flash point of the ester oil.

Citation List

Patent Literature

[0004] PTL 1: JP 2021-175769 A

Summary of Invention

Technical Problem

[0005] Improvement of flash points can be required not only for ester oils but also for other oils.

[0006] The present inventors have intensively studied to improve the flash point of a paraffin-rich lubricant base oil having a viscosity index of 120 or more, a % C_P according to ring analysis (n-d-M method) of 85 or more, a density at 15°C of 0.835 g/cm^3 or less, and a specific kinematic viscosity.

[0007] However, the method proposed in PTL 1 is a method for improving the flash point of an ester oil, and a method for improving the flash point of the paraffin-rich lubricant base oil as described above has not been sufficiently studied so far.

[0008] Thus, an object of the present invention is to provide a lubricating oil composition with a high flash point containing a paraffin-rich lubricant base oil having a viscosity index of 120 or more, a % C_P according to ring analysis (n-d-M method) of 85 or more, a density at 15°C of 0.835 g/cm^3 or less, and a specific kinematic viscosity, a flash point improver for the lubricant base oil, and a method for improving the flash point of the lubricant base oil.

Solution to Problem

[0009] According to the present invention, the following [1] to [3] are provided.

[1] A lubricating oil composition, containing:

a lubricant base oil (X);
a diphenylamine-based antioxidant (A);
a naphthylamine-based antioxidant (B); and
a phosphorus-containing phenol-based antioxidant (C),
in which the lubricant base oil (X) satisfies requirements (1) to (4) below:

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more,

a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

[2] A flash point improver for a lubricant base oil, containing:

a diphenylamine-based antioxidant (A);
a naphthylamine-based antioxidant (B); and
a phosphorus-containing phenol-based antioxidant (C),
in which a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

[3] A method for improving a flash point of a lubricant base oil, including the step of:
blending the flash point improver according to [2] above into a lubricant base oil (X) that satisfies requirements (1) to (4) below to improve a flash point of the lubricant base oil (X):

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

Advantageous Effects of Invention

[0010] According to the present invention, there can be provided a lubricating oil composition with a high flash point containing a paraffin-rich lubricant base oil having a viscosity index of 120 or more, a % C_P according to ring analysis (n-d-M method) of 85 or more, a density at 15°C of 0.835 g/cm^3 or less, and a specific kinematic viscosity, a flash point improver for the lubricant base oil, and a method for improving the flash point of the lubricant base oil.

Description of Embodiments

[0011] Any upper limit value and any lower limit value of numerical ranges described in this specification can be combined. For example, when "A to B" and "C to D" are described as numerical ranges, the numerical ranges of "A to D" and "C to B" are also included in the scope of the present invention.
[0012] In addition, the numerical range "lower limit value to upper limit value" described in this specification means the lower limit value or more and the upper limit value or less, unless otherwise specified.
[0013] In the present specification, numerical values in the Examples are numerical values that can be used as an upper limit value or a lower limit value.

[Embodiment of lubricating oil composition]

[0014] The lubricating oil composition of the present embodiment contains a lubricant base oil (X); a diphenylamine-based antioxidant (A); a naphthylamine-based antioxidant (B); and a phosphorus-containing phenol-based antioxidant (C).
[0015] The lubricant base oil (X) satisfies requirements (1) to (4) below:

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

[0016] A content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio.
[0017] A content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.
[0018] The present inventor has conducted intensive studies to solve the above problem. As a result, the present inventors have found that (I) to (III) below are important to improve the flash point of the lubricant base oil (X).

(I) A diphenylamine-based antioxidant (A), a naphthylamine-based antioxidant (B), and a phosphorus-containing phenol-based antioxidant (C) are used in combination.
(II) A content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is

2.0 or more in mass ratio.
(III) A content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

[0019] Though the mechanism of improvement of the flash point of the lubricant base oil (X) is not clear, it is presumed that, for example, by (I) to (III) above being satisfied, some interaction occurs between the diphenylamine-based antioxidant (A), the naphthylamine-based antioxidant (B), and the phosphorus-containing phenol-based antioxidant (C), which exerts some influence on the flash point of the lubricant base oil (X).

[0020] In the following description, the "lubricant base oil (X)", the "diphenylamine-based antioxidant (A)", the "naphthylamine-based antioxidant (B)", and the "phosphorus-containing phenol-based antioxidant (C)" are also referred to as "component (X)", "component (A)", "component (B)", and "component (C)", respectively.

[0021] The lubricating oil composition of the present embodiment may be composed only of the "component (X)", the "component (A)", the "component (B)", and the "component (C)", but may contain components other than the "component (X)", the "component (A)", the "component (B)", and the "component (C)" within a range that does not depart from the spirit of the present invention.

[0022] In the lubricating oil composition of the present embodiment, the total content of the "component (X)", the "component (A)", the "component (B)", and the "component (C)" is preferably 80% by mass or more, more preferably 85% by mass or more, and further preferably 90% by mass or more based on the total amount of the lubricating oil composition.

[0023] Each component that constitutes the lubricating oil composition of the present embodiment will be described in detail below.

<Lubricant base oil (X)>

[0024] The lubricant base oil (X) satisfies requirements (1) to (4) below:

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

[0025] In the present specification, the kinematic viscosity at 40°C specified in the requirement (4) (hereinafter also referred to as "40°C kinematic viscosity") and the viscosity index specified in the requirement (1) mean values measured and calculated according to JIS K 2283: 2000.

[0026] In the present specification, the % C_P specified in the requirement (2) means a value calculated by ring analysis (n-d-M method) according to ASTM D 3238: 1995.

[0027] In the present specification, the density at 15°C specified in the requirement (3) means a value measured according to JIS K 2249-1: 2011 (Crude petroleum and petroleum products - Determination of density - Part 1: Oscillating U-tube method).

[0028] Examples of the lubricant base oil (X) include a base oil obtained by subjecting a distillate oil obtained by subjecting an atmospheric residue obtained by subjecting a paraffin-based crude oil to atmospheric distillation further to vacuum distillation to hydrogenolysis to obtain a bottom oil, and subjecting the bottom oil to one or more treatments of hydroisomerization dewaxing and hydrorefining. Examples thereof also include a base oil obtained by subjecting one or more stock oils selected from a high wax distillate oil, a slack wax, and a GTL wax to one or more treatments of hydroisomerization dewaxing and hydrorefining.

[0029] These base oils may be used alone or may be used as a mixed-base oil in which two or more kinds are combined. When a mixed-base oil is used, the mixed-base oil only needs to satisfy the requirements (1) to (4).

[0030] From the viewpoint of more easily improving the effects of the present invention, the density at 15°C specified in the requirement (3) is preferably 0.835 g/cm^3 or less, more preferably 0.832 g/cm^3 or less, further preferably 0.830 g/cm^3 or less, and further preferably 0.828 g/cm^3 or less. The density at 15°C is preferably 0.815 g/cm^3 or more.

[0031] From the viewpoint of more easily improving the effects of the present invention and from the viewpoint of easily improving the flash point of the lubricant base oil (X) itself, the kinematic viscosity at 40°C specified in the requirement (4) (hereinafter, also referred to as "40°C kinematic viscosity") is preferably 30.0 mm^2/s or more, more preferably 35.0 mm^2/s or more, and further preferably 41.4 mm^2/s or more. From the viewpoint of more easily improving the effects of the present invention, the kinematic viscosity at 40°C is preferably 50.6 mm^2/s or less, more preferably 48.0 mm^2/s or less, and further preferably 46.0 mm^2/s or less.

[0032] The upper limit of the viscosity index specified in the requirement (1) is not particularly limited, but is, for example, 180 or less.

[0033] The % C_P specified in the requirement (2) is 85 or more, preferably 87 or more, and more preferably 90 or more,

and the upper limit thereof is not particularly limited, but is, for example, 100 or less.

[0034] The flash point of the lubricant base oil (X) is usually 230°C or more, preferably 235°C or more, more preferably 240°C or more, and further preferably 245°C or more.

[0035] In the present specification, the flash point means a value measured according to JIS K 2265-4: 2007 by Cleveland open-cup (COC) method.

[0036] In the lubricating oil composition of the present embodiment, the content of the lubricant base oil (X) is preferably 90.0% by mass or more, more preferably 93.0% by mass or more, and further preferably 95.0% by mass or more based on the total amount of the lubricating oil composition. The content is preferably 99.7% by mass or less.

<Lubricant base oil (X')>

[0037] The lubricating oil composition of the present embodiment may further contain a lubricant base oil (X') that is different from the lubricant base oil (X).

[0038] Examples of the lubricant base oil (X') include one or more selected from the group consisting of a mineral oil that does not satisfy at least one of the requirements (1) to (4) and a synthetic oil that does not satisfy at least one of the requirements (1) to (4).

[0039] However, from the viewpoint of more easily improving the effects of the present invention, the content of the lubricant base oil (X') is preferably small.

[0040] Specifically, the content of the lubricant base oil (X') is preferably less than 50 parts by mass, more preferably less than 30% by mass, further preferably less than 10 parts by mass, further preferably less than 1 part by mass, and further preferably less than 0.1 parts by mass relative to 100 parts by mass of the lubricant base oil (X).

<Diphenylamine-based antioxidant (A)>

[0041] The lubricating oil composition of the present embodiment contains a diphenylamine-based antioxidant (A).

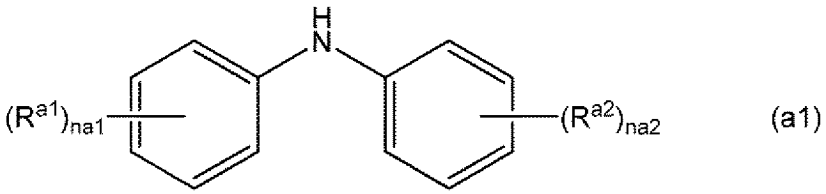
[0042] When the lubricating oil composition of the present embodiment does not contain the diphenylamine-based antioxidant (A), the effect of the present invention is not exhibited.

[0043] As the diphenylamine-based antioxidant (A), a diphenylamine-based antioxidant generally used as an antioxidant for a lubricating oil composition can be used.

[0044] The diphenylamine-based antioxidant (A) may be used alone or in combination of two or more kinds thereof.

[0045] In the lubricating oil composition of the present embodiment, the diphenylamine-based antioxidant (A) preferably contains a compound (A1) represented by general formula (a1) below from the viewpoint of more easily improving the effects of the present invention.

[0046] From the same viewpoint, the content of the compound (A1) in the diphenylamine-based antioxidant (A) is preferably 50% by mass to 100% by mass, more preferably 60% by mass to 100% by mass, further preferably 70% by mass to 100% by mass, further preferably 80% by mass to 100% by mass, further preferably 90% by mass to 100% by mass, and further preferably 95% by mass to 100% by mass based on the total amount of the diphenylamine-based antioxidant (A).



(a1)

[0047] In the general formula (a1), R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms.

[0048] When the carbon numbers of the alkyl groups are 1 to 30, the effect of the present invention is easily improved.

[0049] The carbon numbers of the alkyl groups which can be selected as R^{a1} and R^{a2} are each independently preferably 1 to 20, more preferably 4 to 16, and further preferably 4 to 14 from the viewpoint of more easily improving the effects of the present invention.

[0050] Specific examples of the alkyl groups that can be selected as R^{a1} and R^{a2} include a methyl group, 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 pentadecyl group, a hexadecyl group, a heptadecyl group, an octadecyl group, a nonadecyl group, an icosyl group, a henicosyl group, a docosyl group, a tricosyl group, a tetracosyl group, a pentacosyl group, a hexacosyl group, a heptacosyl group, an octacosyl group, a nonacosyl group, and a triacontyl group. These may be linear or branched.

[0051] In the general formula (a1), na1 and na2 are each independently an integer of 1 to 5.

[0052] From the viewpoint of more easily improving the effects of the present invention, na1 and na2 are each independently preferably 1 to 3, more preferably 1 to 2, and further preferably 1.

[0053] The compound (A1) may be used alone or in combination of two or more kinds thereof.

<Naphthylamine-based antioxidant (B)>

[0054] The lubricating oil composition of the present embodiment contains a naphthylamine-based antioxidant (B).

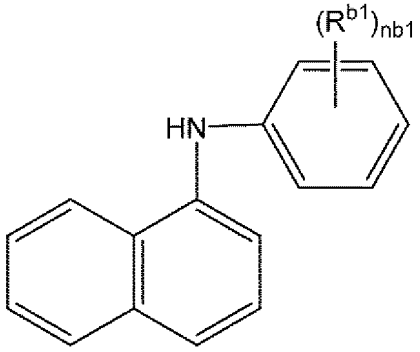
[0055] When the lubricating oil composition of the present embodiment does not contain the naphthylamine-based antioxidant (B), the effect of the present invention is not exhibited.

[0056] As the naphthylamine-based antioxidant (B), a naphthylamine-based antioxidant generally used as an antioxidant for a lubricating oil composition can be used.

[0057] The naphthylamine-based antioxidant (B) may be used alone or in combination of two or more kinds thereof.

[0058] In the lubricating oil composition of the present embodiment, the naphthylamine-based antioxidant (B) preferably contains a compound (B 1) represented by general formula (b 1) below from the viewpoint of more easily improving the effects of the present invention.

[0059] From the same viewpoint, the content of the compound (B 1) in the naphthylamine-based antioxidant (B) is preferably 50% by mass to 100% by mass, more preferably 60% by mass to 100% by mass, further preferably 70% by mass to 100% by mass, further preferably 80% by mass to 100% by mass, further preferably 90% by mass to 100% by mass, and further preferably 95% by mass to 100% by mass based on the total amount of the naphthylamine-based antioxidant (B).



(b1)

[0060] In the general formula (b1), R^{b1} is an alkyl group having 1 to 30 carbon atoms.

[0061] When the carbon numbers of the alkyl groups are 1 to 30, the effect of the present invention is easily improved.

[0062] The carbon numbers of the alkyl groups which can be selected as R^{b1} are each independently preferably 1 to 20, more preferably 4 to 16, and further preferably 4 to 14 from the viewpoint of more easily improving the effects of the present invention.

[0063] Specific examples of the alkyl groups which can be selected as R^{b1} include those exemplified as the alkyl groups which can be selected as R^{a1} and R^{a2}. The alkyl groups may be linear or branched.

[0064] In the general formula (b1), nb1 is an integer of 1 to 5.

[0065] From the viewpoint of more easily improving the effects of the present invention, nb1 is preferably 1 to 3, more preferably 1 to 2, and further preferably 1.

[0066] The compound (B1) may be used alone or in combination of two or more kinds thereof.

<Phosphorus-containing phenol-based antioxidant (C)>

[0067] The lubricating oil composition of the present embodiment contains a phosphorus-containing phenol-based antioxidant (C).

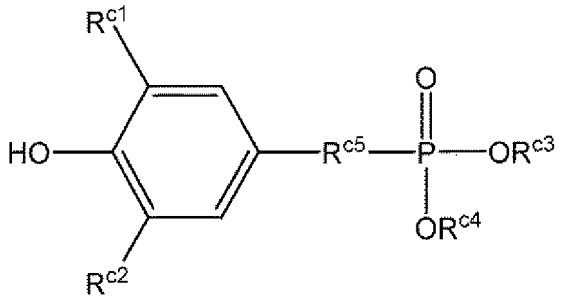
[0068] When the lubricating oil composition of the present embodiment does not contain the phosphorus-containing phenol-based antioxidant (C), the effect of the present invention is not exhibited.

[0069] As the phosphorus-containing phenol-based antioxidant (C), a phosphorus-containing phenol-based antioxidant generally used as an antioxidant for a lubricating oil composition can be used.

[0070] The phosphorus-containing phenol-based antioxidant (C) may be used alone or in combination of two or more kinds thereof.

[0071] In the lubricating oil composition of the present embodiment, the phosphorus-containing phenol-based antioxidant (C) preferably contains a compound (C1) represented by general formula (c1) below from the viewpoint of more easily improving the effects of the present invention.

[0072] From the same viewpoint, the content of the compound (C1) in the phosphorus-containing phenol-based antioxidant (C) is preferably 50% by mass to 100% by mass, more preferably 60% by mass to 100% by mass, further preferably 70% by mass to 100% by mass, further preferably 80% by mass to 100% by mass, further preferably 90% by mass to 100% by mass, and further preferably 95% by mass to 100% by mass based on the total amount of the phosphorus-containing phenol-based antioxidant (C).



(c1)

[0073] In the general formula (c1), R^{c1}, R^{c2}, R^{c3}, and R^{c4} are each independently a hydrogen atom or an alkyl group having 1 to 30 carbon atoms.

[0074] When the carbon numbers of the alkyl groups are 1 to 30, the effect of the present invention is more easily improved.

[0075] Examples of the alkyl groups which can be selected as R^{c1}, R^{c2}, R^{c3}, and R^{c4} include the same alkyl groups as those which can be selected as R^{a1} and R^{a2}.

[0076] However, the carbon numbers of the alkyl groups which can be selected as R^{c1}, R^{c2}, R^{c3}, and R^{c4} are each independently preferably 1 to 20, more preferably 1 to 10, and further preferably 1 to 6 from the viewpoint of more easily improving the effects of the present invention.

[0077] The compound (C1) preferably has a hindered phenol skeleton from the viewpoint of further easily improving the effect of the present invention. Thus, the alkyl groups which can be selected as R^{c1} and R^{c2} are preferably a branched alkyl group, more preferably a branched alkyl group having 1 to 6 carbon atoms, and further preferably a tert-butyl group.

[0078] In the general formula (c1), R^{c5} is an alkylene group having 1 to 5 carbon atoms.

[0079] The carbon numbers of the alkylene groups which can be selected as R^{c5} are preferably 1 to 4, more preferably 1 to 3, further preferably 1 to 2, and further preferably 1 from the viewpoint of more easily improving the effects of the present invention.

[0080] Specific examples of the alkylene groups which can be selected as R^{c5} include linear alkylene groups such as a methylene group, an ethylene group, an n-propylene group, an n-butylene group, and an n-pentylene group; and branched alkylene groups such as an isopropylene group, an isobutylene group, a sec-butylene group, a tert-butylene group, an isopentylene group, and a neopentylene group. Among these, a methylene group is preferred.

[0081] The compound (C1) may be used alone or in combination of two or more kinds thereof.

<Phosphorus-free phenol-based antioxidant (D)>

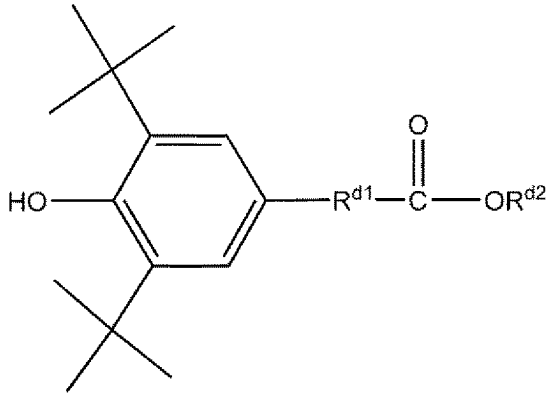
[0082] The lubricating oil composition of the present embodiment preferably further contains a phosphorus-free phenol-based antioxidant (D) from the viewpoint of more easily improving the effects of the present invention.

[0083] As the phosphorus-free phenol-based antioxidant (D), a phosphorus-free phenol-based antioxidant generally used as an antioxidant for a lubricating oil composition can be used.

[0084] The phosphorus-free phenol-based antioxidant (D) may be used alone or in combination of two or more kinds thereof.

[0085] In the lubricating oil composition of the present embodiment, the phosphorus-free phenol-based antioxidant (D) preferably contains a compound (D1) represented by general formula (d1) below from the viewpoint of further easily improving the effect of the present invention.

[0086] From the same viewpoint, the content of the compound (D1) in the phosphorus-free phenol-based antioxidant (D) is preferably 50% by mass to 100% by mass, more preferably 60% by mass to 100% by mass, further preferably 70% by mass to 100% by mass, further preferably 80% by mass to 100% by mass, further preferably 90% by mass to 100% by mass, and further preferably 95% by mass to 100% by mass based on the total amount of the phosphorus-containing phenol-based antioxidant (D).



(d1)

[0087] In the formula (d1), R^{d1} is an alkylene group having 1 to 5 carbon atoms.

[0088] The carbon numbers of the alkylene groups which can be selected as R^{d1} are preferably 1 to 4, more preferably 1 to 3, and further preferably 1 to 2 from the viewpoint of more easily improving the effects of the present invention.

[0089] Specific examples of the alkylene groups which can be selected as R^{d1} include linear alkylene groups such as a methylene group, an ethylene group, an n-propylene group, an n-butylene group, and an n-pentylene group; and branched alkylene groups such as an isopropylene group, an isobutylene group, a sec-butylene, a tert-butylene group, an isopentylene group, and a neopentylene group.

[0090] In the formula (d1), R^{d2} is an alkyl group having 1 to 25 carbon atoms.

[0091] The carbon numbers of the alkyl groups which can be selected as R^{d2} are preferably 2 or more, more preferably 4 or more, and further preferably 6 or more from the viewpoint of more easily improving the effects of the present invention. The carbon numbers are preferably 20 or less, more preferably 15 or less, and further preferably 10 or less. Any upper limit value and any lower limit value of these numerical ranges can be combined. Specifically, the carbon numbers are preferably 2 to 20, more preferably 4 to 15, and further preferably 6 to 10.

[0092] Specific examples of the alkyl groups that can be selected as R^{d2} include a methyl group, 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 pentadecyl group, a hexadecyl group, a heptadecyl group, an octadecyl group, a nonadecyl group, an icosyl group, a henicosyl group, a docosyl group, a tricosyl group, a tetracosyl group, and a pentacosyl group. These may be linear or branched.

[0093] The compound (D1) may be used alone or in combination of two or more kinds thereof.

<Content ratio [(B)/(A)] of component (B) to component (A)>

[0094] In the lubricating oil composition of the present embodiment, the content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) needs to be 2.0 or more in mass ratio.

[0095] When the [(B)/(A)] is less than 2.0, the effect of the present invention is not exhibited.

[0096] From the viewpoint of more easily improving the effects of the present invention, the [(B)/(A)] is preferably 2.1 or more, more preferably 2.2 or more, and further preferably 2.3 or more in mass ratio. The [(B)/(A)] is preferably 3.5 or less, more preferably 3.2 or less, and further preferably 3.0 or less.

[0097] Any upper limit value and any lower limit value of these numerical ranges can be combined. Specifically, the [(B)/(A)] is preferably 2.1 to 3.5, more preferably 2.2 to 3.2, and further preferably 2.3 to 3.0.

<Content ratio [(C)/(B)] of component (C) to component (B)>

[0098] In the lubricating oil composition of the present embodiment, the content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) needs to be 0.15 or less in mass ratio.

[0099] When the [(C)/(B)] is more than 0.15, the effect of the present invention is not exhibited.

[0100] From the viewpoint of more easily improving the effects of the present invention, the [(C)/(B)] is preferably 0.14 or less, more preferably 0.12 or less, and further preferably 0.10 or less in mass ratio. The [(C)/(B)] is preferably 0.03 or more, more preferably 0.04 or more, and further preferably 0.05 or more.

[0101] Any upper limit value and any lower limit value of these numerical ranges can be combined. Specifically, the [(C)/(B)] is preferably 0.03 to 0.14, more preferably 0.04 to 0.12, and further preferably 0.05 to 0.10.

<Total content of component (A), component (B), and component (C)>

[0102] In the lubricating oil composition of the present embodiment, the total content of the diphenylamine-based antioxidant (A), the naphthylamine-based antioxidant (B), and the phosphorus-containing phenol-based antioxidant (C) is preferably 0.30% by mass or more based on the total amount of the lubricating oil composition.

[0103] When the total content is within this range, the effect of the present invention is easily improved.

[0104] From the viewpoint of more easily improving the effects of the present invention, the total content is preferably 0.60% by mass or more, more preferably 0.80% by mass or more, and further preferably 1.0% by mass or more. The total content is preferably 5.0% by mass or less, more preferably 4.0% by mass or less, and further preferably 3.0% by mass or less from the viewpoint of obtaining an effect commensurate with the amount added while suppressing excessive addition of the component (A), the component (B), and the component (C).

[0105] Any upper limit value and any lower limit value of these numerical ranges can be combined. Specifically, the total content is preferably 0.60% by mass to 5.0% by mass, more preferably 0.80% by mass to 4.0% by mass, and further preferably 1.0% by mass to 3.0% by mass.

<Content of component (A)>

[0106] In the lubricating oil composition of the present embodiment, the content of the diphenylamine-based antioxidant (A) is preferably 0.08% by mass to 1.5% by mass, more preferably 0.10% by mass to 1.0% by mass, and further preferably 0.20% by mass to 0.80% by mass based on the total amount of the lubricating oil composition from the viewpoint of more easily improving the effects of the present invention.

<Content of component (B)>

[0107] In the lubricating oil composition of the present embodiment, the content of the naphthylamine-based antioxidant (B) is preferably 0.22% by mass to 3.1% by mass, more preferably 0.40% by mass to 2.5% by mass, and further preferably 0.60% by mass to 2.0% by mass based on the total amount of the lubricating oil composition from the viewpoint of more easily improving the effects of the present invention.

<Content of component (C)>

[0108] In the lubricating oil composition of the present embodiment, the content of the phosphorus-containing phenol-based antioxidant (C) is preferably 0.005% by mass to 0.40% by mass, more preferably 0.010% by mass to 0.30% by mass, and further preferably 0.015% by mass to 0.20% by mass based on the total amount of the lubricating oil composition from the viewpoint of more easily improving the effects of the present invention.

<Content of component (D)>

[0109] When the lubricating oil composition of the present embodiment contains the phosphorus-free phenol-based antioxidant (D), the content of the phosphorus-free phenol-based antioxidant (D) is preferably 0.40% by mass to 5.0% by mass, more preferably 0.90% by mass to 4.0% by mass, and further preferably 1.5% by mass to 3.0% by mass based on the total amount of the lubricating oil composition from the viewpoint of more easily improving the effects of the present invention.

<Content of component (D) relative to total content of component (A), component (B), and component (C)>

[0110] When the lubricating oil composition of the present embodiment contains the phosphorus-free phenol-based antioxidant (D), the content of the phosphorus-free phenol-based antioxidant (D) relative to the total content of the diphenylamine-based antioxidant (A), the naphthylamine-based antioxidant (B), and the phosphorus-containing phenol-based antioxidant (C) [(D)/{(A) + (B) + (C)}] is preferably 0.50 to 10.0, more preferably 0.70 to 8.0, and further preferably 0.80 to 6.0 in mass ratio.

<Additive for lubricating oil>

[0111] The lubricating oil composition of the present embodiment may contain an additive for a lubricating oil other than the components (A) to (D) as long as the effects of the present invention are not impaired.

[0112] Examples of the additive for a lubricating oil include an extreme pressure agent, a detergent additive, a pour point depressant, a viscosity index improver, a rust inhibitor, a metal deactivator, an anti-foaming agent, and a friction modifier.

[0113] These additives for a lubricating oil may be used alone or in combination of two or more kinds thereof.

[Physical properties of lubricating oil composition]

[0114] The flash point of the lubricating oil composition of the present embodiment is preferably 250°C or more, more preferably 260°C or more, further preferably 270°C or more, and further preferably 280°C or more.
[0115] In the present specification, the flash point means a value measured according to JIS K 2265-4: 2007 by Cleveland open-cup (COC) method.

[Method for producing lubricating oil composition]

[0116] The method for producing a lubricating oil composition of the present embodiment is not particularly limited.
[0117] For example, the method for producing a lubricating oil composition of the present embodiment includes the steps of:

mixing a lubricant base oil (X), a diphenylamine-based antioxidant (A), a naphthylamine-based antioxidant (B), and a phosphorus-containing phenol-based antioxidant (C), in which the lubricant base oil (X) satisfies requirements (1) to (4) below:

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more; and

adjusting a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) to 2.0 or more in mass ratio, and
adjusting a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) to 0.15 or less in mass ratio.

[0118] The production method may further include the step of blending a phosphorus-free phenol-based antioxidant (D) as necessary.
[0119] The production method may further include the step of blending the additive for a lubricating oil above as necessary.
[0120] The method for mixing the components is not particularly limited, and examples thereof include a method of blending the components into the lubricant base oil (X). The components may also be blended in the form of a solution (dispersion) obtained by the addition of a dilution oil or the like. After blending the components, the components are preferably stirred and uniformly dispersed by a known method.
[0121] Preferred embodiments of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.
[0122] The blending amounts and blending ratios of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are preferably blending amounts and blending ratios corresponding to the preferred contents and content ratios of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) above.

[Use of lubricating oil composition]

[0123] The lubricating oil composition of the present embodiment is preferably used as an industrial equipment oil. Examples of the industrial equipment oil preferably include a hydraulic oil; a turbine oil; compressor oils such as a rotary air compressor oil and a reciprocating air compressor oil; a machine tool oil; and a gear oil, more preferably include a turbine oil; and compressor oils such as a rotary air compressor oil and a reciprocating air compressor oil, and further preferably include a turbine oil.
[0124] Thus, in the present embodiment, there is provided a use method of using the lubricating oil composition as a hydraulic oil, a turbine oil, a compressor oil, a machine tool oil, or a gear oil. In the present embodiment, there is provided a use method of using the lubricating oil composition as a turbine oil or a compressor oil. Further, in the present embodiment, there is provided a use method of using the lubricating oil composition as a turbine oil.

[Flash point improver]

[0125] In the present embodiment, there is also provided the following flash point improver for a lubricant base oil.

[0126] A flash point improver for a lubricant base oil, containing: a diphenylamine-based antioxidant (A); a naphthylamine-based antioxidant (B); and a phosphorus-containing phenol-based antioxidant (C),

in which a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

[0127] The flash point improver for a lubricant base oil preferably further contain a phosphorus-free phenol-based antioxidant (D) from the viewpoint of more easily improving the flash point of a lubricant base oil.

[0128] The flash point improver for a lubricant base oil is particularly suitable for improving the flash point of the lubricant base oil (X) that satisfies requirements (1) to (4) below.

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

[0129] In the flash point improver for a lubricant base oil of the present embodiment, preferred embodiments of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.

[0130] In the flash point improver for a lubricant base oil of the present embodiment, the preferred content ratios of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.

[0131] The flash point improver for a lubricant base oil of the present embodiment can improve, for example, the flash point of the lubricant base oil (X) having a flash point in the range of 235°C or more (preferably 240°C or more) preferably by 10°C or more, and more preferably by 15°C or more.

[Method for improving flash point]

[0132] In the present embodiment, there is provided a method for improving a flash point of a lubricant base oil, including the step of: blending the flash point improver into a lubricant base oil (X) that satisfies requirements (1) to (4) below to improve a flash point of the lubricant base oil (X):

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

[0133] In the method for improving a flash point of a lubricant base oil of the present embodiment, preferred embodiments of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.

[0134] In the method for improving a flash point of a lubricant base oil of the present embodiment, the preferred content ratios of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.

[0135] According to the method for improving a flash point of a lubricant base oil of the present embodiment, for example, the flash point of the lubricant base oil (X) having a flash point in the range of 235°C or more (preferably 240°C or more) can be improved preferably by 10°C or more, and more preferably by 15°C or more.

[Composition]

[0136] In the present embodiment, the following composition is also provided.

[0137] A composition, containing: a diphenylamine-based antioxidant (A); a naphthylamine-based antioxidant (B); and a phosphorus-containing phenol-based antioxidant (C), in which a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and a content ratio [(C)/(B)] of the

phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

[0138] In the composition of the present embodiment, preferred embodiments of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.

[0139] In the composition of the present embodiment, preferred content ratios of the lubricant base oil (X), the component (A), the component (B), the component (C), and the component (D) are as described above.

[0140] In the present embodiment, there is also provided a method for improving the flash point of the lubricant base oil (X) using the composition.

[0141] Further, in the present embodiment, there is also provided use of the composition for improving the flash point of the lubricant base oil (X).

[0142] According to the method and use of the present embodiment, for example, the flash point of the lubricant base oil (X) having a flash point in the range of 235°C or more (preferably 240°C or more) can be improved preferably by 10°C or more, and more preferably by 15°C or more.

[One embodiment of present invention provided]

[0143] In one embodiment of the present invention, the following [1] to [11] are provided.

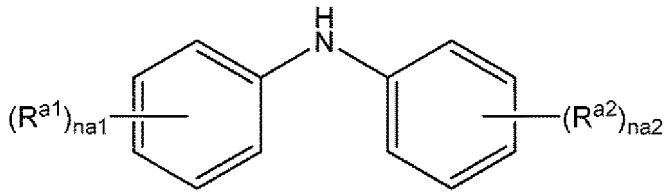
[1] A lubricating oil composition, containing:

a lubricant base oil (X);
a diphenylamine-based antioxidant (A);
a naphthylamine-based antioxidant (B); and
a phosphorus-containing phenol-based antioxidant (C),
in which the lubricant base oil (X) satisfies requirements (1) to (4) below:

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more,

a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

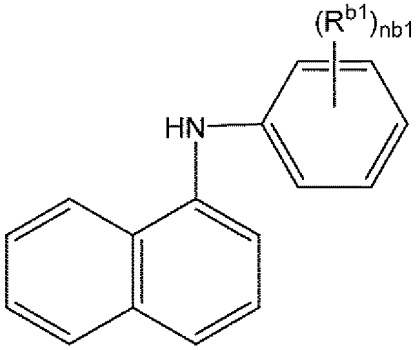
[2] The lubricating oil composition according to [1] above, in which the diphenylamine-based antioxidant (A) contains a compound (A1) represented by general formula (a1) below:



(a1)

[in which R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, and na1 and na2 are each independently an integer of 1 to 5.]

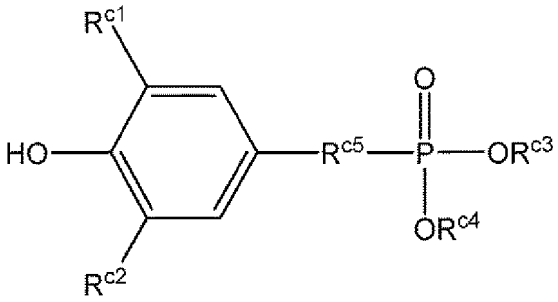
[3] The lubricating oil composition according to [1] or [2] above, in which the naphthylamine-based antioxidant (B) contains a compound (B1) represented by general formula (b1) below:



(b1)

[in which R^{b1} is an alkyl group having 1 to 30 carbon atoms, and nb1 is an integer of 1 to 5.]

[4] The lubricating oil composition according to any one of [1] to [3] above, in which the phosphorus-containing phenol-based antioxidant (C) contains a compound (C1) represented by general formula (c1) below:

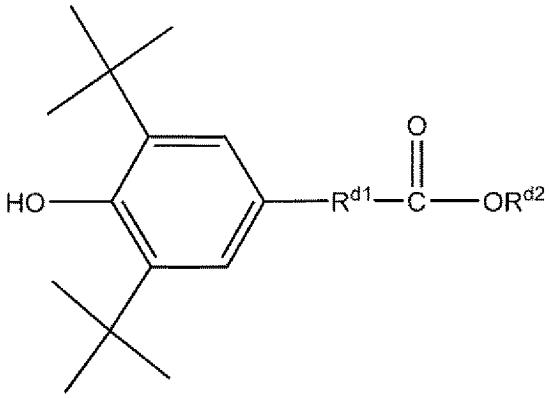


(c1)

[in which R^{c1}, R^{c2}, R^{c3}, and R^{c4} are each independently a hydrogen atom or an alkyl group having 1 to 30 carbon atoms, and R^{c5} is an alkylene group having 1 to 5 carbon atoms.]

[5] The lubricating oil composition according to any one of [1] to [4] above, further containing:
a phosphorus-free phenol-based antioxidant (D).

[6] The lubricating oil composition according to [5] above, in which the phosphorus-free phenol-based antioxidant (D) contains a compound (D1) represented by general formula (d1) below:



(d1)

[in which R^{d1} is an alkylene group having 1 to 5 carbon atoms, and R^{d2} is an alkyl group having 1 to 25 carbon atoms.]

[7] The lubricating oil composition according to any one of [1] to [6] above, in which a total content of the diphenylamine-based antioxidant (A), the naphthylamine-based antioxidant (B), and the phosphorus-containing phenol-based antioxidant (C) is 0.30% by mass or more based on a total amount of the lubricating oil composition.

[8] A flash point improver for a lubricant base oil, containing:

a diphenylamine-based antioxidant (A);
a naphthylamine-based antioxidant (B); and
a phosphorus-containing phenol-based antioxidant (C),
in which a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based

antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

[9] The flash point improver for a lubricant base oil according to [8] above, further containing:
a phosphorus-free phenol-based antioxidant (D).
[10] The flash point improver according to [8] or [9] above, in which the lubricant base oil is a lubricant base oil (X) that satisfies requirements (1) to (4) below, and the flash point improver is used for the lubricant base oil (X):

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

[11] A method for improving a flash point of a lubricant base oil, including the step of:
blending the flash point improver according to any one of [8] to [10] above into a lubricant base oil (X) that satisfies requirements (1) to (4) below to improve a flash point of the lubricant base oil (X):

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

Examples

[0144] The present invention will be more specifically described with reference to the following Examples. However, the present invention is not limited to the following Examples.

[Measurement method of various physical property values]

[0145] The properties of the base oils used in Examples and Comparative Examples were measured according to the following procedure.

(1) 40°C kinematic viscosity and viscosity index
Measurement and calculation were performed according to JIS K 2283:2000.
(2) % C_P
Calculation was performed by ring analysis (n-d-M method) according to ASTM D 3238: 1995.
(3) Density at 15°C
Measurement was performed according to JIS K 2249-1: 2011 (Crude petroleum and petroleum products - Determination of density - Part 1: Oscillating U-tube method).

[Examples 1 to 7, Comparative Examples 1 and 2, and Reference Examples 1 to 3]

[0146] The following components were mixed to prepare the lubricating oil compositions having the compositions shown in Tables 2 to 4.
[0147] The numerical unit of the blending compositions in Tables 2 to 4 is "% by mass".

<Lubricant base oil (X)>

[0148] In the present Examples, a lubricant base oil (X1) and a lubricant base oil (X2) having the properties shown in Table 1 that are base oils that belong to API (American Petroleum Institute) Group III were used.
[0149] Table 1 also shows the properties of the mixed-base oil of the lubricant base oil (X1) and the lubricant base oil (X2) used in Reference Example 2.
[0150] Table 1 also shows the properties of the lubricant base oil (X') used in Reference Example 3. The lubricant base oil (X') is a base oil that belongs to API (American Petroleum Institute) Group II.

Table 1

	Viscosity index	% C_P	Density g/cm^3	40°C Kinematic viscosity mm^2/s
Lubricant base oil (X1)	128	93.7	0.8171	19.44
Lubricant base oil (X2)	143	94.1	0.8274	44.06
Lubricant base oil (X')	103	69.6	0.8712	67.59
Mixed-base oil *	142	94.0	0.8246	34.65
* Lubricant base oil (X1) : lubricant base oil (X2) = 27.00 : 73.00 (mass ratio)				

<Diphenylamine-based antioxidant (A)>

[0151] Dioctyldiphenylamine was used.

[0152] Dioctyldiphenylamine corresponds to the compound (A1) in which R^{a1} and R^{a2} are octyl groups, and na1 = na2 = 1 in the general formula (a1).

<Naphthylamine-based antioxidant (B)>

[0153] Octylphenyl-1-naphthylamine was used.

[0154] The octylphenyl-1-naphthylamine corresponds to the compound (B1) in which R^{b1} is an octyl group and nb1 = 1 in the general formula (b1).

<Phosphorus-containing phenol-based antioxidant (C)>

[0155] Diethyl 3,5-di-tert-butyl-4-hydroxybenzyl phosphonate was used.

[0156] Diethyl 3,5-di-tert-butyl-4-hydroxybenzyl phosphonate corresponds to the compound (C1) in which R^{c1} and R^{c2} are tert-butyl groups, R^{c3} and R^{c4} are ethyl groups, and R^{c5} is a methylene group in the general formula (c1).

<Phosphorus-free phenol-based antioxidant (D)>

[0157] Benzenepropanoic acid-3,5-bis(1,1-dimethylethyl)-4-hydroxyalkyl ester was used.

[0158] Benzenepropanoic acid-3,5-bis(1,1-dimethylethyl)-4-hydroxyalkyl ester corresponds to the compound (D1) in which R^{d1} is an alkylene group having 2 carbon atoms and R^{d2} is an alkyl group having 8 carbon atoms in the general formula (d1).

<Evaluation>

[0159] Prior to the test, the flash points of the lubricant base oils of Reference Examples 1 to 3 were measured.

[0160] In the present Examples, the flash points were measured according to JIS K 2265-4: 2007 by Cleveland open-cup (COC) method.

[0161] Then, the flash points of the lubricating oil compositions of Examples 1 to 7 and Comparative Examples 1 and 2 were measured by the same method.

[0162] For the lubricating oil compositions of Examples 1 to 3 and Comparative Example 1, the degrees of increase of the flash points relative to the flash point of the lubricant base oil (X) of Reference Example 1 were calculated. For the lubricating oil compositions of Examples 4 to 7, the degrees of increase of the flash points relative to the flash point of the lubricant base oil (X) of Reference Example 2 were calculated. For the lubricating oil composition of Comparative Example 2, the degree of increase of the flash point relative to the flash point of the lubricant base oil (X') of Reference Example 3 was calculated.

[0163] Then, those having a degree of increase of the flash point of 10°C or more were evaluated as acceptable.

[0164] The evaluation results are shown in Tables 2 to 4.

Table 2

			Reference Example 1	Example 1	Example 2
Lubricating oil composition (% by mass)	Lubricant base oil (X)	Lubricant base oil (X1)	-	-	-
		Lubricant base oil (X2)	100.00	99.63	98.89
	Lubricant base oil (X')		-	-	-
	Diphenylamine-based antioxidant (A)		-	0.10	0.30
	Naphthylamine-based antioxidant (B)		-	0.25	0.75
	Phosphorus-containing phenol-based antioxidant (C)		-	0.02	0.06
	Phosphorus-free phenol-based antioxidant (D)		-	-	-
	Total		100.00	100.00	100.00
Various ratios and the like	(B)/(A) (mass ratio)		-	2.5	2.5
	(C)/(B) (mass ratio)		-	0.08	0.08
	(A) + (B) + (C) (% by mass)		-	0.37	1.1
	(D)/{(A) + (B) + (C)} (mass ratio)		-	0.0	0.0
Evaluation	Flash point (°C)		264	282	288
	Degree of increase of flash point relative to Reference Example 1		0	18	24

Table 2 (continued)

			Example 3	Comparative Example 1
Lubricating oil composition (% by mass)	Lubricant base oil (X)	Lubricant base oil (X1)	-	-
		Lubricant base oil (X2)	97.78	98.80
	Lubricant base oil (X')		-	-
	Diphenylamine-based antioxidant (A)		0.60	0.50
	Naphthylamine-based antioxidant (B)		1.50	0.60
	Phosphorus-containing phenol-based antioxidant (C)		0.12	0.10
	Phosphorus-free phenol-based antioxidant (D)		-	-
	Total		100.00	100.00
Various ratios and the like	(B)/(A) (mass ratio)		2.5	1.2
	(C)/(B) (mass ratio)		0.08	0.17
	(A) + (B) + (C) (% by mass)		2.2	1.2
	(D)/{(A) + (B) + (C)} (mass ratio)		0.0	-
Evaluation	Flash point (°C)		282	272
	Degree of increase of flash point relative to Reference Example 1		18	8

Table 3

			Reference Example 2	Example 4
Lubricating oil composition (% by mass)	Lubricant base oil (X)	Lubricant base oil (X1)	27.00	27.00
		Lubricant base oil (X2)	73.00	70.78
	Lubricant base oil (X')		-	-
	Diphenylamine-based antioxidant (A)		-	0.60
	Naphthylamine-based antioxidant (B)		-	1.50
	Phosphorus-containing phenol-based antioxidant (C)		-	0.12
	Phosphorus-free phenol-based antioxidant (D)		-	-
	Total		-	100.00
Various ratios and the like	(B)/(A) (mass ratio)		-	2.5
	(C)/(B) (mass ratio)		-	0.08
	(A) + (B) + (C) (% by mass)		-	2.2
	(D)/{(A) + (B) + (C)} (mass ratio)		-	0.0
Evaluation	Flash point (°C)		244	256
	Degree of increase of flash point relative to Reference Example 2		0	12

Table 3 (continued)

			Example 5	Example 6	Example 7
Lubricating oil composition (% by mass)	Lubricant base oil (X)	Lubricant base oil (X1)	26.89	26.63	26.63
		Lubricant base oil (X2)	71.00	72.50	71.00
	Lubricant base oil (X')		-	-	-
	Diphenylamine-based antioxidant (A)		0.30	0.10	0.10
	Naphthylamine-based antioxidant (B)		0.75	0.25	0.25
	Phosphorus-containing phenol-based antioxidant (C)		0.06	0.02	0.02
	Phosphorus-free phenol-based antioxidant (D)		1.00	0.50	2.00
	Total		100.00	100.00	100.00
Various ratios and the like	(B)/(A) (mass ratio)		2.5	2.5	2.5
	(C)/(B) (mass ratio)		0.08	0.08	0.08
	(A) + (B) + (C) (% by mass)		1.1	0.37	0.37
	(D)/{(A) + (B) + (C)} (mass ratio)		0.90	1.4	5.4
Evaluation	Flash point (°C)		254	254	262
	Degree of increase of flash point relative to Reference Example 2		10	10	18

Table 4

			Reference Example 3	Comparative Example 2
Lubricating oil composition (% by mass)	Lubricant base oil (X)	Lubricant base oil (X1)	-	-
		Lubricant base oil (X2)	-	-
	Lubricant base oil (X')		100.00	97.63
	Diphenylamine-based antioxidant (A)		-	0.10
	Naphthylamine-based antioxidant (B)		-	0.25
	Phosphorus-containing phenol-based antioxidant (C)		-	0.02
	Phosphorus-free phenol-based antioxidant (D)		-	2.00
	Total		100.00	100.00
Various ratios and the like	(B)/(A) (mass ratio)		-	2.5
	(C)/(B) (mass ratio)		-	0.08
	(A) + (B) + (C) (% by mass)		-	0.37
	(D)/{(A) + (B) + (C)} (mass ratio)		-	5.4
Evaluation	Flash point (°C)		240	248
	Degree of increase of flash point relative to Reference Example 3		0	8

[0165] From Table 2, it is understood that the flash points of the lubricating oil compositions of Examples 1 to 3 were improved by 10°C or more relative to the reference lubricant base oil of Reference Example 1.

[0166] In contrast, it is understood that in the lubricating oil composition of Comparative Example 1, the content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) was less than 2.0 in mass ratio, the content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) was more than 0.15 in mass ratio, and thus the flash point was not sufficiently improved relative to the reference lubricant base oil of Reference Example 1.

[0167] From Table 3, it is understood that the flash points of the lubricating oil compositions of Examples 4 to 7 were improved by 10°C or more relative to the reference lubricant base oil of Reference Example 2.

[0168] From Table 4, it is understood that the flash point of the lubricating oil composition of Comparative Example 2 was not sufficiently improved relative to the reference lubricant base oil of Reference Example 3, even though the lubricating oil composition of Comparative Example 2 had the same antioxidant structure as that of the lubricating oil composition of Example 7. From this, it is understood that the flash point of the lubricant base oil (X'), which does not satisfy the requirements (1) to (4), was not sufficiently improved even when the diphenylamine-based antioxidant (A), the naphthylamine-based antioxidant (B), the phosphorus-containing phenol-based antioxidant (C), and the phosphorus-free phenol-based antioxidant (D) were blended, the content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) was adjusted to 2.0 or more in mass ratio, and the content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) was adjusted to 0.15 or less in mass ratio.

Claims

1. A lubricating oil composition, comprising:

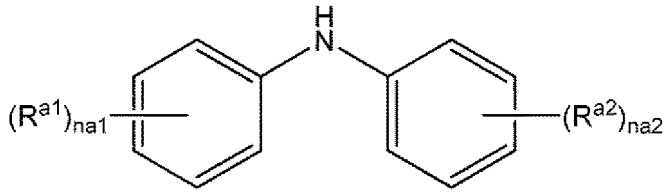
a lubricant base oil (X);
a diphenylamine-based antioxidant (A);
a naphthylamine-based antioxidant (B); and
a phosphorus-containing phenol-based antioxidant (C),
wherein the lubricant base oil (X) satisfies requirements (1) to (4) below:

- requirement (1): having a viscosity index of 120 or more,

- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more,

a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

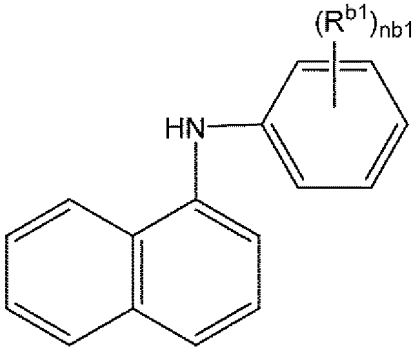
2. The lubricating oil composition according to claim 1, wherein the diphenylamine-based antioxidant (A) comprises a compound (A1) represented by general formula (a1) below:



(a1)

wherein R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, and na1 and na2 are each independently an integer of 1 to 5.

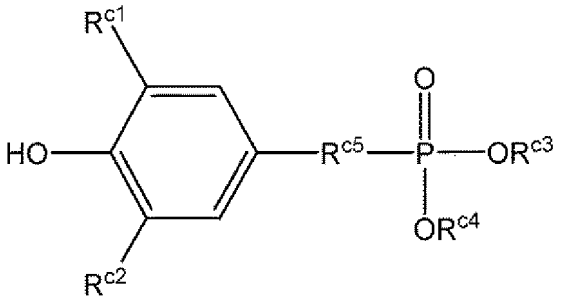
3. The lubricating oil composition according to claim 1 or 2, wherein the naphthylamine-based antioxidant (B) comprises a compound (B1) represented by general formula (b1) below:



(b1)

wherein R^{b1} is an alkyl group having 1 to 30 carbon atoms, and nb1 is an integer of 1 to 5.

4. The lubricating oil composition according to any one of claims 1 to 3, wherein the phosphorus-containing phenol-based antioxidant (C) comprises a compound (C1) represented by general formula (c1) below:



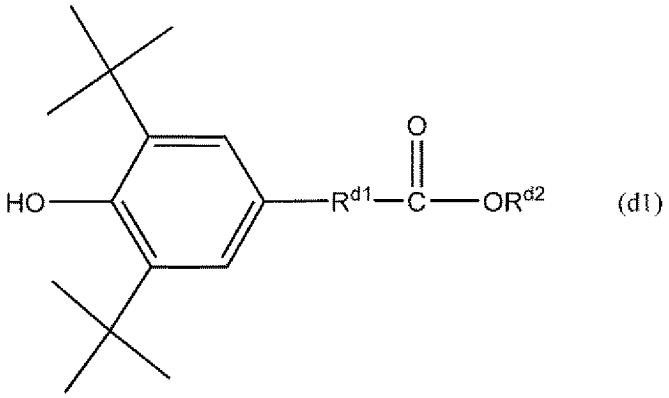
(c1)

wherein R^{c1}, R^{c2}, R^{c3}, and R^{c4} are each independently a hydrogen atom or an alkyl group having 1 to 30 carbon atoms, and R^{c5} is an alkylene group having 1 to 5 carbon atoms.

5. The lubricating oil composition according to any one of claims 1 to 4, further comprising:

a phosphorus-free phenol-based antioxidant (D).

6. The lubricating oil composition according to claim 5, wherein the phosphorus-free phenol-based antioxidant (D) comprises a compound (D1) represented by general formula (d1) below:



(d1)

wherein R^{d1} is an alkylene group having 1 to 5 carbon atoms, and R^{d2} is an alkyl group having 1 to 25 carbon atoms.

7. The lubricating oil composition according to any one of claims 1 to 6, wherein a total content of the diphenylamine-based antioxidant (A), the naphthylamine-based antioxidant (B), and the phosphorus-containing phenol-based antioxidant (C) is 0.30% by mass or more based on a total amount of the lubricating oil composition.

8. A flash point improver for a lubricant base oil, comprising:

a diphenylamine-based antioxidant (A);
a naphthylamine-based antioxidant (B); and
a phosphorus-containing phenol-based antioxidant (C),
wherein a content ratio [(B)/(A)] of the naphthylamine-based antioxidant (B) to the diphenylamine-based antioxidant (A) is 2.0 or more in mass ratio, and
a content ratio [(C)/(B)] of the phosphorus-containing phenol-based antioxidant (C) to the naphthylamine-based antioxidant (B) is 0.15 or less in mass ratio.

9. The flash point improver for a lubricant base oil according to claim 8, further comprising:
a phosphorus-free phenol-based antioxidant (D).

10. The flash point improver according to claim 8 or 9, wherein the lubricant base oil is a lubricant base oil (X) that satisfies requirements (1) to (4) below, and the flash point improver is used for the lubricant base oil (X):

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

11. A method for improving a flash point of a lubricant base oil, comprising the step of:
blending the flash point improver according to any one of claims 8 to 10 into a lubricant base oil (X) that satisfies requirements (1) to (4) below to improve a flash point of the lubricant base oil (X):

- requirement (1): having a viscosity index of 120 or more,
- requirement (2): having a % C_P according to ring analysis (n-d-M method) of 85 or more,
- requirement (3): having a density at 15°C of 0.835 g/cm^3 or less,
- requirement (4): having a kinematic viscosity at 40°C of 28.8 mm^2/s or more.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/010722

A. CLASSIFICATION OF SUBJECT MATTER

C10M 169/04(2006.01)i; *C10M 129/76*(2006.01)n; *C10M 133/12*(2006.01)n; *C10M 137/12*(2006.01)n; *C10N 20/00*(2006.01)n; *C10N 20/02*(2006.01)n; *C10N 30/00*(2006.01)n
FI: C10M169/04; C10M133/12; C10M137/12; C10M129/76; C10N20:00 C; C10N20:02; C10N30:00 Z

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; C10N20/00; C10N20/02; C10N30/00; C10M129/76; C10M133/12; C10M137/12

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 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-162629 A (JX NIPPON OIL & ENERGY CORP) 25 August 2011 (2011-08-25) claims, examples	1-11
A	JP 2017-88778 A (IDEMITSU KOSAN CO) 25 May 2017 (2017-05-25) claims, examples	1-11
A	JP 2008-45111 A (SHOWA SHELL SEKIYU KK) 28 February 2008 (2008-02-28) claims, examples	1-11
A	JP 2017-179197 A (JX NIPPON OIL & ENERGY CORP) 05 October 2017 (2017-10-05) claims, examples	1-11
A	WO 2014/010682 A1 (IDEMITSU KOSAN CO) 16 January 2014 (2014-01-16) claims, examples	1-11
A	JP 8-41480 A (TONEN CORP) 13 February 1996 (1996-02-13) claims, examples	1-11

☑ 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
"E" earlier application or patent but published on or after the international filing date
"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)
"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
"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
"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
"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
18 May 2023	**30 May 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **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/JP2023/010722

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2021-138881 A (IDEMITSU KOSAN CO) 16 September 2021 (2021-09-16) claims, examples	1-11
A	JP 2021-518473 A (BASF SE) 02 August 2021 (2021-08-02) claims, examples	1-11

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/010722

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2011-162629 A	25 August 2011	(Family: none)	
JP 2017-88778 A	25 May 2017	US 2018/0327689 A1 examples, claims WO 2017/081941 A1 EP 3375852 A1 CN 108350387 A	
JP 2008-45111 A	28 February 2008	US 2009/0312209 A1 examples, claims US 2013/0017982 A1 WO 2008/009704 A1 EP 2041250 A1 CN 101506338 A	
JP 2017-179197 A	05 October 2017	(Family: none)	
WO 2014/010682 A1	16 January 2014	US 2015/0166923 A1 examples, claims EP 2873718 A1 CN 104395443 A KR 10-2015-0028296 A	
JP 8-41480 A	13 February 1996	US 5747430 A examples, claims WO 1996/003480 A1 CA 2192491 A	
JP 2021-138881 A	16 September 2021	WO 2021/177441 A1 EP 4116395 A1 CN 115175976 A	
JP 2021-518473 A	02 August 2021	US 2019/0292480 A1 examples, claims WO 2019/183187 A1 EP 3768808 A1 KR 10-2020-0135396 A CN 112189047 A CA 3094639 A	

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2021175769 A **[0004]**