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(54) **LUBRICATING OIL COMPOSITION AND METHOD FOR USING LUBRICATING OIL COMPOSITION**

(57) The task is to provide a lubricating oil composition capable of maintaining oxidation stability over a long period of time by not only making oxidation stability evaluated by an RPVOT value excellent even while using a base oil comprising a certain amount or more of tertiary carbon atom but also suppressing a rise in acid value in the initial stage. Said task is attained by providing a lubricating oil composition comprising a base oil (X) comprising tertiary carbon atom at a content of 8.0 at% or more based on the total carbon of hydrocarbons, and an antioxidant (Y) comprising an amine-based antioxidant (A), a phenol-based antioxidant (B), and a phosphor-based antioxidant (C), and satisfying the following requirements. Specifically, the amine-based antioxidant (A) comprises a diphenylamine compound (A1) having a specific structure. The phenol-based antioxidant (B) comprises a hindered phenol compound (B1) having an ester structure. Furthermore, the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C) was set to greater than 1.0 mass% and 2.0 mass% or less based on the total amount of the lubricating oil composition.

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Description

Technical Field

5 **[0001]** The present invention relates to a lubricating oil composition, and a method for using the lubricating oil composition.

Background Art

10 **[0002]** Lubricating oil compositions used in devices such as turbines such as steam turbines and gas turbines, compressors, and hydraulic equipment are used while circulating in a system under a high-temperature environment. Therefore, oxidation deterioration easily occurs. Under such circumstances, for said lubricating oil compositions, various researches and developments to finely maintain oxidation stability against long period of time use under high temperature environments are being conducted.

15 **[0003]** For example, PTL 1 discloses a lubricating oil composition for a rotary gas compressor, which contains a lubricant base oil having a viscosity index of 120 or more, phenyl- α -naphthylamine or a derivative thereof, p,p'-dialkyldiphenylamine or a derivative thereof, and a viscosity index improver.

[0004] According to PTL 1, the lubricating oil composition can be a lubricating oil composition for a rotary gas compressor that achieves both thermal and oxidation stability and sludge resistance at a high level even when used at a high temperature, and at the same time has an excellent energy saving effect.

Citation List

Patent Literature

25 **[0005]** PTL 1: JP 2011-162629 A

Summary of Invention

30 Technical Problem

[0006] Based on diversification of raw material procurement, etc., the present inventors did intensive studies on lubricating oil compositions that are used for devices such as turbines, gas compressors and hydraulic devices, using various base oils as base oils. As a result, they found that, in the case where a base oil containing tertiary carbon atom at a certain amount or more is used as a base oil, oxidation stability cannot be maintained for a long period of time by blending an antioxidant to conventionally-used base oils such as synthetic oils such as poly α -olefins and polyalkylene glycols (PAGs) and mineral oils.

[0007] On the other hand, as an index for indicating the oxidation stability of lubricating oil compositions, an RPVOT value (Rotating Pressure Vessel Oxidation Test) defined in JIS K 2514-3:2013 or ASTM D 2272 is mainly used, and it is general to evaluate the residual lifetime of an oil used from the decrease in performance of an antioxidant. Evaluation using an RPVOT value (RBOT value) is carried out also in PTL 1.

[0008] However, under the environment for use in an actual device, an oil comes out of the system accompanying with compressed air ejected when the lubricating oil composition is used by being circulated in a device, and thus the device is used while suitably filling the lubricating oil composition so that a predetermined amount of lubricating oil composition is maintained in the actual device in many cases. Therefore, there was a problem that oxidation stability was not be able to be evaluated properly by only the results of the evaluation of RPVOT values carried out under a tightly-closed condition. Incidentally, when the raising velocity of an acid value is fast, an RPVOT value also tends to be short; therefore, suppression of raising in an acid value at the initial stage consequently leads to maintenance of oxidation stability for a long period of time.

50 **[0009]** Therefore, from the viewpoint to evaluate oxidation stability properly for a base oil containing a certain amount or more of tertiary carbon atom, for which it was impossible to maintain oxidation stability for a long period of time by blending an antioxidant in a base oil which has been conventionally used, it is desired not only to make the oxidation stability evaluated by an RPVOT value excellent but also to suppress raising of an acid value (an acid value raising velocity) at the initial stage so that the oxidation stability is maintained for a long period of time.

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Summary of Invention

Technical Problem

[0010] Therefore, the object of the present invention is to provide a lubricating oil composition capable of maintaining oxidation stability over a long period of time by not only making oxidation stability evaluated by an RPVOT value excellent even while using a base oil containing a certain amount or more of tertiary carbon atom but also suppressing a rise in acid value in the initial stage (acid value raising velocity).

Solution to Problem

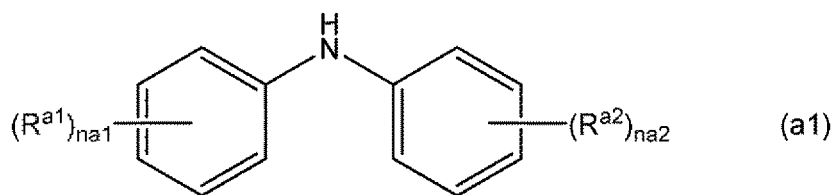
[0011] The present inventors did intensive studies and consequently found that the above-mentioned problem can be solved by a combination of specific antioxidants and adjustment of the total content of these specific antioxidants, and completed the present invention.

[0012] Specifically, the present invention relates to the following [1] and [2].

[1] A lubricating oil composition comprising:

a base oil (X) comprising tertiary carbon atom at a content of 8.0 at% or more based on the total carbon of hydrocarbons; and
 an antioxidant (Y) comprising an amine-based antioxidant (A), a phenol-based antioxidant (B), and a phosphor-based antioxidant (C),
 wherein the amine-based antioxidant (A) comprises a diphenylamine compound (A1) represented by the following general formula (a1):

[Chem. 1]



wherein R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, $na1$ and $na2$ are each independently an integer of 1 to 5, wherein when $na1$ is 2 or more, a plurality of R^{a1} 's may be the same, or may be different from each other, and in the case where $na2$ is 2 or more, a plurality of R^{a2} 's may be the same, or may be different from each other,

the phenol-based antioxidant (B) comprises a hindered phenol compound (B1) having an ester structure, and the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C) based on the total amount of the lubricating oil composition is greater than 1.0 mass% and 2.0 mass% or less.

[2] A method for using the lubricating oil composition according to [1] in one or more device selected from the group consisting of a turbine, a compressor and a hydraulic device.

Advantageous Effects of Invention

[0013] The present invention can provide a lubricating oil composition capable of maintaining oxidation stability over a long period of time by not only making oxidation stability evaluated by an RPVOT value excellent even while using a base oil containing a certain amount or more of tertiary carbon atom but also suppressing a rise in acid value in the initial stage.

Description of Embodiments

[0014] In this specification, regarding a preferable numerical range (for example, a range of contents), the lower limit value and upper limit value which are described stepwise can be each independently combined. For example, from the

description "preferably 10 to 90, more preferably 30 to 60", "preferable lower limit value (10)" and "more preferable upper limit value (60)" can be combined to form "10 to 60".

[0015] Furthermore, in this specification, the numerical values in Examples are numerical values that can be used as the upper limit value or lower limit value.

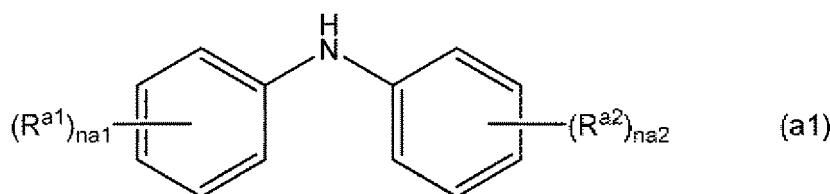
[0016] In this specification, unless otherwise stated, a numerical range expressed as "AA to BB" means "AA or more and BB or less".

[Embodiment of Lubricating Oil Composition of Present Invention]

[0017] The lubricating oil composition of the present invention is a lubricating oil composition containing: a base oil (X) containing tertiary carbon atom at a content of 8.0 at% or more based on the total carbon of hydrocarbons; and an antioxidant (Y) containing an amine-based antioxidant (A), a phenol-based antioxidant (B), and a phosphor-based antioxidant (C).

[0018] The amine-based antioxidant (A) contains a diphenylamine compound (A1) represented by the following general formula (a1).

[Chem. 2]



[0019] In the formula, R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, $na1$ and $na2$ are each independently an integer of 1 to 5, wherein when $na1$ is 2 or more, a plurality of R^{a1} 's may be the same, or may be different from each other, and in the case where $na2$ is 2 or more, a plurality of R^{a2} 's may be the same, or may be different from each other.

[0020] The phenol-based antioxidant (B) contains a hindered phenol compound (B1) having an ester structure.

[0021] Furthermore, the total content $[(A1) + (B1) + (C)]$ of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C) based on the total amount of the lubricating oil composition is greater than 1.0 mass% and 2.0 mass% or less.

[0022] The present inventors did intensive studies aiming at providing a lubricating oil composition capable of not only making oxidation stability evaluated by an RPVOT value excellent but also maintaining oxidation stability over a long period of time by suppressing rising of an acid value in the initial stage even while using a base oil containing a certain amount or more of tertiary carbon atom.

[0023] First, the inventors investigated that the reason why an antioxidant is poorly effective in blending an antioxidant in conventionally-used base oils such as synthetic oils such as poly α -olefin and PAG and mineral oils, in the case where a base oil containing a certain amount or more of tertiary carbon atom is used. As a result, it was considered that one of the causes is that, since radicals of tertiary carbon atom are more stable as compared to lower carbon radicals than tertiary carbon atom, there are more radicals that can capture oxygen atoms in a base oil containing a certain amount or more of tertiary carbon atom, and thus oxidation deterioration occurs easily. Furthermore, from this fact, it is considered that, in the case where a base oil containing a certain amount or more of tertiary carbon atom is used, blending of an antioxidant is more difficult to adjust than before. Actually, when an antioxidant was blended in a similar manner to conventional ones in a base oil containing a certain amount or more of tertiary carbon atom, the antioxidant was poorly effective, and thus it was very difficult to prepare a lubricating oil composition that solves the above-mentioned problem.

[0024] Under such circumstances, the present inventors did intensive studies on blend of an antioxidant, and found the blend of an antioxidant which can solve the above-mentioned problem, and completed the present invention.

[0025] In the following explanation, "base oil (X)" and "antioxidant (Y)" are also referred to "component (X)" and "component (Y)", respectively.

[0026] Although the lubricating oil composition of one aspect of the present invention may be constituted from only the component (X) and the component (Y), it may contain other components other than the component (X) and the component (Y) in the scope in which the effect of the present invention is not deteriorated.

[0027] In the lubricating oil composition of one aspect of the present invention, the total content of the component (X) and the component (Y) is preferably 80 mass% or more, more preferably 85 mass% or more, further preferably 90 mass% or more, further more preferably 95 mass% or more, even further preferably 97 mass% or more, further more

preferably 99.9 mass% or less, based on the total amount of the lubricating oil composition.

[0028] Hereinafter the respective components contained in the lubricating oil composition of the present invention will be explained in detail.

5 <Base oil (X)>

[0029] The lubricating oil composition of the present invention contains a base oil (X).

[0030] The base oil (X) contains tertiary carbon atom at a content of 8.0 at% or more based on the total carbons of hydrocarbons in the base oil (X).

10 **[0031]** According to the studies of the present inventors, it has been found that, in the case where the tertiary carbon atom content in the base oil (X) is 8.0 at% or more based on the total carbons of hydrocarbons in the base oil (X), oxidation deterioration of the base oil (X) occurs easily, and it is more difficult to adjust blend of an antioxidant than before. In the present invention, by adjusting the blend of an antioxidant, which will be mentioned later, raising of an acid value is suppressed while maintaining oxidation stability for a long period of time.

15 **[0032]** Incidentally, in one aspect of the present invention, the tertiary carbon atom content in the base oil (X) may be 8.5 at% or more, may be 9.0 at% or more, may be 9.5 at% or more, or may be 10.0 at% or more. Incidentally, the upper limit value of the tertiary carbon atom content in the base oil (X) is generally 20.0 at% or less.

[0033] Incidentally, the tertiary carbon atom content based on the total carbons of hydrocarbons in the base oil (X) means a rate of the total of the integrated intensity attributable to the tertiary carbon atom with respect to the total of the all integrated intensities of carbon measured by ^{13}C -NMR, but other method may also be used as long as a similar result can be obtained. Incidentally, in ^{13}C -NMR measurement, a method using a sample obtained by adding 3 g of deuterated chloroform to 0.5 g of a sample to be measured and diluting the sample, in which the measurement temperature is room temperature, the resonance frequency is 100 MHz, and the measurement method is a method using a gated decoupling method, may be exemplified. By the above-mentioned analysis, (a) and (b) are measured respectively as mentioned below, and the ratio of (b) (%) when (a) is set as 100% is calculated. The ratio of (b) represents the ratio of the total tertiary carbon atom against the total carbon atom constituting the base oil (X).

(a) Total of the integrated intensities at chemical shifts of about 10-50 ppm (total of the integrated intensities attributable to the total carbon of hydrocarbons)

30 (b) Total of the integrated intensities at chemical shifts of about 27.9-28.1 ppm, 28.4-28.6 ppm, 32.6-33.2 ppm, 34.4-34.6 ppm, 37.4-37.6 ppm, 38.8-39.1 ppm and 40.4-40.6 ppm (the total of the integrated intensities attributable to tertiary carbon atoms and naphthene tertiary carbon atoms with methyl groups, ethyl groups, and other branched groups)

35 **[0034]** Incidentally, in the case where the base oil (X) is a mixed base oil, a value obtained by measuring the tertiary carbon atom content of said mixed base oil by the above-mentioned method is indicated.

(Content of Base Oil (X))

40 **[0035]** In the lubricating oil composition of one aspect of the present invention, the content of the base oil (X) is preferably 90.0 mass% or more, more preferably 93.0 mass% or more, further preferably 95.0 mass% or more based on the total amount of the lubricating oil composition. Furthermore, the content is preferably lower than 99.0 mass%, more preferably 98.5 mass% or less, further preferably 98.0 mass% or less.

45 (Kinds of Base Oil (X))

[0036] As the base oil (X), a base oil containing tertiary carbon atom at a content of 8.0 at% or more based on the total carbons of hydrocarbons in the base oil (X) can be used without any specific limitation. Hereinafter a "base oil containing tertiary carbon atom at a content of 8.0 at% or more based on the total carbons of hydrocarbons in the base oil (X)" is also referred to as a "high tertiary carbon atom-containing base oil".

50 **[0037]** Typical examples of the high tertiary carbon atom-containing base oil include, for example, ordinary pressure residual oils, which are obtained by ordinary pressure distillation of crude oils such as paraffin-based mineral oils, medium-based mineral oils and naphthene-based mineral oils; distilled oils obtained by reduced pressure distillation of said ordinary pressure residual oils; mineral oils or waxes (slack wax, GTL wax, etc.) obtained by subjecting said distilled oils to one or more treatment from purification treatments such as solvent deasphalting, solvent extraction, hydrogenation finishing, solvent dewaxing, contact dewaxing, isomerization dewaxing and reduced pressure distillation and isoparaffin polymers.

[0038] These base oils (X) may be formed of one kind, or may be a mixed oil including two or more kinds in combination.

[0039] Incidentally, the base oil (X) may contain one kind or two or more kinds of base oils containing tertiary carbon atom at a content of lower than 8.0 at% such as synthetic oils and plant oils, within a range in which the content of tertiary carbon atom satisfies 8.0 at% or more based on the total amount of the base oil (X).

[0040] However, from the viewpoint of making the effect of the present invention to exert easier, the base oil (X) is contained by preferably 50 mass% to 100 mass% more preferably 60 mass% to 100 mass%, further preferably 70 mass% to 100 mass%, further more preferably 80 mass% to 100 mass%, and further even preferably 90 mass% to 100 mass%, based on the total amount of the base oil.

(Kinematic Viscosity and Viscosity Index of Base Oil (X) at 40°C)

[0041] The kinematic viscosity of the base oil (X) at 40°C (hereinafter also referred to as "40°C kinematic viscosity") is preferably 10 mm²/s to 100 mm²/s, more preferably 30 mm²/s to 60 mm²/s, further preferably 35 mm²/s to 55 mm²/s, further more preferably 40 mm²/s to 50 mm²/s.

[0042] Furthermore, the viscosity index of the base oil (X) is preferably 100 or more, more preferably 125 or more, further preferably 130 or more. Furthermore, the viscosity index is generally 150 or less.

[0043] In this specification, the 40°C kinematic viscosity and viscosity index of the base oil (X) are values measured and calculated according to JIS K 2283:2000.

<Antioxidant (Y)>

[0044] The lubricating oil composition of the present invention contains an antioxidant (Y).

[0045] In the case where the lubricating oil composition does not contain the antioxidant (Y), the effect of the present invention is not exerted.

[0046] The antioxidant (Y) contained by the lubricating oil composition of the present invention contains an amine-based antioxidant (A), a phenol-based antioxidant (B), and a phosphor-based antioxidant (C). In the following explanations, these are respectively referred to as "component (A)", "component (B)" and "component (C)".

[0047] In the lubricating oil composition of one aspect of the present invention, the antioxidant (Y) may be constituted by only the component (A), the component (B) and the component (C), but may contain other antioxidants than the component (A), the component (B) and the component (C) in the scope in which the effect of the present invention is not deteriorated.

[0048] In the lubricating oil composition of one aspect of the present invention, the total content of the component (A), the component (B) and the component (C) is preferably 60 mass% to 100 mass%, more preferably 70 mass% to 100 mass%, further preferably 80 mass% to 100 mass%, further more preferably 90 mass% to 100 mass%, even further preferably 95 mass% to 100 mass% based on the total amount of the antioxidant (Y), from the viewpoint of making the effect of the present invention exert more easily.

[0049] Hereinafter, the amine-based antioxidant (A), the phenol-based antioxidant (B) and the phosphor-based antioxidant (C) are explained in detail.

<Amine-based Antioxidant (A)>

[0050] The lubricating oil composition of the present invention contains an amine-based antioxidant (A) as the antioxidant (Y).

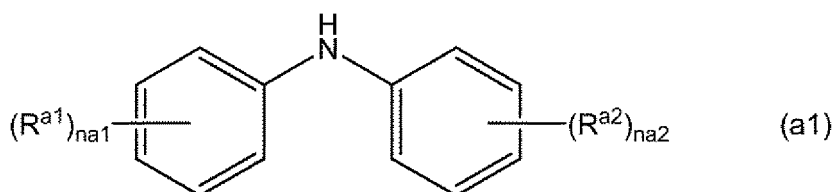
[0051] The amine-based antioxidant (A) is a compound having an anti-oxidation performance and containing an amino group.

[0052] Hereinafter the amine-based antioxidant (A) used in the lubricating oil composition of the present invention is explained in detail.

(Diphenylamine Compound (A1))

[0053] In the lubricating oil composition of the present invention, the amine-based antioxidant (A) contains a diphenylamine compound (A1) represented by the following general formula (a1).

[Chem. 3]



[0054] In the general formula (a1), R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, $na1$ and $na2$ are each independently an integer of 1 to 5, wherein when $na1$ is 2 or more, a plurality of R^{a1} 's may be the same, or may be different from each other, and in the case where $na2$ is 2 or more, a plurality of R^{a2} 's may be the same, or may be different from each other.

[0055] According to the study of the present inventors, the diphenylamine compound (A1) has a performance to make oxidation stability evaluated by an RPVOT value fine by using with the phosphor-based antioxidant (C) in combination. On the other hand, the diphenylamine compound (A1) tends to raise an acid value at the initial stage. Therefore, in the present invention, in order to maintain oxidation stability for a long period of time by suppressing raising of oxidation at the initial stage, the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure and the phosphor-based antioxidant (C) is defined to be within a predetermined range. Incidentally, in the case where the lubricating oil composition does not contain the diphenylamine compound (A1), the effect of the present invention is not exerted.

[0056] In the general formula (a1), the carbon number of the alkyl group that can be selected as R^{a1} and R^{a2} is each independently preferably 1 to 20, more preferably 4 to 16, further preferably 4 to 14 from the viewpoint of making the effect of the present invention exert more easily.

[0057] Specific examples of the alkyl group 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 dococyl group, a tricocyl group, a tetracocyl group, a pentacocyl group, a hexacocyl group, a heptacocyl group, an octacocyl group, a nonacocyl group and a triacontyl group.

[0058] These alkyl groups may be linear or branched, and are preferably linear from the viewpoint of making the effect of the present invention exert more easily.

[0059] In the above-mentioned general formula (a1), $na1$ and $na2$ are each independently preferably 1 to 3, more preferably 1 to 2, further preferably 1, from the viewpoint of making the effect of the present invention exert more easily.

[0060] For the diphenylamine compound (A1), one kind may be used alone, or two or more kinds may be used in combination.

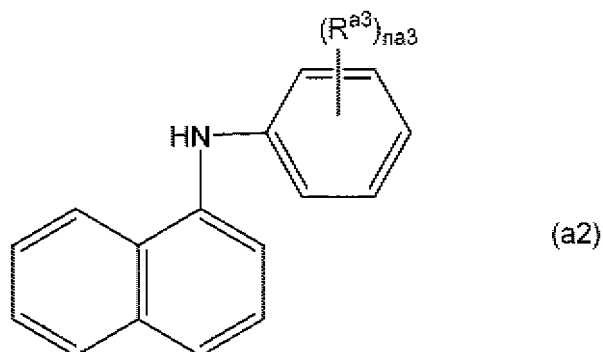
[0061] The content of the diphenylamine compound (A1) is preferably 0.30 mass% to 1.8 mass%, more preferably 0.30 mass% to 1.2 mass%, further preferably 0.40 mass% to 1.1 mass% based on the total amount of the lubricating oil composition.

[0062] Since the content of the diphenylamine compound (A1) is in the above-mentioned range, raising of an acid value at the initial stage of the lubricating oil composition is easily suppressed while making oxidation stability of the lubricating oil composition evaluated by an RPVOT value fine.

(Naphthylamine Compound (A2))

[0063] In the lubricating oil composition of one aspect of the present invention, from the viewpoint of making the effect of the present invention exert more easily, it is preferable that the amine-based antioxidant (A) contains a naphthylamine compound (A2) represented by the following general formula (a2).

[Chem. 4]



[0064] In the general formula (a2), R^{a3} is an alkyl group having 1 to 30 carbon atoms, $na3$ is an integer of 1 to 5, and when $na3$ is 2 or more, a plurality of R^{a3} may be the same or may be different from each other.

[0065] In the general formula (a2), the carbon number of the alkyl group that can be selected as R^{a3} is preferably 1 or more, more preferably 4 or more, further preferably 6 or more from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the carbon number is preferably 20 or less, more preferably 16 or less, further preferably 14 or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 1 to 20, more preferably 4 to 16, further preferably 6 to 14.

[0066] Specific examples of the alkyl group that can be selected as R^{a3} may include those exemplified as the alkyl groups that can be selected as R^{a1} and R^{a2} .

[0067] These alkyl groups may be linear or branched, and are preferably linear from the viewpoint of making the effect of the present invention exert more easily.

[0068] In the above-mentioned general formula (a2), $na3$ is preferably 1 to 3, more preferably 1 to 2, further preferably 1 from the viewpoint of making the effect of the present invention exert more easily.

[0069] For the naphthylamine compound (A2), one kind can be used alone, or two or more kinds can be used in combination.

[0070] The content of the naphthylamine compound (A2) is preferably 0.50 mass% or more, more preferably 0.55 mass% or more, further preferably 0.60 mass% or more based on the total amount of the lubricating oil composition, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the content is preferably 0.80 mass% or less, more preferably 0.75 mass% or less, further preferably 0.70 mass% or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.50 mass% to 0.80 mass%, more preferably 0.55 mass% to 0.75 mass%, further preferably 0.60 mass% to 0.70 mass%.

(Contents and Content Ratio of Various Amine Compounds in Amine-based Antioxidant (A))

[0071] In the lubricating oil composition of one aspect of the present invention, the content of the diphenylamine compound (A1) is preferably 30 mass% to 100 mass%, more preferably, 35 mass% to 100 mass%, further preferably 40 mass% to 100 mass% based on the total amount of the amine-based antioxidant (A), from the viewpoint of making the effect of the present invention exert more easily.

[0072] Furthermore, in the lubricating oil composition of one aspect of the present invention, in the case where the amine-based antioxidant (A) contains the naphthylamine compound (A2), the total content of the diphenylamine compound (A1) and the naphthylamine compound (A2) is preferably 80 mass% to 100 mass%, more preferably 90 mass% to 100 mass%, further preferably 95 mass% to 100 mass%, further more preferably 98 mass% to 100 mass%, even further preferably 99 mass% to 100 mass% based on the total amount of the amine-based antioxidant (A), from the viewpoint of making the effect of the present invention exert more easily.

[0073] Incidentally, in the lubricating oil composition of one aspect of the present invention, the content of the other amine-based antioxidant (A') other than the diphenylamine compound (A1) and the naphthylamine compound (A2) is preferably small from the viewpoint of making the effect of the present invention exert more easily. The content of said other amine-based antioxidant (A') is preferably lower than 5 mass%, more preferably lower than 1 mass%, further preferably lower than 0.1 mass%, further more preferably lower than 0.01 mass% based on the total amount of the amine-based antioxidant (A), even further preferably free from said other amine-based antioxidant (A').

[0074] Said other amine-based antioxidant (A') may include, for example, aralkylated diphenylamines, which do not fall within the diphenylamine compound (A1).

(Total Content and Content Ratio of Diphenylamine Compound (A1) and Naphthylamine Compound (A2))

[0075] In the lubricating oil composition of one aspect of the present invention, in the case where the amine-based antioxidant (A) contains the naphthylamine compound (A2), the total content [(A1) + (A2)] of the diphenylamine compound (A1) and the naphthylamine compound (A2) is preferably 0.80 mass% or more, more preferably 0.90 mass% or more, further preferably 1.0 mass% or more based on the total amount of the lubricating oil composition, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the total content is preferably lower than 2.0 mass%, more preferably 1.9 mass% or less, further preferably 1.7 mass% or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.80 mass% or more and lower than 2.0 mass%, more preferably 0.90 mass% to 1.9 mass%, further preferably 1.0 mass% to 1.7 mass%.

[0076] Furthermore, in the lubricating oil composition of one aspect of the present invention, in the case where the amine-based antioxidant (A) contains the naphthylamine compound (A2), the content ratio [(A1)/(A2)] of the diphenylamine compound (A1) and the naphthylamine compound (A2) is preferably 0.5 or more, more preferably 0.6 or more, further preferably 0.7 or more by mass ratio, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the content ratio is preferably 2.0 or less, more preferably 1.8 or less, further preferably 1.7 or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.5 to 2.0, more preferably 0.6 to 1.8, further preferably 0.7 to 1.7.

<Phenol-based Antioxidant (B)>

[0077] The lubricating oil composition of the present invention contains the phenol-based antioxidant (B) as the antioxidant (Y).

[0078] The phenol-based antioxidant (B) is a compound having an anti-oxidation performance and having a phenol structure. However, of such compounds, compounds containing a phosphor atom are deemed to be encompassed in the phosphor-based antioxidant (C).

[0079] Hereinafter the phenol-based antioxidant (B) used in the lubricating oil composition of the present invention will be explained in detail.

(Hindered Phenol Compound (B1) having Ester Structure)

[0080] In the lubricating oil composition of the present invention, the phenol-based antioxidant (B) contains a hindered phenol compound (B1) having an ester structure.

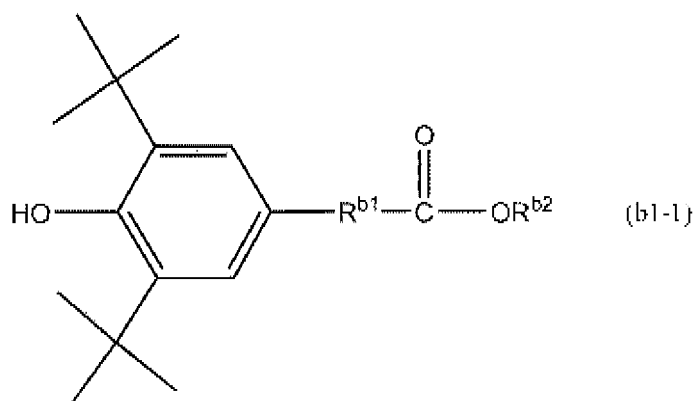
[0081] According to the study by the present inventors, the hindered phenol compound (B1) having an ester structure has a performance to suppress oxidation deterioration at the initial stage, which is easy to occur in a high tertiary carbon atom-containing base oil. However, the ester structure moiety of said hindered phenol compound (B1) is hydrolyzed with a minute amount of moisture contained in the high tertiary carbon atom-containing base oil, and easily raises an acid value at the initial stage. Therefore, in the present invention, the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound having an ester structure (B1) and the phosphor-based antioxidant (C) is defined to be within a predetermined range.

[0082] In the case where the lubricating oil composition does not contain the hindered phenol compound (B1) having an ester structure, the effect of the present invention is not exerted.

[0083] Incidentally, the hindered phenol compound is a compound in which a hydrogen atom on a phenol aromatic ring has been substituted with a bulky substituent such as a tert-butyl group.

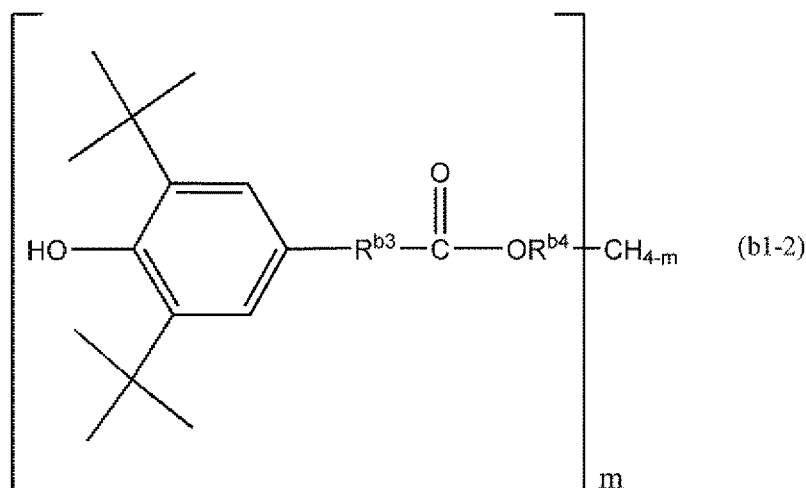
[0084] The hindered phenol compound (B1) having an ester structure includes, for example, one or more kind selected from the group consisting of a compound (B1-1) represented by the following general formula (b1-1) and a compound (B1-2) represented by the following general formula (b1-2). Incidentally, in the following explanation, the hindered phenol compound (B1) having an ester structure is also simply referred to as "hindered phenol compound (B1)".

[Chem. 5]



15 **[0085]** In the formula (b1-1), R^{b1} is an alkylene group having 1 to 5 carbon atoms, and R^{b2} is an alkyl group having 1 to 25 carbon atoms.

[Chem. 6]



[0086] In the formula (b1-2), R^{b3} and R^{b4} are each independently an alkylene group having 1 to 5 carbon atoms, and m is an integer of 2 to 4.

[0087] In the general formula (b1-1), the carbon number of the alkylene group that can be selected as R^{b1} is preferably 1 to 4, more preferably 1 to 3, further preferably 1 to 2, from the viewpoint of making the effect of the present invention exert more easily.

[0088] Specific examples of the alkylene group that can be selected as R^{b1} 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.

[0089] In the general formula (b1-1), the carbon number of the alkyl group that can be selected as R^{b2} is preferably 2 or more, more preferably 4 or more, further preferably 6 or more, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the carbon number is preferably 20 or less, more preferably 15 or less, further preferably 10 or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 2 to 20, more preferably 4 to 15, further preferably 6 to 10.

[0090] Specific examples of the alkyl group that can be selected as R^{b2} may 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 heneicosyl group, a dococyl group, a tricocyl group, a tetracocyl group and a pentacocyl group. These may be linear or branched.

[0091] When the compound (B1-1) represented by the general formula (b1-1) is exemplified, benzenepropanoic acid 3,5-bis(1,1-dimethylethyl)-4-hydroxyalkyl esters, etc. may be included.

[0092] For the compound (B1-1) represented by the general formula (b1-1), one kind may be used alone, or two or

more kinds may be used in combination.

[0093] In the general formula (b1-2), the carbon number of the alkylene group that can be selected as R^{b3} and R^{b4} is preferably 1 to 4, more preferably 1 to 3, further preferably 1 to 2, from the viewpoint of making the effect of the present invention exert more easily.

[0094] Specific examples of the alkylene group that can be selected as R^{b3} and R^{b4} include groups that are similar to the groups exemplified as R^{b2}.

[0095] When the compound (B1-2) represented by the general formula (b1-2) is exemplified, pentaerythritol tetraakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], etc. may be included.

[0096] For the compound (B1-2) represented by the general formula (b1-2), one kind may be used alone, or two or more kinds may be used in combination.

[0097] For the hindered phenol compound (B1), one kind may be used alone, or two or more kinds may be used in combination.

[0098] The content of the hindered phenol compound (B1) is preferably 0.50 mass% or more, more preferably 0.55 mass% or more based on the total amount of the lubricating oil composition. Furthermore, the content is preferably 0.80 mass% or less, more preferably 0.70 mass% or less, further preferably 0.65 mass% or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.50 mass% to 0.80 mass%, more preferably 0.55 mass% to 0.70 mass%, further preferably 0.55 mass% to 0.65 mass%.

[0099] Since the content of the hindered phenol compound (B1) is in the above-mentioned range, raising of an acid value of the lubricating oil composition at the initial stage can be suppressed, and raising of an acid value caused by a hydrolysate generated by a reaction with minute moisture that can be contained in a high tertiary carbon atom-containing base oil can be suppressed.

(Content of Hindered Phenol Compound (B1) in Phenol-based Antioxidant (B))

[0100] In the lubricating oil composition of one aspect of the present invention, the content of the hindered phenol compound (B1) is preferably 80 mass% to 100 mass%, more preferably 90 mass% to 100 mass%, further preferably 95 mass% to 100 mass%, further more preferably 98 mass% to 100 mass%, even further preferably 99 mass% to 100 mass% based on the total amount of the phenol-based antioxidant (B), from the viewpoint of making the effect of the present invention exert more easily.

[0101] Incidentally, in the lubricating oil composition of one aspect of the present invention, it is preferable that the content of the other phenol-based antioxidant (B') than the hindered phenol compound (B1) is small, from the viewpoint of making the effect of the present invention exert more easily. The content of said other phenol-based antioxidant (B') is preferably lower than 5 mass%, more preferably lower than 1 mass%, further preferably lower than 0.1 mass%, further more preferably lower than 0.01 mass%, even further preferably free from said other phenol-based antioxidant (B'), based on the total amount of the phenol-based antioxidant (B).

[0102] Said other phenol-based antioxidant (B') may include, for example, 2,6-di-tert-butyl-p-cresol (DBPC), which does not fall within the hindered phenol compound (B1).

<Phosphor-based Antioxidant (C)>

[0103] The lubricating oil composition of the present invention contains a phosphor-based antioxidant (C) as the antioxidant (Y).

[0104] The phosphor-based antioxidant (C) is a compound containing a phosphor atom, and has a performance to make oxidation stability evaluated by an RPVOT value fine and to maintain oxidation stability for a long period of time, by using with the amine-based antioxidant (A) in combination.

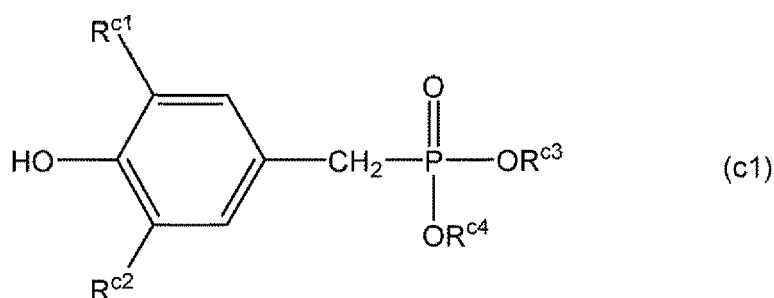
[0105] In the case where the lubricating oil composition does not contain the phosphor-based antioxidant (C), oxidation stability evaluated by an RPVOT value cannot be made excellent, and the oxidation stability cannot be maintained for a long period of time.

[0106] Hereinafter, the phosphor-based antioxidant (C), which is used in the lubricating oil composition of the present invention, will be explained in detail.

(Phosphor atom-containing Compound (C1) having Phenol Structure)

[0107] In the lubricating oil composition of one aspect of the present invention, it is preferable that the phosphor-based antioxidant (C) contains a phosphor atom-containing compound (C1) having a phenol structure represented by the following general formula (c1).

[Chem. 7]



[0108] 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.

[0109] The alkyl groups that can be selected as R^{c1} , R^{c2} , R^{c3} and R^{c4} may include those similar to the alkyl groups that can be selected as the above-mentioned R^{a1} and R^{a2} .

[0110] However, the carbon numbers of the alkyl groups that 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, further preferably 1 to 6.

[0111] Here, it is preferable that the phosphor atom-containing compound (C1) having a phenol structure has a hindered phenol backbone from the viewpoint of making the effect of the present invention exert more easily. Therefore, the alkyl group that can be selected as R^{c1} and R^{c2} is preferably a branched alkyl group, more preferably a branched alkyl group having 1 to 6 carbon atoms, and further preferably a tert-butyl group.

[0112] The content of the phosphor atom-containing compound (C1) having a phenol structure is preferably 0.05 mass% or more, more preferably 0.07 mass% or more, further preferably 0.09 mass% or more based on the total amount of the lubricating oil composition. Furthermore, the content is preferably 0.30 mass% or less, more preferably 0.20 mass% or less, further preferably 0.15 mass% or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.05 mass% to 0.30 mass%, more preferably 0.07 mass% to 0.20 mass%, further preferably 0.09 mass% to 0.15 mass%.

[0113] Since the content of the phosphor atom-containing compound (C1) having a phenol structure is within the above-mentioned range, oxidation stability can be maintained stably for a long period of time while suppressing the contents of the diphenylamine (A1) and the hindered phenol compound (B1).

(Content of Phosphor atom-containing Compound (C1) having Phenol Structure in Phosphor-based Antioxidant (C))

[0114] In the lubricating oil composition of one aspect of the present invention, the content of the phosphor atom-containing compound (C1) having a phenol structure is preferably 80 mass% to 100 mass%, more preferably 90 mass% to 100 mass%, further preferably 95 mass% to 100 mass%, further more preferably 98 mass% to 100 mass%, even further preferably 99 mass% to 100 mass%, based on the total amount of the phosphor-based antioxidant (C), from the viewpoint of making the effect of the present invention exert more easily.

[0115] Incidentally, in the lubricating oil composition of one aspect of the present invention, it is preferable that the content of the other phosphor-based antioxidant (C') than the phosphor atom-containing compound (C1) having a phenol structure is small, from the viewpoint of making the effect of the present invention exert more easily. The content of said other phosphor-based antioxidant (C') is preferably lower than 5 mass%, more preferably lower than 1 mass%, further preferably lower than 0.1 mass%, further more preferably lower than 0.01 mass%, even further preferably free from said other phosphor-based antioxidant (C'), based on the total amount of the phosphor-based antioxidant (C).

[0116] Said other phosphor-based antioxidant (C') may include, for example, metal-based antioxidants containing a phosphor atom which do not fall within the phosphor atom-containing compound (C1) having a phenol structure such as zinc dialkyldithiophosphates.

<Other Antioxidant (Y')>

[0117] In the lubricating oil composition of one aspect of the present invention, it is preferable that the content of the other antioxidant (Y') than the amine-based antioxidant (A), the phenol-based antioxidant (B) and the phosphor-based antioxidant (C) is small from the viewpoint of making the effect of the present invention exert more easily. The content of said other antioxidant (Y') is preferably lower than 5 mass%, more preferably lower than 1 mass%, further preferably lower than 0.1 mass%, further more preferably lower than 0.01 mass%, even further preferably free from said other antioxidant (Y'), based on the total amount of the antioxidant (Y).

[0118] The other antioxidant (Y'), may include, for example, sulfur-based antioxidants and metal-based antioxidants.

<Total Content and Content Ratio of Respective Antioxidants>

[0119] Hereinafter, regarding the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C), the total content and the content ratio are explained in detail.

$$[(A1) + (B1) + (C)]$$

In the lubricating oil composition of the present invention, the total content $[(A1) + (B1) + (C)]$ of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure and the phosphor-based antioxidant (C) needs to be greater than 1.0 mass% and 2.0 mass% or less.

[0120] If $[(A1) + (B1) + (C)]$ is 1.0 mass% or less, oxidation stability evaluated by an RPVOT value cannot be made excellent, and oxidation stability cannot be maintained for a long period of time.

[0121] Furthermore, if $[(A1) + (B1) + (C)]$ is more than 2.0 mass%, a lubricating oil composition in which an acid value easily rises at the initial stage is formed.

[0122] Here, $[(A1) + (B1) + (C)]$ is preferably 1.1 mass% or more, more preferably 1.2 mass% or more, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, $[(A1) + (B1) + (C)]$ is preferably 1.9 mass% or less, more preferably 1.8 mass% or less, further preferably 1.7 mass% or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, 1.1 mass% to 1.9 mass% are preferable, 1.1 mass% to 1.8 mass% are more preferable, and 1.2 mass% to 1.7 mass% are further preferable.

$$[(A1) + (B1)]$$

[0123] In the lubricating oil composition of one aspect of the present invention, the total content $[(A1) + (B1)]$ of the diphenylamine compound (A1) and the hindered phenol compound (B1) having an ester structure is preferably 0.9 mass% or more, more preferably 1.0 mass% or more, further preferably 1.1 mass% or more, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the total content is preferably 1.9 mass% or less, more preferably 1.8 mass% or less, further preferably 1.7 mass% or less, further more preferably 1.6 mass% or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.9 mass% to 1.9 mass%, more preferably 1.0 mass% to 1.8 mass%, further preferably 1.1 mass% to 1.7 mass%, further more preferably 1.1 mass% to 1.6 mass%.

$$[(A1)/(B1)]$$

[0124] In the lubricating oil composition of one aspect of the present invention, the content ratio $[(A1)/(B1)]$ of the diphenylamine compound (A1) to the hindered phenol compound (B1) having an ester structure is preferably 0.5 or more, more preferably 0.6 or more, further preferably 0.7 or more, further more preferably 0.8 or more by mass ratio, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the content ratio is preferably 2.0 or less, more preferably 1.9 or less, further preferably 1.8 or less, further more preferably 1.7 or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 0.5 to 2.0, more preferably 0.6 to 1.9, further preferably 0.7 to 1.8, further more preferably 0.8 to 1.7.

$$[(A1)/(C)]$$

[0125] In the lubricating oil composition of one aspect of the present invention, the content ratio $[(A1)/(C)]$ of the diphenylamine compound (A1) to the phosphor-based antioxidant (C) is preferably 3.0 or more, more preferably 3.5 or more, further preferably 4.0 or more, further more preferably 4.5 or more, even further preferably 5.0 or more by mass ratio, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the content ratio is preferably 15.0 or less, more preferably 13.0 or less, further preferably 12.0 or less, further more preferably 11.0 or

less, even further preferably 10.0 or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 3.0 to 15.0, more preferably 3.5 to 13.0, further preferably 4.0 to 12.0, further more preferably 4.5 to 11.0, even further preferably 5.0 to 10.0.

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$$[(B1)/(C)]$$

[0126] In the lubricating oil composition of one aspect of the present invention, the content ratio [(B1)/(C)] of the hindered phenol compound (B1) having an ester structure to the phosphor-based antioxidant (C) is preferably 4.0 or more, more preferably 4.5 or more, further preferably 5.0 or more, further more preferably 5.5 or more by mass ratio, from the viewpoint of making the effect of the present invention exert more easily. Furthermore, the content ratio is preferably 10.0 or less, more preferably 9.0 or less, further preferably 8.0 or less, further more preferably 7.0 or less, even further preferably 6.5 or less. The upper limit value and lower limit value of these numerical ranges can be arbitrarily combined. Specifically, the combination is preferably 4.0 to 10.0, more preferably 4.5 to 9.0, further preferably 5.0 to 8.0, further more preferably 5.5 to 7.0, even further preferably 5.5 to 6.5.

<Additives for Lubricating Oil>

[0127] The lubricating oil composition according to one aspect of the present invention may contain additives for a lubricating oil other than the antioxidant (Y) as long as the effects of the present invention are not impaired.

[0128] Examples of the additives for a lubricating oil include extreme pressure agents, detergent dispersants, pour point depressants, viscosity index improvers, rust inhibitors, metal deactivators, anti-foaming agents, and friction modifiers.

[0129] These additives for lubricating oil may be used alone or in combination of two or more kinds thereof.

[0130] In this specification, additives such as viscosity index improvers and anti-foaming agents may be blended with other components in the form of a solution dissolved in a diluent oil with consideration for handling property and solubility in a mineral base oil (A). In such case, in this specification, the content of additives such as anti-foaming agents and viscosity index improvers is a content in terms of active ingredients (resin content equivalent) excluding the diluent oil.

[0131] The details of the above-mentioned additives for a lubricating oil will be explained below.

(Extreme Pressure Agent)

[0132] Examples of the extreme pressure agent include phosphorus-based extreme pressure agents such as phosphate esters, phosphite esters, acidic phosphate esters, acidic phosphite esters and dithiophosphoric acid; sulfur-phosphorus-based extreme pressure agents such as monothiophosphate esters and dithiophosphate esters; halogen-based extreme pressure agents such as chlorinated hydrocarbons; and organometallic extreme pressure agents.

[0133] These extreme pressure agents may be used alone or in combination of two or more kinds thereof.

[0134] When the lubricating oil composition according to one aspect of the present invention contains an extreme pressure agent, the content of the extreme pressure agent is preferably 0.01 to 10% by mass, more preferably 0.03 to 5% by mass, and further more preferably 0.05 to 1.0% by mass, based on the total amount of the lubricating oil composition.

(Detergent Dispersant)

[0135] Examples of the detergent dispersant include metal sulfonates, metal salicylates, metal phenates, organic phosphite esters, organic phosphate esters, organic phosphate metal salts, succinimide, benzylamine, succinate esters, and polyhydric alcohol esters.

[0136] Examples of the metals constituting the metal salt such as metal sulfonates are preferably alkali metals or alkaline earth metals, more preferably sodium, calcium, magnesium, or barium, and further more preferably calcium.

The succinimide, benzylamine, and succinate ester may be boron-modified forms. When the lubricating oil composition according to one aspect of the present invention contains a detergent dispersant, the content of the detergent dispersant is preferably 0.01 to 10% by mass, more preferably 0.02 to 7% by mass, and further more preferably 0.03 to 5% by mass, based on the total amount of the lubricating oil composition.

(Pour point depressant)

[0137] Examples of the pour point depressant may include polymethacrylates having a weight average molecular weight of about 50,000 to 150,000. In the case where the lubricating oil composition of one aspect of the present invention

contains a pour point depressant, the content of the pour point depressant is preferably 0.01 to 5 mass%, more preferably 0.02 to 2 mass%, based on the total amount of said lubricating oil composition.

(Viscosity Index Improver)

[0138] Examples of the viscosity index improver include polymers such as non-dispersant-type polymethacrylates, dispersant-type polymethacrylates, olefin-based copolymers (for example, an ethylene-propylene copolymer), dispersant-type olefin-based copolymers, and styrene-based copolymers (for example, a styrene-diene copolymer, a styrene-isoprene copolymer).

[0139] When the lubricating oil composition according to one aspect of the present invention contains a viscosity index improver, the content of the viscosity index improver in terms of a resin content is preferably 0.01 to 10% by mass, more preferably 0.02 to 7% by mass, and further more preferably 0.03 to 5% by mass, based on the total amount of the lubricating oil composition.

(Rust Inhibitor)

[0140] Examples of the rust inhibitor include metal sulfonates, alkylbenzenesulfonates, dinonylnaphthalenesulfonates, organic phosphite esters, organic phosphate esters, organic sulfonic acid metal salts, organic phosphoric acid metal salts, alkenyl succinic acid esters, and alkenyl succinic acid polyhydric alcohol esters.

[0141] When the lubricating oil composition according to one aspect of the present invention contains a rust inhibitor, the content of the rust inhibitor is preferably 0.01 to 10.0% by mass, and more preferably 0.03 to 5.0% by mass, based on the total amount of the lubricating oil composition.

(Metal Deactivator)

[0142] Examples of the metal deactivator include benzotriazole compounds, tolyltriazole compounds, thiadiazole compounds, imidazole compounds, and pyrimidine compounds.

[0143] When the lubricating oil composition according to one aspect of the present invention contains a metal deactivator, the content of the metal deactivator is preferably 0.01 to 5.0% by mass, and more preferably 0.03 to 3.0% by mass, based on the total mass of the lubricating oil composition.

(Anti-foaming Agent)

[0144] Examples of the anti-foaming agent include silicone-based anti-foaming agents, fluorine-based anti-foaming agents such as fluorosilicone oils and fluoroalkyl ethers, and polyacrylate-based anti-foaming agents.

[0145] When the lubricating oil composition according to one aspect of the present invention contains an anti-foaming agent, the content of the anti-foaming agent in terms of a resin content is preferably 0.0001 to 0.20% by mass, and more preferably 0.0005 to 0.10% by mass, based on the total mass of the lubricating oil composition.

(Friction Modifier)

[0146] Examples of the friction modifier include molybdenum-based friction modifiers such as molybdenum dithiocarbamate (MoDTC) and molybdenum dithiophosphate (MoDTP); and ash-free friction modifiers having at least one alkyl or alkenyl group having 6 to 30 carbon atoms in the molecule, such as aliphatic amines, fatty acid esters, fatty acids, aliphatic alcohols, and aliphatic ethers.

[0147] Incidentally, it is preferable that the content of the friction modifier containing a sulfur atom, such as MoDTC or MoDTP, is small from the viewpoint of suppressing the precipitation of sludge generated with long period of time use under a high-temperature environment. Specifically, the content of the sulfur atom-containing friction modifier is preferably lower than 1 mass%, more preferably lower than 0.5 mass%, further preferably lower than 0.1 mass%, further more preferably lower than 0.05 mass%, even further preferably lower than 0.01 mass%, and further still preferably free from a sulfur atom-containing friction modifier, based on the total amount of the lubricating oil composition.

[Various Physical Properties of Lubricating Oil Composition]

<40°C Kinematic Viscosity of Lubricating Oil Composition>

[0148] The 40°C kinematic viscosity of the lubricating oil composition of one aspect of the present invention is preferably 10 mm²/s to 100 mm²/s, more preferably 30 mm²/s to 60 mm²/s, further preferably 35 mm²/s to 55 mm²/s, further more

preferably 40 mm²/s to 50 mm²/s.

[0149] In this specification, the 40°C kinematic viscosity of the lubricating oil composition is a value measured according to JIS K 2283:2000.

<Oxidation Stability>

(Increased Amount of Acid Value)

[0150] In the lubricating oil composition of one aspect of the present invention, an increased amount A acid value of the acid value before and after a test (difference between the acid value after the test and the acid value before the test) by an oxidation stability test according to ASTM D2440, which is carried out by a method described in Examples mentioned below, is preferably lower than 0.10 mgKOH/g, more preferably 0.08 mgKOH/g or less, further preferably 0.06 mgKOH/g or less, further more preferably 0.05 mgKOH/g or less, even further preferably 0.04 mgKOH/g or less.

[0151] In this specification, the acid value is a value measured according to JIS K2501:2003-5 (Indicator titration method).

(RPVOT Value)

[0152] In the lubricating oil composition of one aspect of the present invention, an RPVOT value, which is measured according to ASTM D2272 at a test temperature of 150°C after carrying out an oxidation stability test according to ASTM D2440, is preferably 600 min or more, more preferably 650 min or more, further preferably 700 min or more, further more preferably 750 min or more.

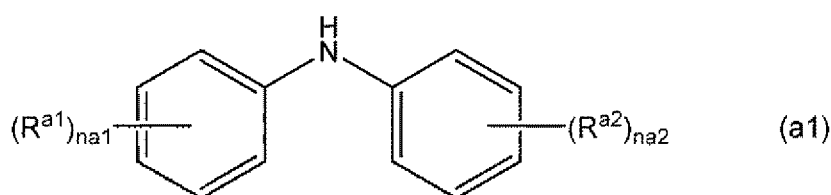
[Method for Producing Lubricating Oil Composition]

[0153] The production method of the lubricating oil composition of the present invention is not specifically limited.

[0154] For example, the method for producing the lubricating oil composition of one aspect of the present invention is a method for producing a lubricating oil composition containing a base oil (X) containing tertiary carbon atom at a content of 8.0 at% or more based on the total carbons of hydrocarbons, and an antioxidant (Y) containing an amine-based antioxidant (A), a phenol-based antioxidant (B) and a phosphor-based antioxidant (C),

wherein the method including a step of mixing the base oil (X) and the antioxidant (Y), the amine-based antioxidant (A) contains a diphenylamine compound (A1) represented by the following general formula (a1):

[Chem. 8]



wherein R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, na1 and na2 are each independently an integer of 1 to 5, wherein when na1 is 2 or more, a plurality of R^{a1}'s may be the same, or may be different from each other, and in the case where na2 is 2 or more, a plurality of R^{a2}'s may be the same, or may be different from each other,

the phenol-based antioxidant (B) contains a hindered phenol compound (B1) having an ester structure, and the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C) based on the total amount of the lubricating oil composition is adjusted to be greater than 1.0 mass% and 2.0 mass% or less.

[0155] The method for mixing the above-mentioned respective components is not specifically limited, and may include, for example, a method including a step of blending the antioxidant (Y) in the base oil (A). The amine-based antioxidant (A), the phenol-based antioxidant (B), and the phosphor-based antioxidant (C) can be simultaneously blended to the base oil (A), or may be blended separately. The same applies to blend of other components (additives for a lubricating

oil) than the antioxidant (Y). Incidentally, the respective components may be blended after a form of a solution (dispersion) is formed by adding a dilution oil, etc. and it is preferable to blend the respective components, and homogeneously disperse by stirring by a known method.

[Use of Lubricating Oil Composition]

[0156] The lubricating oil composition of one aspect of the present invention can be used as turbine oils for lubrication of various turbines such as steam turbines, nuclear turbines, gas turbines and hydroelectric turbines; bearing oils, gear oils, and control system hydraulic oils for lubrication of various turbomachinery such as fans and gas compressors, and further hydraulic oils.

[0157] That is, the lubricating oil composition of the present invention is preferably used for use in lubrication of one or more devices selected from the group consisting of turbines, gas compressors and hydraulic devices.

[0158] Therefore, according to the lubricating oil composition of the present invention, a method for using said lubricating oil composition in one or more devices selected from the group consisting of turbines, gas compressors and hydraulic devices is provided.

[Aspects of Present Invention Provided]

[0159] In aspects of the present invention, the following [1] to [11] are provided.

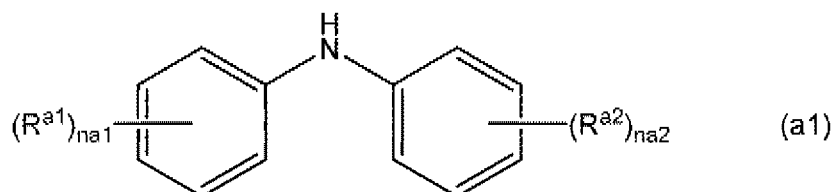
[1] A lubricating oil composition comprising:

a base oil (X) comprising tertiary carbon atom at a content of 8.0 at% or more based on the total carbon of hydrocarbons; and

an antioxidant (Y) comprising an amine-based antioxidant (A), a phenol-based antioxidant (B), and a phosphor-based antioxidant (C),

wherein the amine-based antioxidant (A) comprises a diphenylamine compound (A1) represented by the following general formula (a1):

[Chem. 9]



wherein R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, $na1$ and $na2$ are each independently an integer of 1 to 5, wherein when $na1$ is 2 or more, a plurality of R^{a1} 's may be the same, or may be different from each other, and in the case where $na2$ is 2 or more, a plurality of R^{a2} 's may be the same, or may be different from each other,

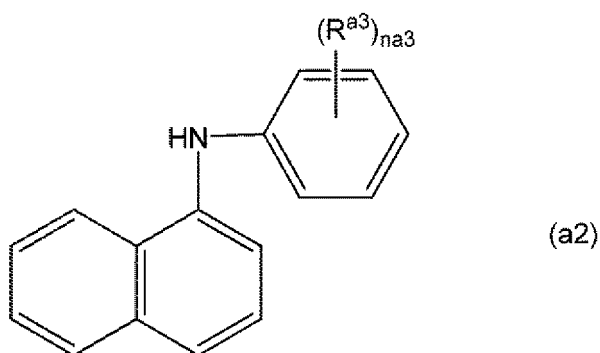
the phenol-based antioxidant (B) comprises a hindered phenol compound (B1) having an ester structure, and the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C) based on the total amount of the lubricating oil composition is greater than 1.0 mass% and 2.0 mass% or less.

[2] The lubricating oil composition of [1], wherein the total content [(A1) + (B1)] of the diphenylamine compound (A1) and the hindered phenol compound (B1) having an ester structure is 0.9 mass% or more based on the total amount of the lubricating oil composition.

[3] The lubricating oil composition of [1] or [2], wherein the content of the diphenylamine compound (A1) is 0.30 mass% to 1.8 mass% based on the total amount of the lubricating oil composition.

[4] The lubricating oil composition of any one of [1] to [3], wherein the amine-based antioxidant (A) further comprises a naphthylamine compound (A2) represented by the following general formula (a2):

[Chem. 10]

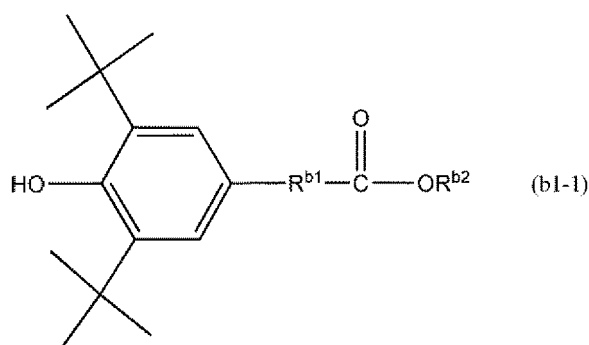


wherein R^{a3} is an alkyl group having 1 to 30 carbon atoms, $na3$ is an integer of 1 to 5, and when $na3$ is 2 or more, a plurality of R^{a3} 's may be the same or may be different from each other.

[5] The lubricating oil composition of [4], wherein the total content [(A1) + (A2)] of the diphenylamine (A1) and the naphthylamine (A2) is 0.8 mass% or more and lower than 2.0 mass% based on the total amount of the lubricating oil composition.

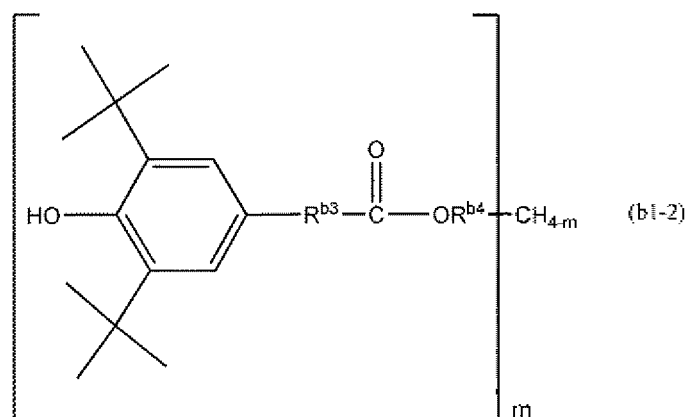
[6] The lubricating oil composition of any one of [1] to [5], wherein the hindered phenol compound (B1) having an ester structure is one or more kind selected from the group consisting of a compound (B1-1) represented by the following general formula (b1-1) and a compound (B1-2) represented by the following general formula (b1-2):

[Chem. 11]



wherein R^{b1} is an alkylene group having 1 to 5 carbon atoms, and R^{b2} is an alkyl group having 1 to 25 carbon atoms:

[Chem. 12]

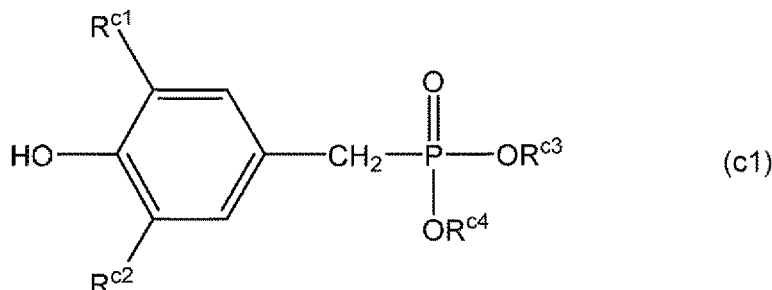


wherein R^{b3} and R^{b4} are each independently an alkylene group having 1 to 5 carbon atoms, and m is an integer of

2 to 4.

[7] The lubricating oil composition of any one of [1] to [6], wherein the phosphor-based antioxidant (C) comprises a phosphor atom-containing compound (C1) having a phenol structure represented by the following general formula (c1).

[Chem. 13]



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.

[8] The lubricating oil composition of any one of [1] to [7], further comprising one or more kind of lubricating oil additive selected from the group consisting of an extreme pressure agent, a detergent dispersant, a pour point depressant, a viscosity index improver, a rust inhibitor, a metal deactivator, an anti-foaming agent and a friction modifier.

[9] The lubricating oil composition of any one of [1] to [8], wherein the content of the base oil (X) is 90.0 mass% or more based on the total amount of the lubricating oil composition.

[10] The lubricating oil composition of any one of [1] to [9], which is used for one or more device selected from the group consisting of a turbine, a compressor and a hydraulic device.

[11] A method for using the lubricating oil composition of any one of [1] to [9] in one or more device selected from the group consisting of a turbine, a compressor and a hydraulic device.

Examples

[0160] The present invention will be described more specifically with reference to examples, but the present invention is not limited to these examples.

[Method for Measuring Various Physical Properties]

[0161] The respective characteristics of the respective raw material and the lubricating oil compositions used in the respective Examples and respective Comparative Examples are measured according to the procedures shown below.

(1) Kinematic Viscosity and Viscosity Index

[0162] The kinematic viscosity and the viscosity index were measured and calculated in accordance with JIS K2283:2000.

(2) Acid Value

[0163] The acid value was measured in accordance with JIS K2501:2003-5 (Indicator titration method).

(3) Tertiary Carbon Atom Content

[0164] The tertiary carbon atom content (based on the total carbons of hydrocarbons) of the base oil was measured by the above-mentioned method using ^{13}C -NMR.

[Examples 1 to 3 and Comparative Examples 1 to 8]

[0165] The base oil and various additives shown below were sufficiently mixed at the contents (mass%) shown in Table 1 to respectively prepare lubricating oil compositions.

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[0166] The details of the base oils and various additives used in Examples 1 to 3 and Comparative Examples 1 to 8 are as shown below.

<Base oil (X)>

- Base oil (X1)

[0167] A base oil belonging to Group III by API Classification, which is obtained by subjecting a raw material oil containing a petroleum-derived wax to a hydrogenation isomerization dewaxing treatment, then subjecting to a hydrogenation finishing treatment.

[0168] Tertiary carbon atom content: 10.0 at% (base oil based on the total amount), 40°C kinematic viscosity: 43.75 mm²/s, viscosity index: 143

- Base oil (X2)

Base oil containing isoparaffin polymer

[0169] Tertiary carbon atom content: 9.2 at% (based on the total carbons of hydrocarbons in base oil), 40°C kinematic viscosity: 45.87 mm²/s, viscosity index: 107

- Base oil (X3)

[0170] Mixed base oil having a tertiary carbon atom content of 5.0 at% (base oil based on the total amount) obtained by mixing two kinds of the following (1) and (2)

(1) A base oil belonging to Group II by API classification, tertiary carbon atom content: 5.0 at% (based on the total carbons of hydrocarbons in base oil), 40°C kinematic viscosity: 30.60 mm²/s, viscosity index: 104

(2) A base oil belonging to Group II by API classification, tertiary carbon atom content: 5.0 at% (based on the total carbons of hydrocarbons in base oil), 40°C kinematic viscosity: 90.51 mm²/s, viscosity index: 107

[0171] * The content ratio of (1) to (2) is (1):(2) = 67.90:30.00 by mass ratio.

- Base oil (X4)

Base oil formed of poly- α -olefin

[0172] Tertiary carbon atom content: 5.0 at% (based on the total carbons of hydrocarbons in base oil), 40°C kinematic viscosity: 46.74 mm²/s, viscosity index: 137

<Amine-based Antioxidant (A)>

- Diphenylamine (A1): di(octylphenyl)amine

[0173] A compound wherein, in the general formula (a1), R^{a1} and R^{a2} are octyl groups, and na1 = na2 = 1.

- Naphthylamine (A2): octylphenyl- α -naphthylamine

[0174] A compound wherein, in the general formula (a2), R^{a3} is an octyl group and na3 = 1.

<Phenol-based Antioxidant (B)>

- Hindered phenol compound (B1): benzenepropanoic acid-3,5-bis(1,1-dimethylethyl)-4-hydroxyalkyl ester

[0176] A compound wherein, in the general formula (b1-1), R^{b1} is an alkylene group having two carbon atoms, and R^{b2} is an alkyl group having 8 carbon atoms.

<Phosphor-based antioxidant (C)>

- Phosphor atom-containing compound (C1) having a phenol structure: diethyl di-tert-butyl-4-hydroxybenzyl-

phosphate

[0178] A compound wherein, in the general formula (c1), R^{c1} and R^{c2} are tert-butyl groups, and R^{c3} and R^{c4} are ethyl groups.

5 <Additives for Lubricating Oil>

[0179]

- Extreme pressure agent: dithiophosphoric acid
- 10 • Rust inhibitor: an alkenyl succinate polyhydric alcohol ester,
- Metal deactivator: an N-dialkylaminomethylbenzotriazole
- Anti-foaming agent: a silicone-based anti-foaming agent having a resin content concentration of 1 mass%

[0180] For each of the lubricating oil compositions of Examples 1 to 3 and Comparative Examples 1 to 8, the following
15 two tests were carried out.

<Oxidation stability test 1 (evaluation of increased amount of acid value before and after test)>

[0181] First, the acid value before test of each lubricating oil composition was measured. Second, an oxidation stability
20 test was carried out under the following conditions in accordance with ASTM D2440. In this test, raising of an acid value at the initial stage was confirmed with setting the test time to a week (168 hours).

- Test temperature: 110°C
- Catalyst: copper
- 25 • Test time: 1 week (168 hours)
- Oxygen blow amount: 1 L/h

[0182] After the test, the acid value of each lubricating oil composition was measured, and the amount of raising from
30 the acid value before the test (Δ acid value) was obtained. Furthermore, the lubricating oil composition having Δ acid value of lower than 0.10 mgKOH/g was judged to be acceptable.

<Oxidation Stability Test 2 (Evaluation of RPVOT Values Before and After Test)>

[0183] First, the RPVOT value of each lubricating oil composition was measured in accordance with ASTM D2272 at
35 a test temperature of 150°C. Second, the RPVOT value of each lubricating oil composition after the oxidation stability test was carried out was similarly measured in accordance with ASTM D2440. In this test, the residual lifetime of the test oil was confirmed from the decrease in performance of the antioxidant.

[0184] Furthermore, the test oil having a RPVOT value of 600 min or more was judged to be acceptable.

[0185] The results are shown in Table 1.
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[Table 1]

	Unit	Examples			Comparative Examples							
		1	2	3	1	2	3	4	5	6	7	8

(continued)

		Unit	Examples			Comparative Examples							
			1	2	3	1	2	3	4	5	6	7	8
Lubricating oil composition	Base oil (X)	Base oil (X1)	97.90	97.40	-	96.60	96.60	98.40	97.60	98.50	-	-	98.00
		Base oil (X2)	-	-	97.90	-	-	-	-	-	-	-	-
		Base oil (X3)			-						97.90		
		Base oil (X4)									-	97.90	
	Antioxidant (Y)	Amine-based antioxidant (A)	0.50	1.00	0.50	2.00	1.00		1.00	0.50	0.50	0.50	0.50
		Naphthylamine (A2)	0.60	0.60	0.60	-	1.00	0.60	-	0.60	0.60	0.60	0.60
		Phenol-based antioxidant (B)											
		Hindered phenol compound (B1) having an ester structure											
	Additives for lubricating oil	Phosphor-based antioxidant (C)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
		Phosphor atom-containing compound (C1) having phenol structure											
		Pour point depressant	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Rust inhibitor	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Tertiary carbon atom content of base oil (X)	Metal deactivator	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
		Anti-foaming agent	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
		Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
		(A1) + (B1) + (C)	1.2	1.7	1.2	3.1	2.1	0.7	2.1	0.6	1.2	1.2	1.0
	(A1)/(B1)	(A1) + (B1)	1.1	1.6	1.1	3.0	2.0	0.6	2.0	0.5	1.1	1.1	1.1
		(A1)/(B1)	0.8	1.7	0.8	2.0	1.0	0.0	1.0	-	0.8	0.8	0.8
		(A1)/(C)	5.0	10.0	5.0	20.0	10.0	0.0	10.0	5.0	5.0	5.0	-
		(B1)/(C)	6.0	6.0	6.0	10.0	10.0	6.0	10.0	0.0	6.0	6.0	6.0
	(A1) + (A2)	(A1) + (A2)	1.10	1.60	1.10	2.00	2.00	0.60	1.00	1.10	1.10	1.10	1.10

(continued)

		Unit	Examples			Comparative Examples							
			1	2	3	1	2	3	4	5	6	7	8
Evaluation	Fresh oil	Acid value	0.26	0.27	0.25	0.27	0.25	0.28	0.28	0.29	0.23	0.26	0.24
		RPVOT value	1633	1777	1555	1769	1656	796	1372	3046	1090	1180	1565
	Test oil	Acid value	0.24	0.27	0.28	0.52	0.35	0.54	0.41	0.24	0.26	0.26	0.31
		RPVOT value	865	990	789	851	821	330	1023	232	456	542	348
	Δ Acid value		0.02	0.00	0.03	0.25	0.10	0.26	0.13	0.05	0.03	0.00	0.07

[0186] The following matters are understood from Table 1.

[0187] It is understood that the lubricating oil compositions of Examples 1 to 3 gave excellent results for both Δ acid value and RPVOT value, and thus are lubricating oil compositions capable of suppressing raising of an acid value at the initial stage and maintaining oxidation stability for a long period of time.

[0188] On the other hand, it is understood that, in the lubricating oil compositions in which the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) and the phosphor-based antioxidant (C) is greater than 2.0 mass% like Comparative Examples 1, 2 and 4, the value of Δ acid value is large, and raising of an acid value at the initial stage occurs easily.

[0189] Furthermore, it is understood that, in the lubricating oil compositions in which the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1), and the phosphor-based antioxidant (C) is 1.0 mass% or less like Comparative Examples 3, 5 and 8, the RPVOT value decreases, and thus oxidation stability cannot be maintained for a long period of time.

[0190] Moreover, in the lubricating oil compositions using a base oil having a tertiary carbon atom content of lower than 8.0 at% like Comparative Examples 6 and 7, the value of Δ acid value is small, and thus raising of an acid value at the initial stage is difficult to occur, whereas the RPVOT value decreases, and thus oxidation stability cannot be maintained for a long period of time.

Claims

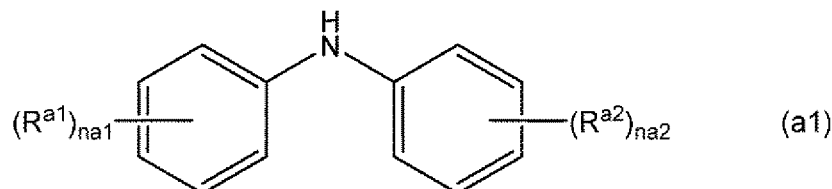
1. A lubricating oil composition comprising:

a base oil (X) comprising tertiary carbon atom at a content of 8.0 at% or more based on the total carbon of hydrocarbons; and

an antioxidant (Y) comprising an amine-based antioxidant (A), a phenol-based antioxidant (B), and a phosphor-based antioxidant (C),

wherein the amine-based antioxidant (A) comprises a diphenylamine compound (A1) represented by the following general formula (a1):

[Chem. 1]



wherein R^{a1} and R^{a2} are each independently an alkyl group having 1 to 30 carbon atoms, $na1$ and $na2$ are each independently an integer of 1 to 5, wherein when $na1$ is 2 or more, a plurality of R^{a1} 's may be the same, or may be different from each other, and in the case where $na2$ is 2 or more, a plurality of R^{a2} 's may be the same, or may be different from each other,

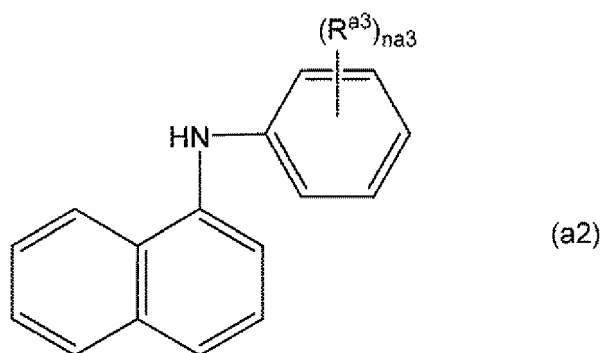
the phenol-based antioxidant (B) comprises a hindered phenol compound (B1) having an ester structure, and the total content [(A1) + (B1) + (C)] of the diphenylamine compound (A1), the hindered phenol compound (B1) having an ester structure, and the phosphor-based antioxidant (C) based on the total amount of the lubricating oil composition is greater than 1.0 mass% and 2.0 mass% or less.

2. The lubricating oil composition according to claim 1, wherein the total content [(A1) + (B1)] of the diphenylamine compound (A1) and the hindered phenol compound (B1) having an ester structure is 0.9 mass% or more based on the total amount of the lubricating oil composition.

3. The lubricating oil composition according to claim 1 or 2, wherein the content of the diphenylamine compound (A1) is 0.3 mass% to 1.8 mass% based on the total amount of the lubricating oil composition.

4. The lubricating oil composition according to any one of claims 1 to 3, wherein the amine-based antioxidant (A) further comprises a naphthylamine compound (A2) represented by the following general formula (a2):

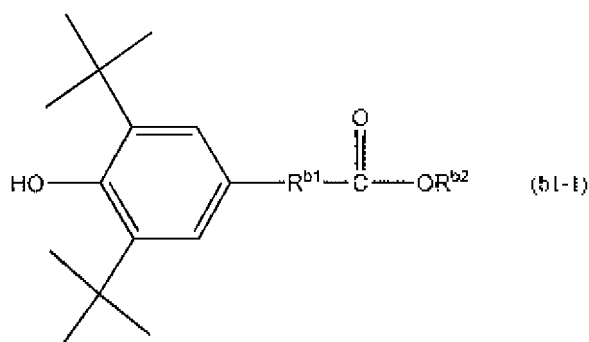
[Chem. 2]



wherein R^{a3} is an alkyl group having 1 to 30 carbon atoms, $na3$ is an integer of 1 to 5, and when $na3$ is 2 or more, a plurality of R^{a3} 's may be the same or may be different from each other.

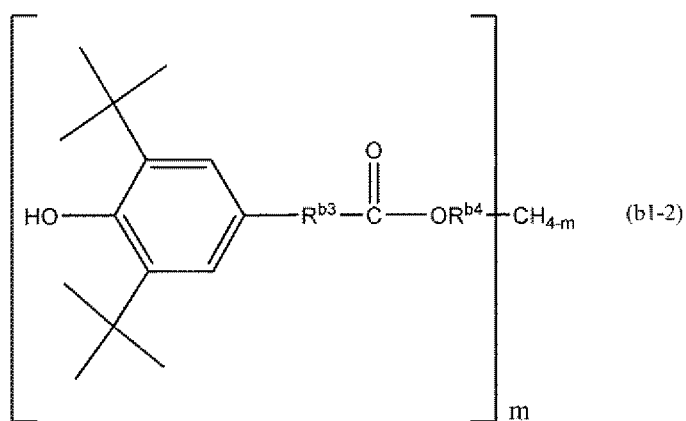
5. The lubricating oil composition according to claim 4, wherein the total content [(A1) + (A2)] of the diphenylamine (A1) and the naphthylamine (A2) is 0.8 mass% or more and lower than 2.0 mass% based on the total amount of the lubricating oil composition.
6. The lubricating oil composition according to any one of claims 1 to 5, wherein the hindered phenol compound (B1) having an ester structure is one or more kind selected from the group consisting of a compound (B1-1) represented by the following general formula (b1-1) and a compound (B1-2) represented by the following general formula (b1-2):

[Chem. 3]



wherein R^{b1} is an alkylene group having 1 to 5 carbon atoms, and R^{b2} is an alkyl group having 1 to 25 carbon atoms;

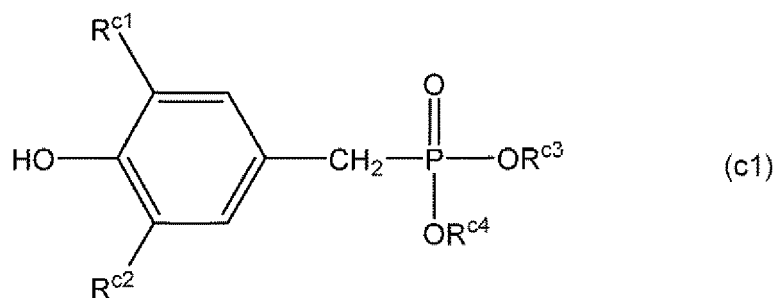
[Chem. 4]



wherein R^{b3} and R^{b4} are each independently an alkylene group having 1 to 5 carbon atoms, and m is an integer of 2 to 4.

7. The lubricating oil composition according to any one of claims 1 to 6, wherein the phosphor-based antioxidant (C) comprises a phosphor atom-containing compound (C1) having a phenol structure represented by the following general formula (c1):

[Chem. 5]



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.

8. The lubricating oil composition according to any one of claims 1 to 7, further comprising one or more kind of lubricating oil additive selected from the group consisting of an extreme pressure agent, a detergent dispersant, a pour point depressant, a viscosity index improver, a rust inhibitor, a metal deactivator, an anti-foaming agent and a friction modifier.
9. The lubricating oil composition according to any one of claims 1 to 8, wherein the content of the base oil (X) is 90.0 mass% or more based on the total amount of the lubricating oil composition.
10. The lubricating oil composition according to any one of claims 1 to 9, which is used for one or more device selected from the group consisting of a turbine, a compressor and a hydraulic device.
11. A method for using the lubricating oil composition according to any one of claims 1 to 9 in one or more device selected from the group consisting of a turbine, a compressor and a hydraulic device.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/008644

A. CLASSIFICATION OF SUBJECT MATTER C10N 30/10(2006.01)n; C10N 40/02(2006.01)n; C10N 40/04(2006.01)n; C10N 40/08(2006.01)n; C10N 40/12(2006.01)n; C10M 129/10(2006.01)i; C10M 129/70(2006.01)i; C10M 129/74(2006.01)i; C10M 133/12(2006.01)i; C10M 137/00(2006.01)i; C10M 137/12(2006.01)i FI: C10M133/12; C10M129/10; C10M137/00; C10M129/70; C10M129/74; C10M137/12; C10N40:12; C10N30:10; C10N40:04; C10N40:02; C10N40:08 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) C10N30/10; C10N40/02; C10N40/04; C10N40/08; C10N40/12; C10M129/10; C10M129/70; C10M129/74; C10M133/12; C10M137/00; 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 1971-2021 Registered utility model specifications of Japan 1996-2021 Published registered utility model applications of Japan 1994-2021													
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													
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>WO 2016/032246 A1 (SK INNOVATION CO., LTD.) 03 March 2016 (2016-03-03) paragraphs [0002]-[0004], [0023], [0026], [0040]-[0041], [0050]-[0051], [0064]-[0067], table 2</td> <td>1-11</td> </tr> <tr> <td>Y</td> <td>JP 2008-156527 A (NIPPON OIL CORPORATION) 10 July 2008 (2008-07-10) paragraphs [0001]-[0003], [0018], [0043]-[0044], [0147], tables 1-2</td> <td>1-11</td> </tr> <tr> <td>Y</td> <td>JP 2004-501234 A (PUB SERVICES INC.) 15 January 2004 (2004-01-15) claims</td> <td>6</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	WO 2016/032246 A1 (SK INNOVATION CO., LTD.) 03 March 2016 (2016-03-03) paragraphs [0002]-[0004], [0023], [0026], [0040]-[0041], [0050]-[0051], [0064]-[0067], table 2	1-11	Y	JP 2008-156527 A (NIPPON OIL CORPORATION) 10 July 2008 (2008-07-10) paragraphs [0001]-[0003], [0018], [0043]-[0044], [0147], tables 1-2	1-11	Y	JP 2004-501234 A (PUB SERVICES INC.) 15 January 2004 (2004-01-15) claims	6	
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Y	WO 2016/032246 A1 (SK INNOVATION CO., LTD.) 03 March 2016 (2016-03-03) paragraphs [0002]-[0004], [0023], [0026], [0040]-[0041], [0050]-[0051], [0064]-[0067], table 2	1-11											
Y	JP 2008-156527 A (NIPPON OIL CORPORATION) 10 July 2008 (2008-07-10) paragraphs [0001]-[0003], [0018], [0043]-[0044], [0147], tables 1-2	1-11											
Y	JP 2004-501234 A (PUB SERVICES INC.) 15 January 2004 (2004-01-15) claims	6											
☒ Further documents are listed in the continuation of Box C.	☒ See patent family annex.												
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-161773 A (IDEMITSU KOSAN CO., LTD.) 28 June 2007 (2007-06-28) claims, paragraphs [0018]-[0020]	7
Y	JP 05-302093 A (TONEN CORP.) 16 November 1993 (1993-11-16) example 5	7
Y	JP 2012-102191 A (JTEKT CORP.) 31 May 2012 (2012-05-31) example 4	7

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/008644

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2016/032246 A1	03 Mar. 2016	KR 10-2016-0025480 A paragraphs [0002]-[0004], [0023], [0026], [0040]-[0041], [0051]-[0052], [0063]-[0065], table 2	
JP 2008-156527 A	10 Jul. 2008	CN 106604981 A US 2008/0110799 A1 paragraphs [0001]-[0004], [0039], [0184]-[0187], [0263], tables 1-2	
JP 2004-501234 A	15 Jan. 2004	US 2003/0171227 A1 claims	
JP 2007-161773 A	28 Jun. 2007	WO 2001/085878 A2 EP 1280872 A US 2009/0186785 A1 claims, paragraphs [0035]-[0036]	
JP 05-302093 A	16 Nov. 1993	WO 2007/066713 A1 EP 1964910 A1 CN 101326273 A (Family: none)	
JP 2012-102191 A	31 May 2012	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011162629 A [0005]