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(54) LUBRICANT COMPOSITION

(57) Provided is a lubricating oil composition containing a base oil (A), a phosphorous acid ester (B), an imide-based compound (C), an amide-based compound (D), an amine-based compound (E), and a benzotriazole-based compound (F), wherein a content of the component (F) is 0.005 to 1.00 mass% based on the total amount of the lubricating oil composition.

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Description

Technical Field

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

Background Art

[0002] Various apparatuses such as an engine, a transmission, a speed reducer, a compressor and a hydraulic system have mechanisms such as a torque converter, a clutch, a gear bearing mechanism, an oil pump and a hydraulic control mechanism. In these mechanisms, lubricating oil compositions are used, and lubricating oil compositions capable of meeting various requirements have been developed.

[0003] For example, Patent Literature 1 discloses an invention relating to a lubricating oil composition containing a base oil, a diamine, a glycolic acid amide, and a phosphorous acid ester, which can balance different friction characteristics between different sites and can be preferably used as a lubricating oil for metal belt type continuously variable transmission.

Citation List

Patent Literature

[0004] Patent Literature 1: International Publication No. WO 2019/167812

Summary of Invention

Technical Problem

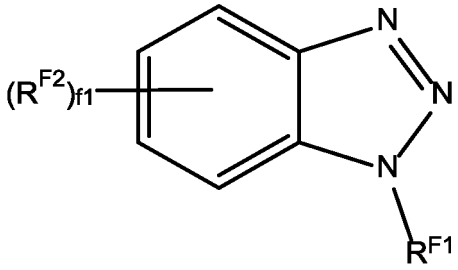
[0005] By the way, for example, a lubricating oil composition used for a transmission equipped with a clutch mechanism requires various characteristics, such as seizure resistance, clutch characteristics, and copper corrosion resistance, depending on the mode of a transmission. That is to say, a novel lubricating oil composition having characteristics (e.g., seizure resistance, clutch characteristics, copper corrosion resistance) suitable for lubrication of various mechanisms has been desired.

Solution to Problem

[0006] The present invention provides a lubricating oil composition comprising a base oil, a phosphorous acid ester, an imide-based compound, an amide-based compound, an amine-based compound, and a benzotriazole-based compound. Specifically, the present invention provides lubricating oil compositions according to the following embodiments [1], [1a] to [1c], and [2] to [11], a transmission according to the following embodiment [12], and a method for using a lubricating oil composition according to the following embodiment [13].

[1] A lubricating oil composition comprising a base oil (A), a phosphorous acid ester (B), a non-boron modified imide-based compound (C), an amide-based compound (D), an amine-based compound (E), and a benzotriazole-based compound (F), wherein
a content of the component (F) is 0.005 to 1.00 mass% based on the total amount of the lubricating oil composition.
[1a] A lubricating oil composition comprising:

a base oil (A),
a phosphorous acid ester (B),
a non-boron modified imide-based compound (C) comprising a non-boron modified alkenyl succinimide (C1),
an amide-based compound (D) comprising a fatty acid amide (D1),
an amine-based compound (E) comprising a monoamine (E1), and
a benzotriazole-based compound (F) represented by the following general formula (f-0):

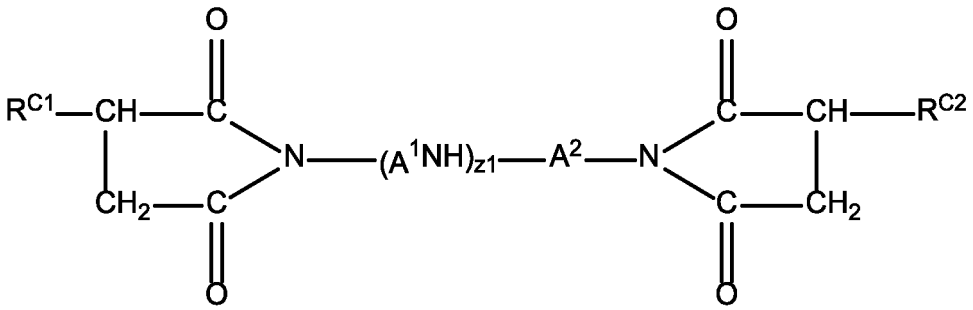


(f-0)

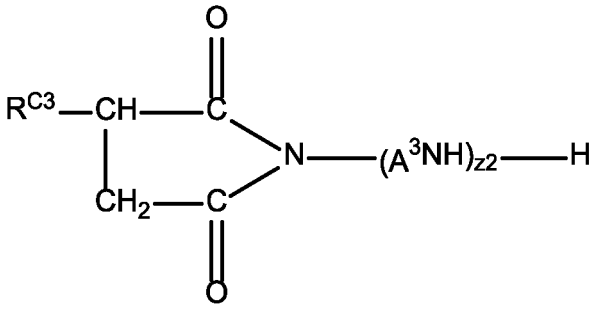
wherein R^{F1} is a hydrocarbon group optionally containing at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, and a nitrogen atom, or a hydrogen atom, each R^{F2} is independently a hydrocarbon group optionally containing at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, and a nitrogen atom, and f1 is an integer of 0 to 4, wherein
a content of the component (F) is 0.005 to 1.00 mass% based on the total amount of the lubricating oil composition.

[1b] A lubricating oil composition comprising:

a base oil (A),
a phosphorous acid ester (B),
a non-boron modified imide-based compound (C) comprising one or more selected from a non-boron modified alkenyl bis-succinimide (C11) represented by the following general formula (c-1) and a non-boron modified alkenyl mono-succinimide (C12) represented by the following general formula (c-2):

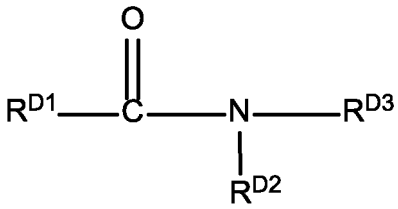


(c-1)

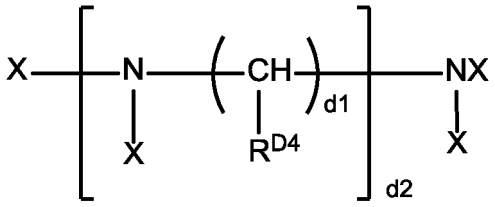


(c-2)

wherein R^{C1}, R^{C2}, and R^{C3} are each independently an alkenyl group having a mass-average molecular weight (Mw) of 500 to 3000, A^1, A^2, and A^3 are each independently an alkylene group having 2 to 5 carbon atoms, z1 is an integer of 0 to 10, and z2 is an integer of 1 to 10,
an amide-based compound (D) comprising one or more selected from a fatty acid monoamide (D11) represented by the following general formula (d-1) and a fatty acid polyamide (D12) represented by the following general formula (d-2):

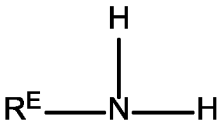


(d-1)

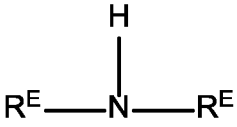


(d-2)

wherein R^{D1} is a hydrocarbon group, and R^{D2} and R^{D3} are each independently a hydrogen atom or a hydrocarbon group optionally substituted by a hydroxyl group, wherein R^{D4} is a hydrogen atom or a hydrocarbon group having 1 to 30 carbon atoms optionally substituted by a hydroxyl group, each X is independently a hydrogen atom or an acyl group represented by -(C=O)-R^{D5} (R^{D5} is a hydrocarbon group), at least one of multiple X is the acyl group, d1 is an integer of 1 to 6, and d2 is an integer of 1 or more,
an amine-based compound (E) comprising one or more selected from a primary amine (E11) represented by the following general formula (e-1) and a secondary amine (E12) represented by the following general formula (e-2):

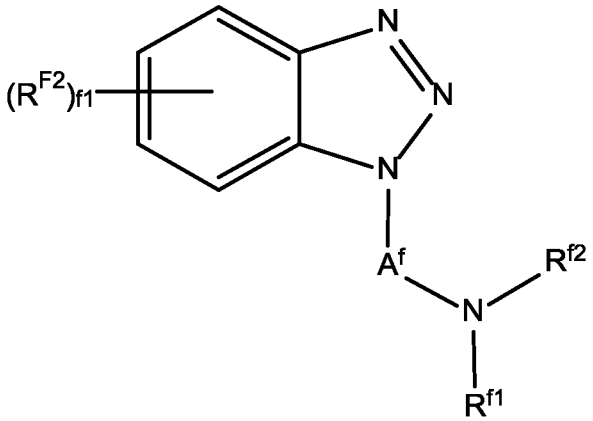


(e-1)



(e-2)

wherein each R^{E} is independently an alkyl group having 1 to 30 carbon atoms, an alkyl group having 1 to 30 carbon atoms and having a hydroxyl group, an alkenyl group having 2 to 30 carbon atoms, a cycloalkyl group having 3 to 30 ring-forming carbon atoms, a phenyl group, or a benzyl group, and
a benzotriazole-based compound (F) comprising a compound (F1) represented by the following general formula (f-1):



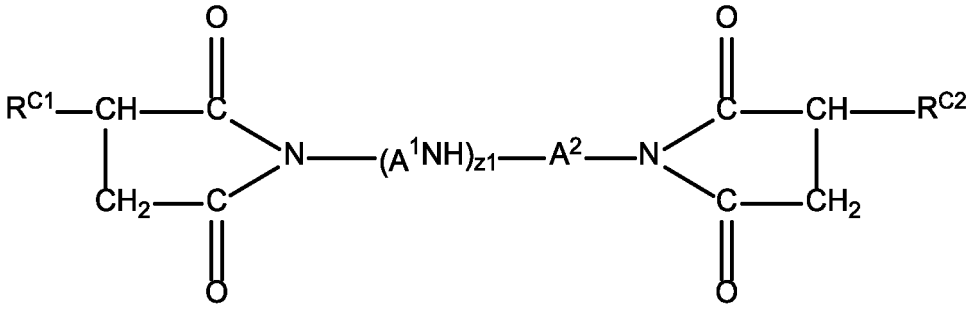
(f-1)

wherein each R^{F2} is independently a hydrocarbon group optionally containing at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, and a nitrogen atom, A^{f} is a divalent hydrocarbon group, R^{f1} and R^{f2} are each independently a monovalent hydrocarbon group, and f1 is an integer of 0 to 4, wherein
a content of the component (F) is 0.005 to 1.00 mass% based on the total amount of the lubricating oil composition.

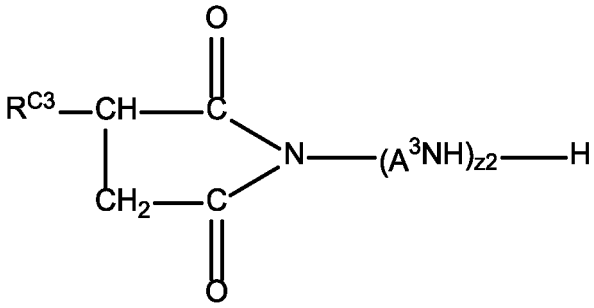
[1c] A lubricating oil composition comprising:

a base oil (A),
a phosphorous acid ester (B),
a non-boron modified imide-based compound (C) comprising one or more selected from a non-boron modified

alkenyl bis-succinimide (C11) represented by the following general formula (c-1) and a non-boron modified alkenyl mono-succinimide (C12) represented by the following general formula (c-2):



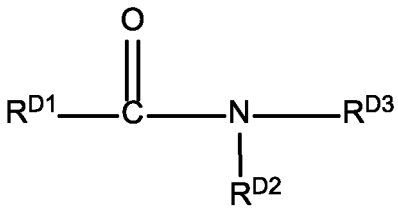
(c-1)



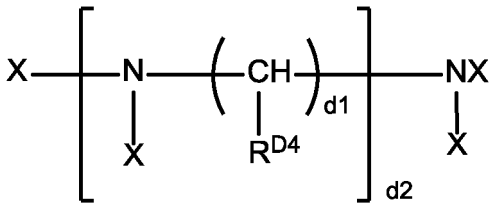
(c-2)

wherein R^{C1}, R^{C2}, and R^{C3} are each independently a polybutenyl group having a mass-average molecular weight (Mw) of 500 to 3000, A^1, A^2, and A^3 are each independently an alkylene group having 2 to 5 carbon atoms, z1 is an integer of 0 to 10, and z2 is an integer of 1 to 10,

an amide-based compound (D) comprising one or more selected from a fatty acid monoamide (D11) represented by the following general formula (d-1) and a fatty acid polyamide (D12) represented by the following general formula (d-2):



(d-1)

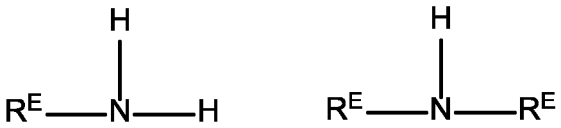


(d-2)

wherein R^{D1} is an alkyl group having 1 to 30 carbon atoms or an alkenyl group having 2 to 30 carbon atoms, and R^{D2} and R^{D3} are each independently a hydrogen atom, an alkyl group having 1 to 30 carbon atoms, or an alkenyl group having 2 to 30 carbon atoms,

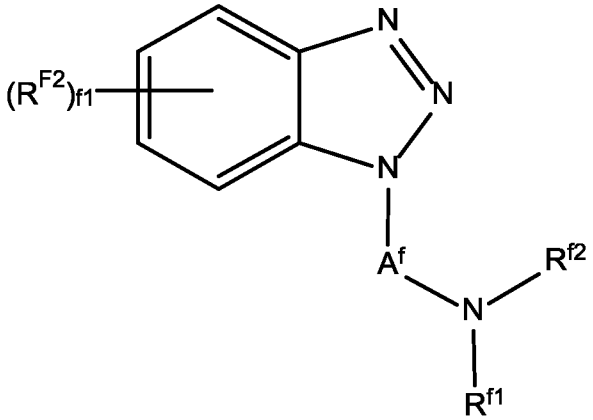
wherein R^{D4} is a hydrogen atom, an alkyl group having 1 to 30 carbon atoms, or an alkenyl group having 2 to 30 carbon atoms, each X is independently a hydrogen atom or an acyl group represented by -(C=O)-R^{D5} (R^{D5} is a hydrocarbon group), at least one of multiple X is the acyl group, d1 is an integer of 1 to 6, and d2 is an integer of 1 or more,

an amine-based compound (E) comprising one or more selected from a primary amine (E11) represented by the following general formula (e-1) and a secondary amine (E12) represented by the following general formula (e-2):



(e-1) (e-2)

wherein each R^E is independently an alkyl group having 1 to 30 carbon atoms, an alkyl group having 1 to 30 carbon atoms and having a hydroxyl group, or an alkenyl group having 2 to 30 carbon atoms, and
a benzotriazole-based compound (F) comprising a compound (F1) represented by the following general formula (f-1):



(f-1)

wherein each R^{F2} is independently an alkyl group having 1 to 20 carbon atoms, A^f is an alkylene group having 1 to 20 carbon atoms, R^{f1} and R^{f2} are each independently an alkyl group having 1 to 20 carbon atoms, and f1 is an integer of 0 to 4, wherein
a content of the component (F) is 0.005 to 1.00 mass% based on the total amount of the lubricating oil composition.

[2] The lubricating oil composition according to any one of the above [1] and [1a] to [1c], wherein a content of the component (B) is 0.01 to 3.00 mass% based on the total amount of the lubricating oil composition.
[3] The lubricating oil composition according to any one of the above [1], [1a] to [1c], and [2], wherein a content ratio [(F)/(B)] by mass of the component (F) to the component (B) is 0.01 to 0.50.
[4] The lubricating oil composition according to any one of the above [1] to [3], wherein the component (C) comprises a non-boron modified alkenyl succinimide (C1).
[5] The lubricating oil composition according to any one of the above [1] to [4], wherein the component (D) comprises a fatty acid amide (D1).
[6] The lubricating oil composition according to the above [5], wherein a content of the fatty acid amide (D1) is 0.04 mass% or more based on the total amount of the lubricating oil composition.
[7] The lubricating oil composition according to any one of the above [1] to [6], wherein the component (E) comprises a monoamine (E1).
[8] The lubricating oil composition according to any one of the above [1] to [7], wherein the component (E) comprises one or more selected from a primary monoamine (E11) and a secondary monoamine (E12).
[9] The lubricating oil composition according to any one of the above [1], [1a] to [1c], and [2] to [8], wherein a content ratio [(E)/(D)] by mass of the component (E) to the component (D) is 0.05 to 0.90.
[10] The lubricating oil composition according to any one of the above [1], [1a] to [1c], and [2] to [9], wherein a content of a fatty acid partial ester compound is less than 0.05 mass% based on the total amount of the lubricating oil composition.
[11] The lubricating oil composition according to any one of the above [1], [1a] to [1c], and [2] to [10], being used for a transmission equipped with a clutch mechanism.
[12] A transmission filled with the lubricating oil composition according to any one of the above [1], [1a] to [1c], and [2] to [11].
[13] A method for using a lubricating oil composition, wherein the lubricating oil composition according to any one of the

above [1], [1a] to [1c], and [2] to [11] is applied to lubrication of a transmission equipped with a clutch mechanism.

Advantageous Effects of Invention

[0007] The lubricating oil composition of one preferred embodiment of the present invention is a lubricating oil composition having characteristics suitable for lubrication of various mechanisms, and the lubricating oil composition of a more specific embodiment of the present invention can be improved in seizure resistance, clutch characteristics, and copper corrosion resistance in a balanced manner. On that account, these lubricating oil compositions can be preferably used for lubrication of, for example, a transmission.

Description of Embodiments

[0008] Regarding the numerical range described in the present specification, the upper limit and the lower limit can be arbitrarily combined. For example, with the description "preferably 30 to 100, more preferably 40 to 80" as a numerical range, the range of "30 to 80" and the range of "40 to 100" are also included in the numerical range described in the present specification. Alternatively, for example, with the description "preferably 30 or more, more preferably 40 or more, and preferably 100 or less, more preferably 80 or less" as a numerical range, the range of "30 to 80" and the range of "40 to 100" are also included in the numerical range described in the present specification.

[0009] In addition, for example, the description of "60 to 100" as the numerical range described in the present specification means a range of "60 or more (60 or more than 60) and 100 or less (100 or less than 100)".

[0010] The numerical range of a lower limit to an upper limit can be defined by appropriately selecting values from among respective options and optionally combining them in the definition of the upper limit and the lower limit described in the present specification.

[0011] In the present specification, the kinematic viscosity and the viscosity index mean values measured or calculated in accordance with JIS K2283:2000.

[0012] The contents of phosphorus atoms (P), boron atoms

(B), and calcium atoms (Ca) mean values measured in accordance with JPI-5S-38-92.
The content of nitrogen atoms (N) means a value measured in accordance with JIS K2609:1998.
The content of sulfur atoms (S) means a value measured in accordance with JIS K2541-6:2013.

[0013] [Constitution of lubricating oil composition] The lubricating oil composition of one embodiment of the present invention comprises a base oil (A) (also referred to as a "component (A)" hereinafter), a phosphorous acid ester (B) (also referred to as a "component (B)" hereinafter), a non-boron modified imide-based compound (C) (also referred to as a "component (C)" hereinafter), an amide-based compound (D) (also referred to as a "component (D)" hereinafter), an amine-based compound (E) (also referred to as a "component (E)" hereinafter), and a benzotriazole-based compound (F) (also referred to as a "component (F)" hereinafter).

[0014] The lubricating oil composition of one embodiment of the present invention can become a lubricating oil composition having characteristics suitable for lubrication of various mechanisms by containing the components (A) to (F), and as a more specific embodiment, the lubricating oil composition can become a lubricating oil composition having been improved in seizure resistance, clutch characteristics, and copper corrosion resistance in a balanced manner.

[0015] In the lubricating oil composition of one embodiment of the present invention, particularly, the component (B) contributes to improvement in seizure resistance, the components (C), (D), and (E) contribute to improvement in clutch characteristics, and the component (F) contributes to improvement in copper corrosion resistance.

[0016] Since the lubricating oil composition of one embodiment of the present invention has such characteristics, it can be preferably used for, for example, various devices equipped with clutch mechanisms, and more specifically, it can be more preferably used for a transmission equipped with a clutch mechanism.

[0017] The lubricating oil composition of one embodiment of the present invention may further contain various additives other than the components (B) to (F) when needed as long as the effects of the present invention are not impaired.

[0018] In the lubricating oil composition of one embodiment of the present invention, the total content of the components (A) to (F) is preferably 50 mass% or more, more preferably 60 mass% or more, still more preferably 70 mass% or more, still much more preferably 75 mass% or more, and particularly preferably 80 mass% or more, and it may be 100 mass% or less, 99.5 mass% or less, 99.0 mass% or less, 98.0 mass% or less, 97.0 mass% or less, 96.0 mass% or less, 95.0 mass% or less, 94.0 mass% or less, or 93.0 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0019] Details of the components contained in the lubricating oil composition of one embodiment of the present invention will be described hereinafter.

<Component (A): base oil>

[0020] As the base oil that is the component (A) used in one embodiment of the present invention, one or more selected from mineral oils and synthetic oils can be mentioned.

[0021] Examples of the mineral oils include atmospheric residues obtained by subjecting crude oils, such as paraffinic crude oil, intermediate base crude oil, and naphthenic crude oil, to atmospheric distillation; distillates obtained by subjecting these atmospheric residues to vacuum distillation; refined oils obtained by subjecting the distillates to one or more of refining treatments, such as solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, and hydrorefining (hydrocracking); and mineral oils (GTL) obtained by isomerizing GTL wax (Gas To Liquids WAX) produced from natural gas through Fischer-Tropsch process or the like.

[0022] Examples of the synthetic oils include poly-α-olefins, such as an α-olefin homopolymer and an α-olefin copolymer (for example, an α-olefin copolymer having 8 to 14 carbon atoms such as an ethylene-α-olefin copolymer); isoparaffin; polyalkylene glycol; ester oils, such as polyol ester, dibasic acid ester, and phosphoric acid ester; ether oils, such as polyphenyl ether; alkylbenzene; and alkylnaphthalene.

[0023] The component (A) used in one embodiment of the present invention preferably contains one or more selected from mineral oils classified in Group II and Group III of API (American Petroleum Institute) base oil categories, and synthetic oils.

[0024] The kinematic viscosity of the component (A) used in one embodiment of the present invention at 100°C is preferably 2.0 mm^2/s or more, more preferably 2.2 mm^2/s or more, still more preferably 2.3 mm^2/s or more, still much more preferably 2.5 mm^2/s or more, and particularly preferably 2.6 mm^2/s or more, and it is preferably 6.0 mm^2/s or less, more preferably 5.7 mm^2/s or less, more preferably 5.5 mm^2/s or less, still more preferably 5.2 mm^2/s or less, still more preferably 5.0 mm^2/s or less, still much more preferably 4.8 mm^2/s or less, and particularly preferably 4.6 mm^2/s or less.

[0025] The viscosity index of the component (A) used in one embodiment of the present invention is preferably 70 or more, more preferably 80 or more, still more preferably 90 or more, and still much more preferably 100 or more.

[0026] When a mixed oil that is a combination of two or more base oils is used as the component (A) in one embodiment of the present invention, the kinematic viscosity and the viscosity index of the mixed oil are preferably in the above ranges. On that account, by using a low-viscosity base oil and a high-viscosity base oil in combination, the mixed oil may be prepared so as to have a kinematic viscosity and a viscosity index in the above ranges.

[0027] The mixed oil may be a mixed oil of a combination of two or more base oils each having a kinematic viscosity at 100°C and a viscosity index belonging to the aforementioned ranges, or may be a mixed oil of a combination of a base oil having a kinematic viscosity at 100°C and a viscosity index belonging to the aforementioned ranges and a base oil having those not belonging to the aforementioned ranges. Alternatively, the mixed oil may be a mixed oil obtained by combining a low-viscosity base oil having a kinematic viscosity at 100°C and a viscosity index not belonging to the aforementioned ranges and a high-viscosity base oil to adjust them so that they will belong to the aforementioned ranges.

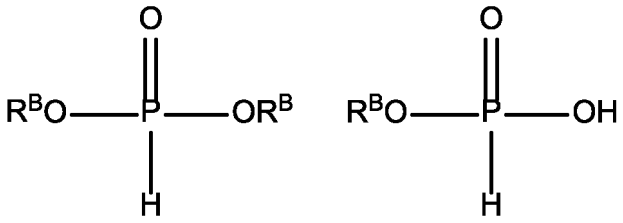
[0028] In the lubricating oil composition of one embodiment of the present invention, the content of the component (A) is preferably 30 mass% or more, more preferably 40 mass% or more, still more preferably 50 mass% or more, still much more preferably 55 mass% or more, and particularly preferably 60 mass% or more, and it may be 99 mass% or less, 98 mass% or less, 97 mass% or less, 95 mass% or less, 92 mass% or less, 90 mass% or less, 85 mass% or less, 80 mass% or less, or 75 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

<Component (B): phosphorous acid ester>

[0029] The lubricating oil composition of one embodiment of the present invention contains a phosphorous acid ester as the component (B). A lubricating oil composition having been improved in seizure resistance can be obtained by containing the component (B).

[0030] In one embodiment of the present invention, the component (B) may be used singly, or may be used in combination of two or more.

[0031] The phosphorous acid ester used as the component (B) in one embodiment of the present invention is, for example, an acidic phosphorous acid ester represented by the following general formula (b-1) or (b-2).



(b-1) (b-2)

[0032] In the above formulae, each R^B is independently an alkyl group having 1 to 30 carbon atoms, an alkenyl group having 2 to 30 carbon atoms, an aryl group having 6 to 30 carbon atoms which may be substituted by an alkyl group having 1 to 6 carbon atoms, a group having a sulfide bond, or the like. Multiple R^B may be the same as each other, or may be different from each other.

[0033] Examples of the alkyl groups capable of being selected as R^B include a methyl group, an ethyl group, a propyl group (n-propyl group, isopropyl group), a butyl group (n-butyl group, s-butyl group, t-butyl group, isobutyl group), a pentyl group, a hexyl group, a 2-ethylhexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, a hexadecyl group, and an octadecyl group.

[0034] These alkyl groups may be straight-chain alkyl groups or may be branched chain alkyl groups.

[0035] The number of carbon atoms of the alkyl group is 1 to 30, but it may be 3 or more, 5 or more, 6 or more, or 8 or more, and it may be 20 or less, 16 or less, 14 or less, or 12 or less.

[0036] Examples of the alkenyl groups capable of being selected as R^B include an ethenyl group, a propenyl group, a butenyl group, a pentenyl group, a hexenyl group, a heptenyl group, an octenyl group, a nonenyl group, a decenyl group, an undecenyl group, a dodecenyl group, a tridecenyl group, a tetradecenyl group, a pentadecenyl group, a hexadecenyl group, and an octadecenyl group.

[0037] These alkenyl groups may be straight-chain alkenyl groups or may be branched chain alkenyl groups.

[0038] The number of carbon atoms of the alkenyl group is 2 to 30, but it may be 3 or more, 5 or more, 6 or more, or 8 or more, and it may be 16 or less, 14 or less, or 12 or less.

[0039] Examples of the aryl groups capable of being selected as R^B include a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a biphenyl group, a terphenyl group, and a phenylnaphthyl group, and preferable is a phenyl group.

[0040] Examples of the "alkyl group having 1 to 6 carbon atoms" that can substitute these aryl groups include alkyl groups having 1 to 6 carbon atoms among the aforementioned alkyl groups.

[0041] The group having a sulfide bond, which is capable of being selected as R^B, is preferably a group represented by the following general formula (b-i).

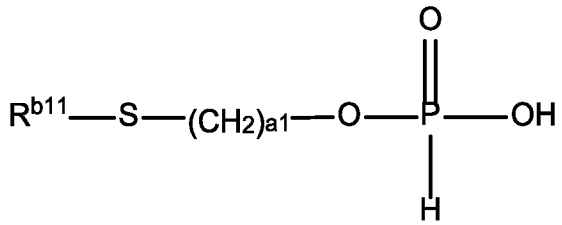
***-R^{b2}-S_x-R^{b1} (b-i)**

[0042] In the formula (b-i), R^{b1} is a hydrogen atom or a monovalent organic group having 1 to 20 carbon atoms. R^{b2} is a divalent organic group, x is an integer of 1 or more, preferably an integer of 1 to 10, more preferably an integer of 1 to 5, still more preferably an integer of 1 to 3, still much more preferably 1 or 2, and particularly preferably 1. * represents a bonding position.

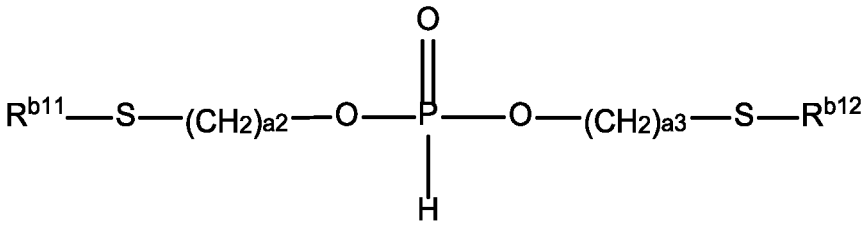
[0043] Examples of the monovalent organic groups capable of being selected as R^{b1} include an alkyl group, an alkenyl group and an aryl group, and preferable is an alkyl group having 1 to 20 carbon atoms or a group wherein at least one $-CH_2-$ structure of an alkyl group having 1 to 20 (preferably 2 to 18, more preferably 4 to 16, still more preferably 6 to 12, still much more preferably 8 to 10) carbon atoms has been substituted by -O-, -S-, -COO-, -OCO-, -CSO-, -OCS-, -CH=CH- or -C=C-, and more preferable is an alkyl group.

[0044] Examples of the divalent organic groups capable of being selected as R^{b2} include an alkylene group having 1 to 20 carbon atoms, a cycloalkylene group, an alkenylene group having 1 to 20 carbon atoms, a cycloalkenylene group, and an arylene group, and preferable is an alkylene group having 1 to 20 carbon atoms or a group wherein at least one $-CH_2-$ structure of an alkylene group having 1 to 20 (preferably 2 to 12, more preferably 2 to 8, still more preferably 2 to 4) carbon atoms has been substituted by -O-, -S-, -COO-, -OCO-, -CSO-, -OCS-, - CH=CH- or -C=C-, and more preferable is an alkylene group having 2 to 20 carbon atoms.

[0045] Examples of the phosphorous acid ester of the aforementioned general formula (b-1) or (b-2) wherein R^B is a group having a sulfide bond include a compound represented by the following general formula (b-11) and a compound represented by the following general formula (b-21) .



(b-11)



(b-21)

[0046] In the formulae (b-11) and (b-21), R^{b11} and R^{b12} are each independently a hydrogen atom or an alkyl group having 1 to 20 (preferably 2 to 18, more preferably 4 to 16, still more preferably 6 to 12, still much more preferably 8 to 10) carbon atoms. The alkyl group may be a straight-chain alkyl group or may be a branched chain alkyl group.

[0047] a1, a2 and a3 are each independently an integer of 1 to 20, but preferably an integer of 1 to 12, more preferably an integer of 1 to 8, still more preferably an integer of 1 to 4, still much more preferably 1, 2 or 4, and particularly preferably 2.

[0048] The phosphorous acid ester used as the component (B) in one embodiment of the present invention may be in the form of an amine salt.

[0049] The amine to form an amine salt is preferably a compound represented by the following general formula (b-3). The amine may be used singly, or may be used in combination of two or more.

$$(R^x)_r\text{-}N\text{-}(H)_{3-r} \qquad \text{(b-3)}$$

[0050] In the general formula (b-3), r is an integer of 1 to 3, and is preferably 1.

[0051] Each R^x is independently an alkyl group having 6 to 18 carbon atoms, an alkenyl group having 6 to 18 carbon atoms, an aryl group having 6 to 18 carbon atoms, or a hydroxyalkyl group having 6 to 18 carbon atoms.

[0052] When multiple R^x are present, the multiple R^x may be the same as one another, or may be different from one another.

[0053] Examples of the alkyl group having 6 to 18 carbon atoms, the alkenyl group having 6 to 18 carbon atoms and the aryl group having 6 to 18 carbon atoms capable of being selected as R^x include groups having carbon atoms of the above ranges among the groups given as examples of the alkyl group, the alkenyl group and the aryl group capable of being selected as R^B.

[0054] As the hydroxyalkyl group having 6 to 18 carbon atoms, a group wherein a hydrogen atom of an alkyl group having 6 to 18 carbon atoms is substituted by a hydroxyl group can be mentioned, and specific examples thereof include a hydroxyhexyl group, a hydroxyoctyl group, a hydroxydodecyl group, and a hydroxytridecyl group.

[0055] From the viewpoint of obtaining a lubricating oil composition having been more improved in seizure resistance, the content of the component (B) in the lubricating oil composition of one embodiment of the present invention is preferably 0.01 mass% or more, more preferably 0.05 mass% or more, still more preferably 0.07 mass% or more, still much more preferably 0.10 mass% or more, and particularly preferably 0.15 mass% or more, or may be 0.20 mass% or more, 0.30 mass% or more, 0.40 mass% or more, 0.50 mass% or more, 0.60 mass% or more, or 0.70 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having a good balance among various characteristics such as seizure resistance, clutch characteristics, and copper corrosion resistance, it is preferably 3.00 mass% or less, more preferably 2.70 mass% or less, still more preferably 2.50 mass% or less, still much more preferably 2.20 mass% or less, and particularly preferably 2.00 mass% or less, or may be 1.80 mass% or less, 1.70 mass% or less, or 1.60 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

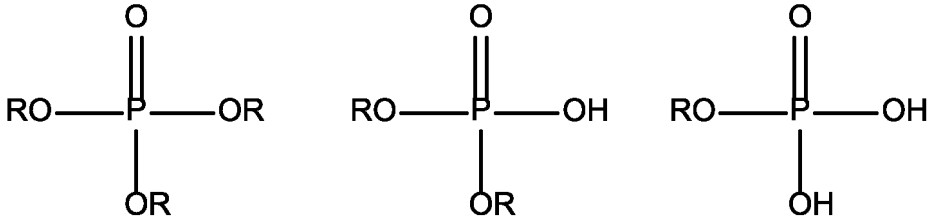
[0056] From the above viewpoint, the content of the component (B) in terms of phosphorus atoms in the lubricating oil composition of one embodiment of the present invention is preferably 10 ppm by mass or more, more preferably 20 ppm by mass or more, still more preferably 30 ppm by mass or more, still much more preferably 40 ppm by mass or more, and particularly preferably 50 ppm by mass or more, or may be 60 ppm by mass or more, 70 ppm by mass or more, 80 ppm by mass or more, 90 ppm by mass or more, 100 ppm by mass or more, or 110 ppm by mass or more, and is preferably 800 ppm by mass or less, more preferably 700 ppm by mass or less, still more preferably 600 ppm by mass or less, still much more preferably 500 ppm by mass or less, and particularly preferably 400 ppm by mass or less, or may be 350 ppm by mass or

less, 300 ppm by mass or less, 250 ppm by mass or less, 220 ppm by mass or less, 200 ppm by mass or less, or 180 ppm by mass or less, based on the total amount (100 mass%) of the lubricating oil composition.

<Phosphoric acid ester>

[0057] The lubricating oil composition of one embodiment of the present invention may further contain a phosphoric acid ester as long as the effects of the present invention are not impaired.

[0058] Examples of the phosphoric acid esters include a neutral phosphoric acid ester represented by the following general formula (b'-4) and an acidic phosphoric acid ester represented by the following general formula (b'-5) or (b'-6).



[0059] In the above formulae, each R is independently an alkyl group having 1 to 30 carbon atoms, an alkenyl group having 2 to 20 carbon atoms, an aryl group having 6 to 18 carbon atoms which may be substituted by an alkyl group having 1 to 6 carbon atoms, a group having a sulfide bond, or the like, and specific examples include the same groups as groups capable of being selected as R^B in the aforementioned formulae (b-1) and (b-2). Multiple R may be the same as one another, or may be different from one another.

[0060] These phosphoric acid esters may be used singly, or may be used in combination of two or more.

[0061] In the lubricating oil composition of one embodiment of the present invention, the content of the phosphoric acid ester may be, for example, 0.01 mass% or more, 0.03 mass% or more, 0.05 mass% or more, 0.07 mass% or more, 0.10 mass% or more, or 0.12 mass% or more, and may be 2.00 mass% or less, 1.50 mass% or less, 1.20 mass% or less, 1.00 mass% or less, 0.80 mass% or less, 0.70 mass% or less, 0.60 mass% or less, or 0.50 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

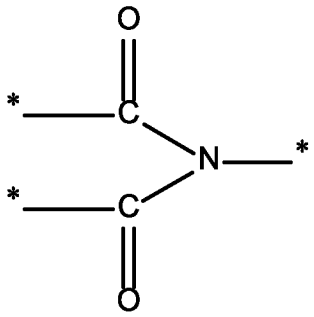
[0062] In the lubricating oil composition of one embodiment of the present invention, the content of the phosphoric acid ester may be, for example, 1.0 part by mass or more, 3.0 parts by mass or more, 5.0 parts by mass or more, 7.0 parts by mass or more, 10 parts by mass or more, or 12 parts by mass or more, and may be 100 parts by mass or less, 80 parts by mass or less, 70 parts by mass or less, 60 parts by mass or less, 50 parts by mass or less, 40 parts by mass or less, 30 parts by mass or less, or 20 parts by mass or less, based on the total amount 100 parts by mass of the component (B) contained in the lubricating oil composition.

<Component (C): non-boron modified imide-based compound>

[0063] The lubricating oil composition of one embodiment of the present invention contains a non-boron modified imide-based compound as the component (C). A lubricating oil composition having been improved in clutch characteristics can be obtained by containing the component (C), and the component (C) particularly contributes to improvement in clutch capacity.

[0064] In one embodiment of the present invention, the component (C) may be used singly, or may be used in combination of two or more.

[0065] In the present specification, the "imide-based compound" means a compound having an imide structure represented by the following formula (c-0), and a chain compound having the imide structure and a cyclic compound having the imide structure are also included.



(c-0)

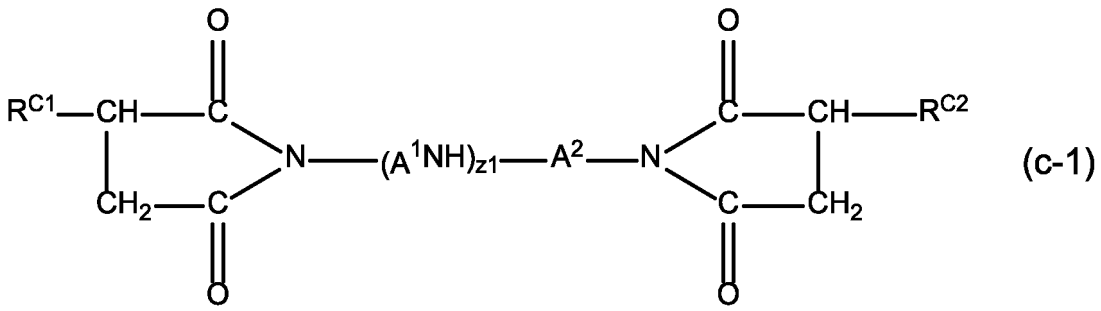
wherein * represents a bonding position.

[0066] The component (C) used in one embodiment of the present invention is a non-boron modified imide-based compound, and may be any compound as long as it is a compound having an imide structure represented by the formula (c-0) that is not modified with boron. On that account, it may be a modified product of an imide-based compound obtained by reacting a compound having the imide structure with one or more selected from an alcohol, an aldehyde, a ketone, an alkylphenol, a cyclic carbonate, an epoxy compound, an organic acid, and the like. Alternatively, it may be a non-modified imide-based compound.

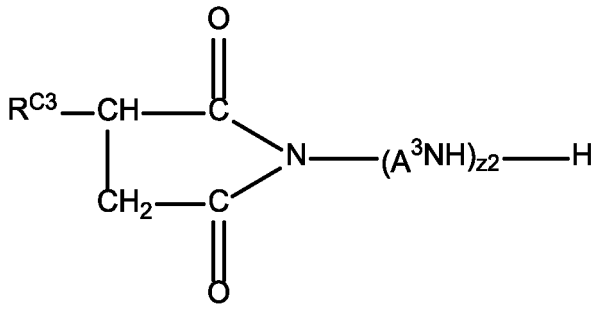
[0067] From the viewpoint of obtaining a lubricating oil composition having been more improved in clutch characteristics (particularly, clutch capacity), the component (C) used in one embodiment of the present invention preferably contains a non-boron modified alkenyl succinimide (C1).

[0068] In the lubricating oil composition of one embodiment of the present invention, the content of the component (C1) in the component (C) is preferably 50 to 100 mass%, more preferably 65 to 100 mass%, still more preferably 80 to 100 mass%, still much more preferably 90 to 100 mass%, and particularly preferably 95 to 100 mass%, based on the total amount (100 mass%) of the component (C) contained in the lubricating oil composition.

[0069] The non-boron modified alkenyl succinimide (C1) used in one embodiment of the present invention is preferably, for example, one or more selected from a non-boron modified alkenyl bis-succinimide (C11) represented by the following general formula (c-1) and a non-boron modified alkenyl mono-succinimide (C12) represented by the following general formula (c-2).



(c-1)



(c-2)

[0070] In the general formulae (c-1) and (c-2), R^{c1}, R^{c2} and R^{c3} are each independently an alkenyl group having a mass-average molecular weight (Mw) of 500 to 30000 (preferably 900 to 2500).

[0071] Examples of the alkenyl groups capable of being selected as R^{c1}, R^{c2} and R^{c3} include a polybutenyl group, a polyisobutenyl group, and an ethylene-propylene copolymer, and among these, a polybutenyl group or a polyisobutenyl group is preferable.

[0072] A^1, A^2 and A^3 are each independently an alkylene group having 2 to 5 carbon atoms.

[0073] z1 is an integer of 0 to 10, preferably an integer of 1 to 4, and more preferably 2 or 3.

[0074] z2 is an integer of 1 to 10, preferably an integer of 2 to 5, and more preferably 3 or 4.

[0075] The components (C11) and (C-12) may be each a modified alkenyl succinimide obtained by the reaction with one or more compounds selected from an alcohol, an aldehyde, a ketone, an alkylphenol, a cyclic carbonate, an epoxy compound, an organic acid, and the like, or may be each a non-modified alkenyl succinimide that is not modified with such a compound.

[0076] From the viewpoint of obtaining a lubricating oil composition having been more improved in clutch characteristics (particularly, clutch capacity), the content of the component (C) in the lubricating oil composition of one embodiment of the present invention is preferably 0.01 mass% or more, more preferably 0.05 mass% or more, still more preferably 0.07 mass% or more, still much more preferably 0.10 mass% or more, and particularly preferably 0.15 mass% or more, or may be 0.20 mass% or more, 0.25 mass% or more, 0.30 mass% or more, 0.35 mass% or more, or 0.40 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having a good balance among various characteristics such as seizure resistance, clutch characteristics, and copper corrosion resistance, it is preferably 3.00 mass% or less, more preferably 2.50 mass% or less, still more preferably 2.00 mass% or less, still much more preferably 1.50 mass% or less, and particularly preferably 1.20 mass% or less, or may be 1.00 mass% or less, 0.90 mass% or less, or 0.80 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0077] From the above viewpoint, the content of the component (C) in terms of nitrogen atoms in the lubricating oil composition of one embodiment of the present invention is preferably 10 ppm by mass or more, more preferably 30 ppm by mass or more, still more preferably 50 ppm by mass or more, still much more preferably 70 ppm by mass or more, and particularly preferably 90 ppm by mass or more, and is preferably 600 ppm by mass or less, more preferably 500 ppm by mass or less, still more preferably 400 ppm by mass or less, still much more preferably 300 ppm by mass or less, and particularly preferably 200 ppm by mass or less, based on the total amount (100 mass%) of the lubricating oil composition.

<Boron-modified imide-based compound>

[0078] The lubricating oil composition of one embodiment of the present invention may further contain a boron-modified imide-based compound as long as the effects of the present invention are not impaired. A lubricating oil composition capable of maintaining excellent clutch characteristics (particularly, clutch capacity) even after a long-term use can be obtained by containing the boron-modified imide-based compound.

[0079] As the boron-modified imide-based compound, a modified product obtained by reacting the aforementioned non-modified imide-based compound with a boron compound can be mentioned.

[0080] From the above viewpoint, the content of the boron-modified imide-based compound in the lubricating oil composition of one embodiment of the present invention is preferably 0.01 mass% or more, 0.05 mass% or more, 0.10 mass% or more, 0.30 mass% or more, 0.50 mass% or more, 1.00 mass% or more, 1.50 mass% or more, 2.00 mass% or more, or 2.50 mass% or more, and is preferably 7.00 mass% or less, 6.00 mass% or less, 5.50 mass% or less, 5.00 mass% or less, 4.50 mass% or less, 4.00 mass% or less, 3.80 mass% or less, or 3.60 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0081] From the above viewpoint, the content of the boron-modified imide-based compound in the lubricating oil composition of one embodiment of the present invention is preferably 100 parts by mass or more, 200 parts by mass or more, 300 parts by mass or more, 400 parts by mass or more, 500 parts by mass or more, or 600 parts by mass or more, and is preferably 1200 parts by mass or less, 1000 parts by mass or less, 900 parts by mass or less, 800 parts by mass or less, 750 parts by mass or less, or 700 parts by mass or less, based on the total amount 100 parts by mass of the component (C) contained in the lubricating oil composition.

[0082] From the above viewpoint, the content of the boron-modified imide-based compound in terms of boron atoms in the lubricating oil composition of one embodiment of the present invention is preferably 10 ppm by mass or more, 30 ppm by mass or more, 50 ppm by mass or more, 70 ppm by mass or more, or 100 ppm by mass or more, and is preferably 800 ppm by mass or less, 600 ppm by mass or less, 500 ppm by mass or less, 400 ppm by mass or less, 300 ppm by mass or less, 250 ppm by mass or less, 200 ppm by mass or less, or 180 ppm by mass or less, based on the total amount (100 mass%) of the lubricating oil composition.

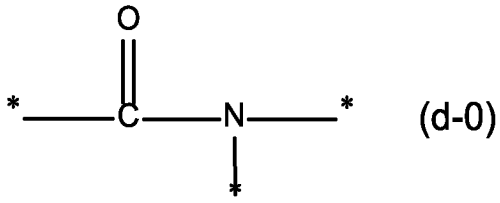
[0083] In the lubricating oil composition of one embodiment of the present invention, the content ratio [B/N] of boron atoms derived from the boron-modified imide-based compound to nitrogen atoms derived from the component (C) and the boron-modified imide-based compound is preferably 0.01 or more, more preferably 0.03 or more, more preferably 0.05 or more, still more preferably 0.07 or more, still more preferably 0.10 or more, still much more preferably 0.12 or more, and particularly preferably 0.15 or more, and is preferably 0.80 or less, more preferably 0.70 or less, more preferably 0.60 or less, still more preferably 0.50 or less, still more preferably 0.40 or less, still much more preferably 0.30 or less, and particularly preferably 0.25 or less.

<Component (D): amide-based compound>

[0084] The lubricating oil composition of one embodiment of the present invention contains an amide-based compound as the component (D). A lubricating oil composition having been improved in clutch characteristics (particularly, shudder prevention property) can be obtained by containing the component (D).

[0085] In one embodiment of the present invention, the component (D) may be used singly, or may be used in combination of two or more.

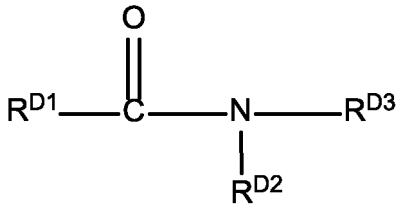
[0086] In the present specification, the "amide-based compound" means a compound having an amide structure represented by the following formula (d-0) (excluding a structure corresponding to an imide structure), and a chain compound having the amide structure and a cyclic compound having the amide structure are also included. Further, the "amide-based compound" may be any compound as long as it is a compound having the amide structure, and for example, a fatty acid amide, an aromatic amide, and an alicyclic amide are included.



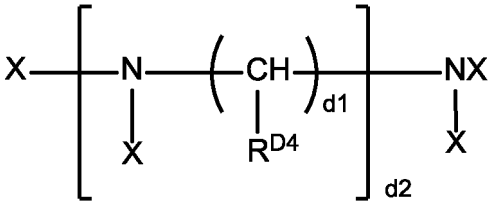
(d-0)

wherein * represents a bonding position.

[0087] The component (D) used in one embodiment of the present invention is, for example, a condensation compound of a monoamine or a polyamine and carboxylic acid, and is specifically a compound represented by the following general formula (d-1) or (d-2).



(d-1)



(d-2)

[0088] In the general formula (d-1), R^{D1} is a hydrocarbon group. R^{D2} and R^{D3} are each independently a hydrogen atom or a hydrocarbon group which may be substituted by a hydroxyl group.

[0089] In the general formula (d-2), R^{D4} is a hydrogen atom or a hydrocarbon group having 1 to 30 carbon atoms which may be substituted by a hydroxyl group.

[0090] Each X is independently a hydrogen atom or an acyl group represented by - (C=O) -R^{D5} (R^{D5} is a hydrocarbon group), and at least one of multiple X is the acyl group.

[0091] d1 is an integer of 1 to 6, preferably an integer of 1 to 4, more preferably an integer of 2 to 3, and still more preferably 2.

[0092] d2 is an integer of 1 or more, preferably an integer of 1 to 20, more preferably an integer of 1 to 15, still more preferably an integer of 1 to 10, still much more preferably an integer of 2 to 8, and particularly preferably an integer of 2 to 6.

[0093] Examples of the hydrocarbon groups capable of being selected as R^{D1}, R^{D2}, R^{D3}, R^{D4}, and R^{D5} include an alkyl group having 1 to 30 carbon atoms, an alkenyl group having 2 to 30 carbon atoms, and an aryl group having 6 to 30 carbon atoms which may be substituted by an alkyl group having 1 to 6 carbon atoms.

[0094] Examples of the alkyl groups include a methyl group, an ethyl group, a propyl group (n-propyl group, isopropyl group), a butyl group (n-butyl group, s-butyl group, t-butyl group, isobutyl group), a pentyl group, a hexyl group, a 2-ethylhexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, a hexadecyl group, and an octadecyl group.

[0095] These alkyl groups may be straight-chain alkyl groups or may be branched chain alkyl groups.

[0096] The number of carbon atoms of the alkyl group is 1 to 30, but it may be 2 or more, 5 or more, 8 or more, 10 or more, or 12 or more, and it may be 28 or less, 26 or less, 24 or less, 22 or less, or 20 or less.

[0097] Examples of the alkenyl groups include an ethenyl group, a propenyl group, a butenyl group, a pentenyl group, a hexenyl group, a heptenyl group, an octenyl group, a nonenyl group, a decenyl group, an undecenyl group, a dodecenyl

group, a tridecenyl group, a tetradecenyl group, a pentadecenyl group, a hexadecenyl group, and an octadecenyl group.

[0098] These alkenyl groups may be straight-chain alkenyl groups or may be branched chain alkenyl groups.

[0099] The number of carbon atoms of the alkenyl group is 2 to 30, but it may be 3 or more, 5 or more, 8 or more, 10 or more, or 12 or more, and it may be 28 or less, 26 or less, 24 or less, 22 or less, or 20 or less.

[0100] Examples of the aryl groups include a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a biphenyl group, a terphenyl group, and a phenylnaphthyl group, and preferable is a phenyl group.

[0101] Examples of the "alkyl group having 1 to 6 carbon atoms" that can substitute these aryl groups include alkyl groups having 1 to 6 carbon atoms among the aforementioned alkyl groups.

[0102] From the viewpoint of obtaining a lubricating oil composition having been improved in clutch characteristics (particularly, shudder prevention property), the component (D) in one embodiment of the present invention preferably contains a fatty acid amide (D1) .

[0103] In the lubricating oil composition of one embodiment of the present invention, the content of the component (D1) in the component (D) is preferably 60 to 100 mass%, more preferably 70 to 100 mass%, still more preferably 80 to 100 mass%, still much more preferably 90 to 100 mass%, and particularly preferably 95 to 100 mass%, based on the total amount (100 mass%) of the component (D) contained in the lubricating oil composition.

[0104] The component (D1) used in one embodiment of the present invention is preferably a fatty acid monoamide (D11) of the aforementioned general formula (d-1) wherein R^{D1} is an alkyl group having 1 to 30 carbon atoms or an alkenyl group having 2 to 30 carbon atoms, and R^{D2} and R^{D3} are each independently a hydrogen atom, an alkyl group having 1 to 30 carbon atoms, or an alkenyl group having 2 to 30 carbon atoms.

[0105] The component (D1) used in another embodiment of the present invention is preferably a fatty acid polyamide (D12) of the aforementioned general formula (d-2) wherein R^{D4} is a hydrogen atom, an alkyl group having 1 to 30 carbon atoms, or an alkenyl group having 2 to 30 carbon atoms, each X is independently a hydrogen atom or an acyl group represented by - (C=O) -R^{D5} (R^{D5} is a hydrocarbon group), and at least one of multiple X is the acyl group.

[0106] In other words, the component (D) used in one embodiment of the present invention preferably contains at least one selected from the components (D11) and (D12), and more preferably contains at least the component (D12).

[0107] The number of carbon atoms of the alkyl group of the fatty acid monoamide (D11) and the fatty acid polyamide (D12) is 1 to 30, but it is preferably 2 or more, more preferably 5 or more, still more preferably 8 or more, still much more preferably 10 or more, and particularly preferably 12 or more, and it is preferably 28 or less, more preferably 26 or less, still more preferably 24 or less, still much more preferably 22 or less, and particularly preferably 20 or less.

[0108] The number of carbon atoms of the alkenyl group of the fatty acid monoamide (D11) and the fatty acid polyamide (D12) is 2 to 30, but it is preferably 3 or more, more preferably 5 or more, still more preferably 8 or more, still much more preferably 10 or more, and particularly preferably 12 or more, and it is preferably 28 or less, more preferably 26 or less, still more preferably 24 or less, still much more preferably 22 or less, and particularly preferably 20 or less.

[0109] From the viewpoint of obtaining a lubricating oil composition having been more improved in clutch characteristics (particularly, shudder prevention property), the content of the component (D) in the lubricating oil composition of one embodiment of the present invention is preferably 0.04 mass% or more, more preferably 0.05 mass% or more, still more preferably 0.07 mass% or more, still much more preferably 0.10 mass% or more, and particularly preferably 0.12 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having a good balance among various characteristics such as seizure resistance, clutch characteristics, and copper corrosion resistance, it is preferably 3.00 mass% or less, more preferably 2.50 mass% or less, still more preferably 2.00 mass% or less, still much more preferably 1.50 mass% or less, and particularly preferably 1.20 mass% or less, or may be 1.00 mass% or less, 0.90 mass% or less, 0.80 mass% or less, 0.70 mass% or less, 0.60 mass% or less, 0.50 mass% or less, 0.40 mass% or less, or 0.30 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0110] From the viewpoint of obtaining a lubricating oil composition having been more improved in clutch characteristics (particularly, shudder prevention property), the content of the component (D1) in the lubricating oil composition of one embodiment of the present invention is preferably 0.04 mass% or more, more preferably 0.05 mass% or more, still more preferably 0.07 mass% or more, still much more preferably 0.10 mass% or more, and particularly preferably 0.12 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having a good balance among various characteristics such as seizure resistance, clutch characteristics, and copper corrosion resistance, it is preferably 3.00 mass% or less, more preferably 2.50 mass% or less, still more preferably 2.00 mass% or less, still much more preferably 1.50 mass% or less, and particularly preferably 1.20 mass% or less, or may be 1.00 mass% or less, 0.90 mass% or less, 0.80 mass% or less, 0.70 mass% or less, 0.60 mass% or less, 0.50 mass% or less, 0.40 mass% or less, or 0.30 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0111] The component (D) used in one embodiment of the present invention may contain glycolic acid amide, or may not contain glycolic acid amide.

[0112] Examples of the glycolic acid amides include a compound of the aforementioned general formula (d-1) wherein at least one of R^{D2} and R^{D3} is a hydrocarbon group having at least one hydroxyl group and a compound of the aforementioned general formula (d-2) wherein at least one of R^{D4} is a hydrocarbon group having at least one hydroxyl group.

[0113] In the lubricating oil composition of one embodiment of the present invention, the content of the glycolic acid amide may be less than 0.8 mass%, less than 0.5 mass%, less than 0.1 mass%, less than 0.05 mass%, less than 0.01 mass%, less than 0.001 mass%, less than 0.0001 mass%, or 0 mass% (not detected), based on the total amount (100 mass%) of the lubricating oil composition.

<Component (E): amine-based compound>

[0114] The lubricating oil composition of one embodiment of the present invention contains an amine-based compound as the component (E). A lubricating oil composition having been improved in clutch characteristics (particularly, shudder prevention property) can be obtained by containing the component (E).

[0115] In one embodiment of the present invention, the component (E) may be used singly, or may be used in combination of two or more.

[0116] The component (E) used in one embodiment of the present invention may be any of a monoamine having one amino nitrogen atom in one molecule, a diamine having two amino nitrogen atoms in one molecule, and a polyamine having 3 or more amino nitrogen atoms in one molecule.

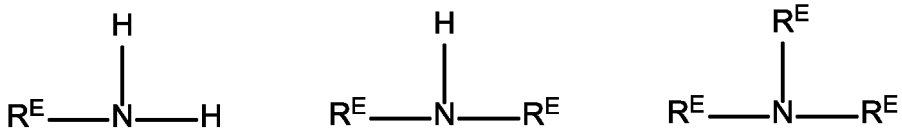
[0117] In the present specification, from the "amine-based compound" used as the component (E), a cyclic compound containing an amino nitrogen atom as a ring-forming atom, such as hexahydro-1,3,5-tris-(2-hydroxyethyl)triazine, is excluded. On that account, a benzotriazole-based compound (F) described later is not included in the component (E).

[0118] From the viewpoint of obtaining a lubricating oil composition having been improved in clutch characteristics (particularly, shudder prevention property), the component (E) used in one embodiment of the present invention preferably contains a monoamine (E1) among these.

[0119] In the lubricating oil composition of one embodiment of the present invention, the content of the component (E1) in the component (E) is preferably 60 to 100 mass%, more preferably 70 to 100 mass%, still more preferably 80 to 100 mass%, still much more preferably 90 to 100 mass%, and particularly preferably 95 to 100 mass%, based on the total amount (100 mass%) of the component (E) contained in the lubricating oil composition.

[0120] The monoamine (E1) used as the component (E) in one embodiment of the present invention is classified into a primary monoamine (E11) represented by the following general formula (e-1), a secondary monoamine (E12) represented by the following general formula (e-2), and a tertiary monoamine (E13) represented by the following general formula (e-3), depending on the number of substituents.

[0121] However, the component (E) used in one embodiment of the present invention preferably contains one or more selected from a primary monoamine (E11) represented by the following general formula (e-1) and a secondary monoamine (E12) represented by the following general formula (e-2).



(e-1) (e-2) (e-3)

[0122] In the above formulae, each R^E independently represents a substituent. Multiple R^E may be the same as one another, or may be different from one another. Examples of the substituents include an alkyl group, an alkyl group having a hydroxyl group, an alkenyl group, a cycloalkyl group, a phenyl group, and a benzyl group.

[0123] From the viewpoint of obtaining a lubricating oil composition having been improved in clutch characteristics (particularly, shudder prevention property), each R^E is independently preferably an alkyl group, an alkyl group having a hydroxyl group, or an alkenyl group, and more preferably an alkenyl group, among these.

[0124] Examples of the alkyl groups capable of being selected as a substituent R^E include a methyl group, an ethyl group, a propyl group (n-propyl group, i-propyl group), a butyl group (n-butyl group, i-butyl group, s-butyl group, t-butyl group), a pentyl group, (n-pentyl group, i-pentyl group, neopentyl group), a hexyl group, a heptyl group, an octyl group, a 2-ethylhexyl 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, and an octadecyl group.

[0125] The alkyl groups may be straight-chain alkyl groups or may be branched chain alkyl groups.

[0126] The number of carbon atoms of the alkyl group is, for example, 1 to 30, but it is preferably 3 or more, more preferably 6 or more, more preferably 8 or more, still more preferably 10 or more, still much more preferably 12 or more, and particularly preferably 15 or more, and it is preferably 28 or less, more preferably 26 or less, still more preferably 24 or less, still much more preferably 22 or less, and particularly preferably 20 or less.

[0127] Examples of the alkyl group having a hydroxyl group, which is capable of being selected as a substituent R^E, include groups wherein at least one hydrogen atom of each of the aforementioned alkyl groups is substituted by a hydroxyl group.

[0128] The alkyl groups to constitute the above groups may also be straight-chain alkyl groups or may also be branched chain alkyl groups.

[0129] A preferred range of the number of carbon atoms of the alkyl group having a hydroxyl group is the same as the number of carbon atoms of the aforementioned alkyl group.

[0130] Examples of the alkenyl groups capable of being selected as a substituent R^E include an ethenyl group (vinyl group), a propenyl group, a butenyl group, a pentenyl group, a hexenyl group, a heptenyl group, an octenyl group, a nonenyl group, a decenyl group, a dodecenyl group, a tridecenyl group, a tetradecenyl group, a pentadecenyl group, a hexadecenyl group, and an octadecenyl group (oleyl group).

[0131] The alkenyl group may be a straight-chain alkenyl group, or may be a branched chain alkenyl group.

[0132] The number of carbon atoms of the alkenyl group is, for example, 2 to 30, but it is preferably 3 or more, more preferably 6 or more, more preferably 8 or more, still more preferably 10 or more, still much more preferably 12 or more, and particularly preferably 15 or more, and it is preferably 28 or less, more preferably 26 or less, still more preferably 24 or less, still much more preferably 22 or less, and particularly preferably 20 or less.

[0133] Examples of the cycloalkyl groups capable of being selected as a substituent R^E include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, and an adamantyl group.

[0134] The number of ring-forming carbon atoms of the cycloalkyl group is, for example, 3 to 30, but it is preferably 5 or more, more preferably 6 or more, and it is preferably 24 or less, more preferably 20 or less, still more preferably 18 or less, still much more preferably 16 or less, and particularly preferably 12 or less.

[0135] The component (E) used in one embodiment of the present invention preferably contains one or more selected from a primary monoamine and a secondary monoamine, and more preferably contains at least a primary monoamine.

[0136] From the viewpoint of obtaining a lubricating oil composition having been more improved in clutch characteristics (particularly, shudder prevention property), the content of the component (E) in the lubricating oil composition of one embodiment of the present invention is preferably 0.001 mass% or more, more preferably 0.005 mass% or more, still more preferably 0.007 mass% or more, still much more preferably 0.010 mass% or more, and particularly preferably 0.012 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having a good balance among various characteristics such as seizure resistance, clutch characteristics, and copper corrosion resistance, it is preferably 2.00 mass% or less, more preferably 1.50 mass% or less, still more preferably 1.00 mass% or less, still much more preferably 0.50 mass% or less, and particularly preferably 0.20 mass% or less, or may be 0.15 mass% or less, 0.10 mass% or less, or 0.080 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0137] The component (E) used in one embodiment of the present invention may contain a diamine or may not contain a diamine.

[0138] In the lubricating oil composition of one embodiment of the present invention, the content of the diamine may be less than 0.07 mass%, less than 0.05 mass%, less than 0.03 mass%, less than 0.01 mass%, less than 0.001 mass%, less than 0.0001 mass%, or 0 mass% (not detected), based on the total amount (100 mass%) of the lubricating oil composition.

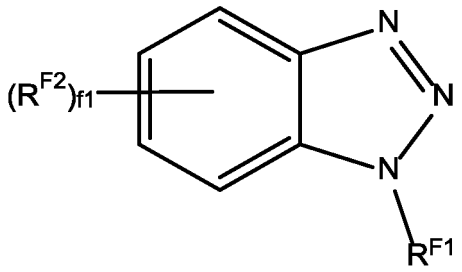
[0139] From the viewpoint of obtaining a lubricating oil composition having been more improved in clutch characteristics (particularly, shudder prevention property), the content ratio by mass of the component (E) to the component (D), [(E)/(D)], in the lubricating oil composition of one embodiment of the present invention is preferably 0.05 or more, more preferably 0.07 or more, still more preferably 0.09 or more, still much more preferably 0.10 or more, and particularly preferably 0.11 or more, and it is preferably 0.90 or less, more preferably 0.80 or less, still more preferably 0.70 or less, still much more preferably 0.60 or less, and particularly preferably 0.50 or less.

<Component (F): benzotriazole-based compound>

[0140] The lubricating oil composition of one embodiment of the present invention contains a benzotriazole-based compound as the component (F). A lubricating oil composition having been improved in copper corrosion resistance can be obtained by containing the component (F) .

[0141] In one embodiment of the present invention, the component (F) may be used singly, or may be used in combination of two or more.

[0142] The benzotriazole-based compound used as the component (F) in one embodiment of the present invention may be any compound as long as it is a compound having a benzotriazole structure, and is, for example, a compound represented by the following general formula (f-0).



(f-0)

[0143] In the general formula (f-0), R^{F1} is a hydrocarbon group which may contain at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, and a nitrogen atom, or a hydrogen atom.

[0144] Each R^{F2} is independently a hydrocarbon group which may contain at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, and a nitrogen atom.

[0145] f1 is an integer of 0 to 4, preferably an integer of 0 to 2, more preferably an integer of 0 to 1, and still more preferably 1.

[0146] Examples of the hydrocarbon groups include an alkyl group, an alkenyl group, a cycloalkyl group, an aryl group, and a group of a combination of two or more of these groups.

[0147] The number of carbon atoms of the hydrocarbon group capable of being selected as R^{F1} is, for example, 1 to 30, but it is preferably 3 or more, more preferably 6 or more, more preferably 8 or more, still more preferably 10 or more, still much more preferably 12 or more, and particularly preferably 15 or more, and it is preferably 28 or less, more preferably 26 or less, still more preferably 24 or less, still much more preferably 22 or less, and particularly preferably 20 or less.

[0148] The number of carbon atoms of the hydrocarbon group capable of being selected as R^{F2} is, for example, 1 to 20, but it is preferably 1 to 16, more preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 6, still much more preferably 1 to 4, and particularly preferably 1 to 2.

[0149] Examples of the alkyl groups include a methyl group, an ethyl group, a propyl group (n-propyl group, i-propyl group), a butyl group (n-butyl group, i-butyl group, s-butyl group, t-butyl group), a pentyl group (n-pentyl group, i-pentyl group, neopentyl group), a hexyl group, a heptyl group, an octyl group, a 2-ethylhexyl 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, and an octadecyl group.

[0150] The alkyl group may be a straight-chain alkyl group, or may be a branched chain alkyl group.

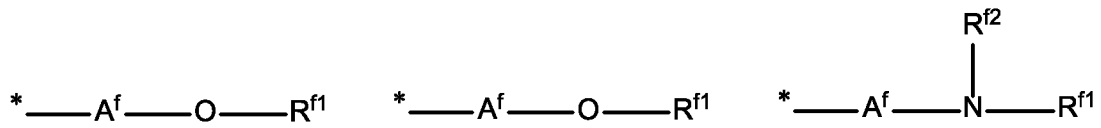
[0151] Examples of the alkenyl groups include an ethenyl group (vinyl group), a propenyl group, a butenyl group, a pentenyl group, a hexenyl group, a heptenyl group, an octenyl group, a nonenyl group, a decenyl group, a dodecenyl group, a tridecenyl group, a tetradecenyl group, a pentadecenyl group, a hexadecenyl group, and an octadecenyl group (oleyl group).

[0152] The alkenyl groups may be straight-chain alkenyl groups or may be branched chain alkenyl groups.

[0153] Examples of the cycloalkyl groups include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, and an adamantyl group.

[0154] Examples of the aryl groups include a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a biphenyl group, a terphenyl group, and a phenylnaphthyl group.

[0155] The hydrocarbon group capable of being selected as R^{F1} and R^{F2} and containing at least one atom selected from the group consisting of an oxygen atom, a sulfur atom, and a nitrogen atom is, for example, a group represented by the following formulae (f-i) to (f-iii).



(f-i) (f-ii) (f-iii)

[0156] In the general formulae (f-i) to (f-iii), A^f is a divalent hydrocarbon group, and R^{f1} and R^{f2} are each independently a monovalent hydrocarbon group.

[0157] Examples of the divalent hydrocarbon groups capable of being selected as A^f include an alkylene group having 1 to 20 (preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 4, still much more preferably 1 to 2) carbon atoms, an alkenylene group having 2 to 20 (preferably 2 to 12, more preferably 2 to 8, still more preferably 2 to 4) carbon atoms, a

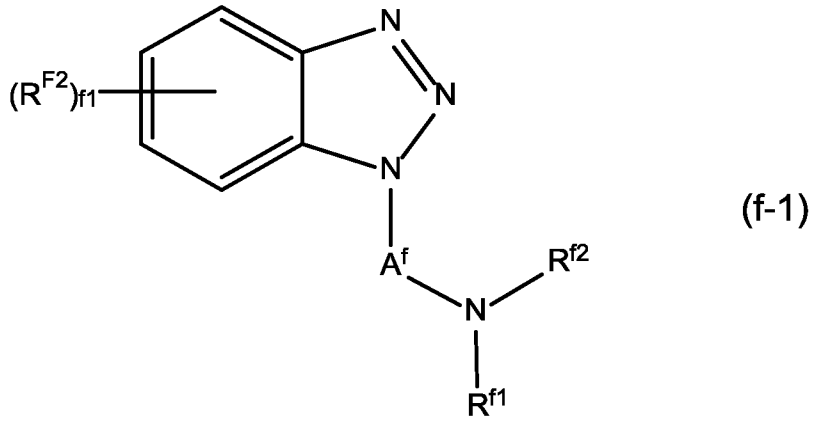
cycloalkylene group having 3 to 20 (preferably 3 to 15, more preferably 5 to 12, still more preferably 5 to 6) ring-forming carbon atoms, and an arylene group having 6 to 30 (preferably 6 to 18, more preferably 6 to 15, still more preferably 6 to 12) ring-forming carbon atoms.

[0158] A^f is preferably an alkylene group having 1 to 20 (preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 4, still much more preferably 1 to 2) carbon atoms, among these.

[0159] Examples of the monovalent hydrocarbon groups capable of being selected as R^{f1} and R^{f2} include an alkyl group having 1 to 20 (preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 4, still much more preferably 1 to 2) carbon atoms, an alkenyl group having 2 to 20 (preferably 2 to 12, more preferably 2 to 8, still more preferably 2 to 4) carbon atoms, a cycloalkyl group having 3 to 20 (preferably 3 to 15, more preferably 5 to 12, still more preferably 5 to 6) ring-forming carbon atoms, and an aryl group having 6 to 30 (preferably 6 to 18, more preferably 6 to 15, still more preferably 6 to 12) ring-forming carbon atoms.

[0160] R^{f1} and R^{f2} are each independently preferably an alkyl group having 1 to 20 (preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 4, still much more preferably 1 to 2) carbon atoms, among these.

[0161] The component (F) used in one embodiment of the present invention preferably contains a compound (F1) represented by the following general formula (f-1).



(f-1)

[0162] R^{F2} and f1 in the general formula (f-1) are the same as R^{F2} and f1 in the aforementioned general formula (f-0), and embodiments of preferred groups are also the same. Further, A^f, R^{f1}, and R^{f2} are the same as A^f, R^{f1}, and R^{f2} in the aforementioned general formula (f-iii), and embodiments of preferred groups are also the same.

[0163] In the general formula (f-1) in a preferred embodiment of the compound (F1), each R^{F2} is independently an alkyl group having 1 to 20 (preferably 1 to 16, more preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 6, still much more preferably 1 to 4, particularly preferably 1 to 2) carbon atoms, A^f is an alkylene group having 1 to 20 (preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 4, still much more preferably 1 to 2) carbon atoms, and R^{f1} and R^{f2} are each independently an alkyl group having 1 to 20 (preferably 1 to 12, more preferably 1 to 8, still more preferably 1 to 4, still much more preferably 1 to 2) carbon atoms, f1 is an integer of 0 to 4 (preferably an integer of 0 to 2, more preferably an integer of 0 to 1, still more preferably 1).

[0164] In the lubricating oil composition of one embodiment of the present invention, the content of the component (F1) in the component (F) is preferably 60 to 100 mass%, more preferably 70 to 100 mass%, still more preferably 80 to 100 mass, still much more preferably 90 to 100 mass%, and particularly preferably 95 to 100 mass%, based on the total amount (100 mass%) of the component (F) contained in the lubricating oil composition.

[0165] From the viewpoint of obtaining a lubricating oil composition having been improved in copper corrosion resistance, the content of the component (F) in the lubricating oil composition of one embodiment of the present invention is 0.005 mass% or more, but is preferably 0.007 mass% or more, more preferably 0.010 mass% or more, still more preferably 0.015 mass% or more, still much more preferably 0.020 mass% or more, and particularly preferably 0.025 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having a good balance among various characteristics such as seizure resistance, clutch characteristics, and copper corrosion resistance, it is 1.00 mass% or less, but is preferably 0.80 mass% or less, more preferably 0.70 mass% or less, still more preferably 0.60 mass% or less, still much more preferably 0.50 mass% or less, and particularly preferably 0.40 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0166] From the viewpoint of obtaining a lubricating oil composition having been more improved in copper corrosion resistance and seizure resistance in a balanced manner, the content ratio by mass of the component (F) to the component (B), [(F)/(B)], in the lubricating oil composition of one embodiment of the present invention is preferably 0.01 or more, more preferably 0.015 or more, still more preferably 0.02 or more, still much more preferably 0.025 or more, and particularly

preferably 0.028 or more, and it is preferably 0.50 or less, more preferably 0.40 or less, still more preferably 0.30 or less, still much more preferably 0.20 or less, and particularly preferably 0.10 or less.

<Various additives other than components (B) to (F)>

[0167] The lubricating oil composition of one embodiment of the present invention may contain various additives other than the components (B) to (F) when needed as long as the effects of the present invention are not impaired.

[0168] Examples of such various additives include a pour point depressant, a viscosity index improver, an antioxidant, a metal-based detergent, an anti-rust agent, an anti-foaming agent, and a colorant.

[0169] These lubricating oil additives may be each used singly, or may be each used in combination of two or more.

[0170] The contents of these lubricating oil additives can be each appropriately adjusted as long as the effects of the present invention are not impaired, and the contents of the additives are each independently usually 0.001 to 15 mass%, preferably 0.005 to 10 mass%, and more preferably 0.01 to 5 mass%, based on the total amount (100 mass%) of the lubricating oil composition.

[Pour point depressant]

[0171] The lubricating oil composition of one embodiment of the present invention may further contain a pour point depressant. The pour point depressant may be used singly, or may be used in combination of two or more.

[0172] Examples of the pour point depressants used in one embodiment of the present invention include an ethylene-vinyl acetate copolymer, a condensate of chlorinated paraffin and naphthalene, a condensate of chlorinated paraffin and phenol, polymethacrylate, and polyalkylstyrene.

[0173] The mass-average molecular weight (Mw) of the pour point depressant used in one embodiment of the present invention may be 5,000 or more, 7,000 or more, 10,000 or more, 15,000 or more, 20,000 or more, 25,000 or more, 30,000 or more, 35,000 or more, 40,000 or more, 45,000 or more, 50,000 or more, 55,000 or more, or 60,000 or more, and it may be 150,000 or less, 120,000 or less, 100,000 or less, 90,000 or less, or 80,000 or less.

[Viscosity index improver]

[0174] The lubricating oil composition of one embodiment of the present invention may further contain a viscosity index improver. The viscosity index improver may be used singly, or may be used in combination of two or more.

[0175] Examples of the viscosity index improvers used in one embodiment of the present invention include polymers, such as non-dispersion type polymethacrylate, dispersion type polymethacrylate, an olefin-based copolymer (for example, ethylene-propylene copolymer), a dispersion type olefin-based copolymer, and a styrene-based copolymer (for example, styrene-diene copolymer, styrene-isoprene copolymer).

[0176] The weight-average molecular weight (Mw) of the viscosity index improver used in one embodiment of the present invention may be 5,000 or more, 7,000 or more, 10,000 or more, 15,000 or more, or 20,000 or more, and it may be 1,000,000 or less, 700,000 or less, 500,000 or less, 300,000 or less, 200,000 or less, 100,000 or less, or 50,000 or less.

[Antioxidant]

[0177] The lubricating oil composition of one embodiment of the present invention may further contain an antioxidant. The antioxidant may be used singly, or may be used in combination of two or more.

[0178] Examples of the antioxidants used in one embodiment of the present invention include amine-based antioxidants, such as alkylated diphenylamine, phenylnaphthylamine, and alkylated phenylnaphthylamine; phenol-based antioxidants, such as 2,6-di-t-butylphenol, 4,4'-methylenebis(2,6-di-t-butylphenol), isooctyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, and n-octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate; and sulfur-based antioxidants, such as phenothiazine, dioctadecyl sulfide, dilauryl-3,3'-thiodipropionate, and 2-mercaptobenzimidazole.

[Metal-based detergent]

[0179] The lubricating oil composition of one embodiment of the present invention may further contain a metal-based detergent. The metal-based detergent may be used singly, or may be used in combination of two or more.

[0180] Examples of the metal-based detergents used in one embodiment of the present invention include metal salts, such as a metal sulfonate, a metal salicylate, and a metal phenate. The metal to constitute the metal salts is preferably a metal atom selected from alkali metals and alkaline earth metals, more preferably sodium, calcium, magnesium or barium, and still more preferably calcium.

[0181] In the lubricating oil composition of one embodiment of the present invention, the metal-based detergent

preferably contains one or more selected from calcium sulfonate, calcium salicylate and calcium phenate, and more preferably contains calcium sulfonate.

[0182] The content of the calcium sulfonate is preferably 50 to 100 mass%, more preferably 60 to 100 mass%, still more preferably 70 to 100 mass%, and still much more preferably 80 to 100 mass%, based on the total amount (100 mass%) of the metal-based detergent contained in the lubricating oil composition.

[0183] The base number of the metal-based detergent is preferably 0 to 600 mgKOH/g.

[0184] In the lubricating oil composition of one embodiment of the present invention, however, the metal-based detergent is preferably an overbased metal-based detergent having a base number of 100 mgKOH/g or more.

[0185] The base number of the overbased metal-based detergent is 100 mgKOH/g or more, but it is preferably 150 to 500 mgKOH/g, and more preferably 200 to 450 mgKOH/g.

[0186] In the present specification, the "base number" means a base number measured by perchloric acid method in accordance with JIS K2501:2003 "Petroleum products and lubricants - Determination of neutralization number", 7.

[Anti-rust agent]

[0187] The lubricating oil composition of one embodiment of the present invention may further contain an anti-rust agent. The anti-rust agent may be used singly, or may be used in combination of two or more.

[0188] Examples of the anti-rust agents used in one embodiment of the present invention include a fatty acid, an alkenyl succinic acid half ester, a fatty acid soap, an alkyl sulfonic acid salt, a polyhydric alcohol fatty acid ester, a fatty acid amine, oxidized paraffin, and an alkyl polyoxyethylene ether.

[Anti-foaming agent]

[0189] The lubricating oil composition of one embodiment of the present invention may further contain an anti-foaming agent. The anti-foaming agent may be used singly, or may be used in combination of two or more.

[0190] Examples of the anti-foaming agents used in one embodiment of the present invention include an alkyl silicone-based anti-foaming agent, a fluorosilicone-based anti-foaming agent, and a fluoroalkyl ether-based anti-foaming agent.

[Colorant]

[0191] The lubricating oil composition of one embodiment of the present invention may further contain a colorant.

[0192] The colorant may be used singly, or may be used in combination of two or more.

[0193] Examples of the colorants used in one embodiment of the present invention include a dye and a pigment.

[Fatty acid partial ester compound]

[0194] The lubricating oil composition of one embodiment of the present invention may contain or may not contain a fatty acid partial ester compound.

[0195] As the fatty acid partial ester compound, a partial ester obtained by reacting a fatty acid having a hydrocarbon group having 6 to 30 carbon atoms with a fatty acid polyhydric alcohol can be mentioned.

[0196] In the lubricating oil composition of one embodiment of the present invention, the content of the fatty acid partial ester compound may be less than 0.05 mass%, less than 0.01 mass%, or less than 0.001 mass%, based on the total amount (100 mass%) of the lubricating oil composition.

<Method for producing lubricating oil composition>

[0197] The method for producing a lubricating oil composition of one embodiment of the present invention is not particularly limited, but from the viewpoint of productivity, the method preferably has a step of adding the components (B) to (F), and if needed, additives other than the components (B) to (F), to the component (A).

[0198] Here, preferred compounds and amounts of the components (A) to (F) and various additives are as previously described.

[0199] The additives, such as the viscosity index improver, the pour point depressant, and the anti-foaming agent, are each preferably added in a state of being dissolved in a diluent oil.

[Properties of lubricating oil composition]

[0200] The kinematic viscosity of the lubricating oil composition of one embodiment of the present invention at 100°C is preferably 2.5 mm^2/s or more, more preferably 3.0 mm^2/s or more, still more preferably 3.5 mm^2/s or more, still much more

preferably 4.0 mm^2/s or more, and particularly preferably 4.5 mm^2/s or more, and it is preferably 7.0 mm^2/s or less, more preferably 6.7 mm^2/s or less, still more preferably 6.5 mm^2/s or less, still much more preferably 6.2 mm^2/s or less, and particularly preferably 6.0 mm^2/s or less.

[0201] The viscosity index of the lubricating oil composition of one embodiment of the present invention is preferably 80 or more, more preferably 100 or more, still more preferably 120 or more, still much more preferably 140 or more, and particularly preferably 160 or more.

[0202] The base number (perchloric acid method) of the lubricating oil composition of one embodiment of the present invention is preferably 2.5 to 8.0 mgKOH/g, more preferably 2.5 to 7.5 mgKOH/g, still more preferably 3.0 to 7.0 mgKOH/g, still much more preferably 3.5 to 6.5 mgKOH/g, and particularly preferably 4.0 to 6.0 mgKOH/g.

[0203] The content of phosphorus atoms in the lubricating oil composition of one embodiment of the present invention is preferably 150 ppm by mass or more, more preferably 200 ppm by mass or more, still more preferably 250 ppm by mass or more, still much more preferably 300 ppm by mass or more, and particularly preferably 350 ppm by mass or more, and it is preferably 800 ppm by mass or less, more preferably 700 ppm by mass or less, still more preferably 600 ppm by mass or less, still much more preferably 550 ppm by mass or less, and particularly preferably 500 ppm by mass or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0204] The content of nitrogen atoms in the lubricating oil composition of one embodiment of the present invention is preferably 0.01 mass% or more, more preferably 0.05 mass% or more, still more preferably 0.10 mass% or more, still much more preferably 0.15 mass% or more, and particularly preferably 0.20 mass% or more, and it is preferably 1.00 mass% or less, more preferably 0.80 mass% or less, still more preferably 0.70 mass% or less, still much more preferably 0.60 mass% or less, and particularly preferably 0.50 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0205] The content of sulfur atoms in the lubricating oil composition of one embodiment of the present invention is preferably 0.001 mass% or more, more preferably 0.005 mass% or more, still more preferably 0.010 mass% or more, still much more preferably 0.030 mass% or more, and particularly preferably 0.050 mass% or more, and it is preferably 0.50 mass% or less, more preferably 0.40 mass% or less, still more preferably 0.30 mass% or less, still much more preferably 0.20 mass% or less, and particularly preferably 0.15 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0206] The content of boron atoms in the lubricating oil composition of one embodiment of the present invention is preferably 0 ppm by mass or more, more preferably 10 ppm by mass or more, still more preferably 50 ppm by mass or more, still much more preferably 70 ppm by mass or more, and particularly preferably 100 ppm by mass or more, and it is preferably 700 ppm by mass or less, more preferably 500 ppm by mass or less, still more preferably 400 ppm by mass or less, still much more preferably 300 ppm by mass or less, and particularly preferably 200 ppm by mass or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0207] A seizure load at 100°C, as measured for the lubricating oil composition of one embodiment of the present invention under the measurement conditions in Example described later in accordance with ASTM D 3233, is preferably 5000 N or more, more preferably 5500 N or more, still more preferably 5700 N or more, still much more preferably 6000 N or more, and particularly preferably 6200 N or more.

[0208] It can be said that the higher the seizure load is, the more excellent seizure resistance the lubricating oil composition has.

[0209] A static friction coefficient (μs) at 3000 cycles, as measured for the lubricating oil composition of one embodiment of the present invention under the measurement conditions in Example described later in accordance with JASO M348-2002, is preferably 0.115 or more, more preferably 0.117 or more, still more preferably 0.118 or more, still much more preferably 0.120 or more, and particularly preferably 0.121 or more.

[0210] When μs is regarded as an index indicating clutch capacity, it can be said that the larger the μs is, the more sufficient transmission torque capacity the lubricating oil composition has.

[0211] A μ ratio ($\mu 0/\mu d$) of a static friction coefficient ($\mu 0$) to a dynamic friction coefficient (μd) at 3000 cycles, as measured for the lubricating oil composition of one embodiment of the present invention under the measurement conditions in Example described later in accordance with JASO M348-2002, is preferably 1.036 or less, more preferably 1.030 or less, still more preferably 1.025 or less, still much more preferably 1.020 or less, and particularly preferably 1.017 or less.

[0212] When a μ ratio is regarded an index indicating shudder prevention property, it can be said that the smaller the μ ratio is, the more excellent the shudder prevention property is, and the smoother clutch shifting the lubricating oil composition enables.

[0213] An elution amount of copper in the ISOT test according to JIS K2514-1:2013, in which a copper plate that is a catalyst is added to the lubricating oil composition of one embodiment of the present invention and the lubricating oil composition is deteriorated under the conditions of an oil temperature of 175°C and a test time of 48 hours, is preferably 100 ppm by mass or less, more preferably 80 ppm by mass or less, still more preferably 70 ppm by mass or less, still much more preferably 60 ppm by mass or less, and particularly preferably 55 ppm by mass or less.

[0214] It can be said that the smaller the elution amount of copper is, the higher the copper corrosion resistance of the lubricating oil composition is. The elution amount of copper means a value measured by the method described in Example described later.

[Use application of lubricating oil composition]

[0215] The lubricating oil composition of one preferred embodiment of the present invention can be improved in seizure resistance, clutch characteristics, and copper corrosion resistance in a balanced manner.

[0216] Taking such characteristics into consideration, the lubricating oil composition of one embodiment of the present invention can be preferably used for lubrication in mechanisms, such as a torque converter, a wet clutch, a gear bearing mechanism, an oil pump and a hydraulic control mechanism, which are incorporated in various apparatuses, such as an engine, a transmission, a speed reducer, a compressor and a hydraulic system. The lubricating oil composition of one embodiment of the present invention is preferably used for lubrication of a speed reducer among these, and is more preferably used for a transmission equipped with a clutch mechanism, and is still more preferably used for a transmission equipped with a clutch mechanism and to be mounted on a hybrid vehicle.

[0217] The lubricating oil composition of one embodiment of the present invention is not only excellent in lubrication characteristics, such as seizure resistance and clutch characteristics, but also excellent in copper corrosion resistance. On that account, the lubricating oil composition of one embodiment of the present invention also has such characteristics that when the lubricating oil composition of one embodiment of the present invention is used in a device requiring both the lubrication performance and the cooling performance, such as a hybrid vehicle, it improves lubricity of a clutch mechanism and a transmission mechanism, and moreover, it can prevent corrosion of a copper-based member to constitute a motor even if it is used for cooling of the motor, because it has excellent copper corrosion resistance. Accordingly, the lubricating oil composition of one embodiment of the present invention is also preferably used for lubrication and cooling of a device in which a transmission equipped with a clutch mechanism and a mechanism constituted of a copper-based member, such as a motor, are integrated.

[0218] When the aforementioned characteristics of the lubricating oil composition of one embodiment of the present invention are taken into consideration, the present invention can also provide the following [1] and [2] .

[1] A transmission filled with the aforementioned lubricating oil composition of one embodiment of the present invention.

[2] Use of a lubricating oil composition, in which the aforementioned lubricating oil composition of one embodiment of the present invention is applied to lubrication of a transmission equipped with a clutch mechanism.

[0219] Preferred embodiments of the lubricating oil compositions described in the above [1] and [2] are as previously described.

[0220] The transmissions described in the above [1] and [2] are each preferably a transmission equipped with a clutch mechanism, and are each more preferably a transmission equipped with a clutch mechanism and to be mounted on a hybrid vehicle.

Examples

[0221] Next, the present invention will be described in much more detail with reference to Examples, but the present invention is in no way limited to these Examples. Measuring methods for various properties are as follows.

(1) Kinematic viscosity, viscosity index

[0222] The kinematic viscosity and viscosity index were measured and calculated in accordance with JIS K2283:2000.

(2) Contents of phosphorus atoms, boron atoms, and calcium atoms

[0223] The contents were measured in accordance with JPI-5S-38-92.

(3) Content of nitrogen atoms

[0224] The content was measured in accordance with JIS K2609.

(4) Content of sulfur atoms

[0225] The content was measured in accordance with JIS K2541-6:2013.

(5) Base number (perchloric acid method)

[0226] The base number was measured in accordance with JIS K2501:2003 (perchloric acid method).

(6) Weight-average molecular weight (Mw)

[0227] The weight-average molecular weight was measured under the following conditions using a gel permeation chromatograph (manufactured by Agilent Technologies, "1260 type HPLC"), and a value measured in terms of standard polystyrene was used.

(Measurement conditions)

[0228]

Column: Two of "Shodex LF404" that are sequentially connected.
Column temperature: 35°C
Developing solvent: chloroform
Flow rate: 0.3 mL/min

Example 1, Comparative Examples 1 to 5

[0229] The base oil and various additives of the types shown in Table 1 were added in amounts shown in Table 1, and they were sufficiently mixed to prepare each lubricating oil composition. Details of each component used in the preparation of the lubricating oil composition are as follows.

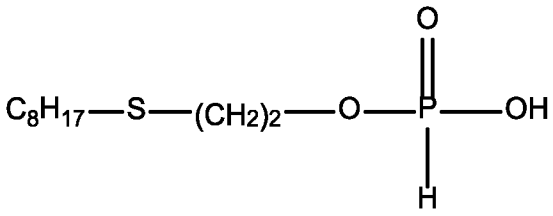
<Base oil>

[0230]

"Mineral oil (1)": 70N mineral oil classified into Group II of API base oil categories, 100°C kinematic viscosity = 2.7 mm^2/s, viscosity index = 110.
"Mineral oil (2)": 100N mineral oil classified into Group III of API base oil categories, 100°C kinematic viscosity = 4.1 mm^2/s, viscosity index = 120.

<Various additives>

[0231] "Phosphorous acid ester": mixture containing a compound of the aforementioned general formula (b-11) wherein R^{b11} is a n-octyl group ($-C_8H_{17}$), and a1 is 2 (compound represented by the following formula (b-11-1)) and a compound of the aforementioned general formula (b-21) wherein R^{b11} and R^{b12} are each a n-octyl group ($-C_8H_{17}$), and a2 and a3 are each 2 (compound represented by the following formula (b-21-1)), in which sulfur atom content = 1.5 mass%, and phosphorus atom content = 1.3 mass%; mixture of phosphorous acid esters corresponding to the component (B).
[0232] "Non-boron modified succinimide": non-boron modified bis-succinimide having a polybutenyl group of Mw = 960, compound corresponding to the component (C11), nitrogen atom content = 2.0 mass%.
[0233] "Boron-modified succinimide": boron-modified bis-succinimide having a polybutenyl group, boron atom content = 0.35 mass%, nitrogen atom content = 1.58 mass%.
[0234] "Fatty acid amide": condensation reaction product of isostearic acid and tetraethylenepentamine, corresponding to the component (D1); compound of the aforementioned general formula (d-2) wherein R^{D4} is a hydrogen atom, X is a hydrogen atom or a group represented by $-C(=O)-C_{17}H_{35}$, at least one X is $-C(=O)-C_{17}H_{35}$, d1 is 2, and d2 is 4 (compound represented by the following formula (d-1-1)).
[0235] "Monoamine": oleyl amine, primary monoamine corresponding to the component (E1) (compound represented by the following formula (e-1-1)).
[0236] "Benzotriazole-based compound": N,N-bis(2-ethylhexyl)aminomethyl-1H-methylbenzotriazole, compound of the aforementioned general formula (f-1) wherein R^{F2} is a methyl group, f1 is 1, A^f is a methylene group, and R^{f1} and R^{f2} are each a n-octyl group, which corresponds to the component (F1) (compound represented by the following formula (f-1-1)).



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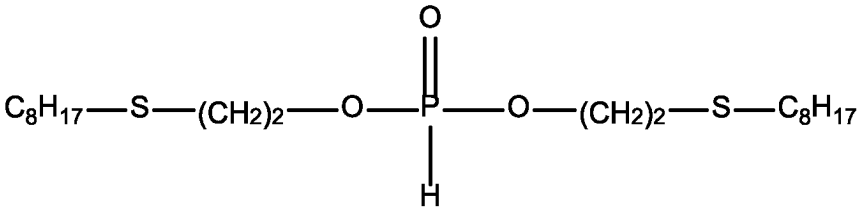

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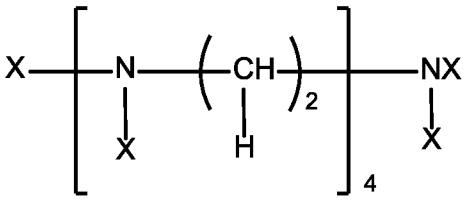
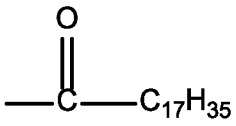


X=H, or 

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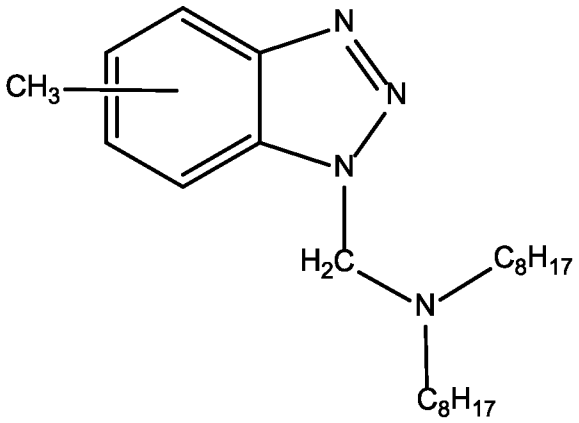

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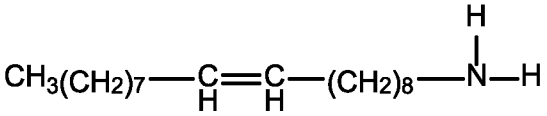

(e-1-1)

[0237] "Additive PKG": additive mixture containing the following components.

[0238] Viscosity index improver: olefin copolymer having Mw of 15,000.

[0239] Pour point depressant: polymethacrylate having Mw of 30,000.

[0240] Antioxidant: phenol-based antioxidant, amine-based antioxidant, sulfur-based antioxidant.

[0241] Phosphoric acid ester: tricresyl phosphate.

[0242] Metal-based detergent: calcium sulfonate of base number (perchloric acid method) = 350 mgKOH/g

[0243] Anti-foaming agent: dimethyl silicone-based anti-foaming agent, fluorosilicone-based anti-foaming agent.

Colorant

[0244] Regarding the prepared lubricating oil composition, a kinematic viscosity, a viscosity index, and a content of each atom were measured or calculated, and moreover, the following tests were carried out. The results of these are shown in Table 1.

(1) Falex test

[0245] Using a closed type Falex seizure test machine, a seizure load was measured under the following measurement conditions in accordance with ASTM D 3233.

Oil temperature: 100°C
Material of pin: AISI 3135
Material of block: AISI C-1137
Rotational speed: 290 rpm
Running-in operation: under a load of 1112 N for 5 minutes

[0246] It can be said that the higher the seizure load is, the more excellent the seizure resistance of the lubricating oil composition is. In the present example, the acceptability criterion of seizure resistance was that the seizure load was 5000 N or more.

(2) Evaluation test for clutch characteristics

[0247] Using a SAE No. 2 friction test machine, a dynamic friction coefficient (μd) and a static friction coefficient (μ0) were measured during dynamic operation, and a static friction coefficient (μs) was measured during static operation, under the following measurement conditions in accordance with JASO M348-2012.

Surface pressure: 785 kPa
Oil temperature: 100°C
Dynamic rotational speed: 3600 rpm
Static rotational speed: 0.7 rpm

[0248] Under the above experiment conditions, μs at 5000 cycles was measured, and a μ ratio (μ0/μd) was determined. When μs is regarded as an index indicating clutch capacity, it can be said that the larger the μs is, the more sufficient transmission torque capacity the lubricating oil composition has. When a μ ratio is regarded as an index indicating shudder prevention property, it can be said that the smaller the μ ratio is, the more excellent the shudder prevention property is, and the smoother clutch shifting the lubricating oil composition enables. In the present example, the acceptability criterion of clutch characteristics was that the μs was 0.115 or more, and the μ ratio was 1.036 or less.

(3) Copper corrosion resistance test

[0249] In the ISOT test according to JIS K2514-1:2013, a copper plate that was a catalyst was added to a test oil, and the sample oil was deteriorated under the conditions of an oil temperature of 175°C and a test time of 48 hours. Regarding the sample oil after the deterioration, an elution amount of copper (ppm by mass) was measured in accordance with JPI-5S-38. It can be said that the smaller the elution amount of copper is, the higher the copper corrosion resistance of the lubricating oil composition is. In the present example, the acceptability criterion of copper corrosion resistance was that the elution amount of copper was 100 ppm by mass or less.

[Table 1]

[0250]

Table 1

			Example 1	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
Formulation of lubricating oil composition	Mineral oil (1)	mass%	66.835	67.835	67.335	66.985	66.855	66.865
	Mineral oil (2)	mass%	16.200	16.200	16.200	16.200	16.200	16.200
	Phosphorous acid ester	mass%	1.000	-	1.000	1.000	1.000	1.000
	Non-boron modified succinimide	mass%	0.500	0.500	-	0.500	0.500	0.500
	Boron-modified succinimide	mass%	3.200	3.200	3.200	3.200	3.200	3.200
	Fatty acid amide	mass%	0.150	0.150	0.150	-	0.150	0.150
	Monoamine	mass%	0.020	0.020	0.020	0.020	-	0.020
	Benzotriazole-based compound	mass%	0.030	0.030	0.030	0.030	0.030	-
	Additive PKG (*1)	mass%	12.065	12.065	12.065	12.065	12.065	12.065
	Total	mass%	100.00	100.00	100.00	100.00	100.00	100.00
Benzotriazole-based compound/phosphorous acid ester		-	0.030	-	0.030	0.030	0.030	-
Monoamine/fatty acid amide		-	0.133	0.133	0.133	-	-	0.133
Properties of lubricating oil composition	40°C kinematic viscosity	mm^2/s	22.95	22.56	22.41	22.86	22.95	22.97
	100°C kinematic viscosity	mm^2/s	5.189	5.128	5.105	5.178	5.191	5.190
	Viscosity index	-	167	167	166	167	167	166
	Acid value	mgKOH/g	1.45	1.19	1.43	1.42	1.43	1.41
	Base number (perchloric acid method)	mgKOH/g	5.08	4.65	4.95	4.96	5.07	5.03
	B content	ppm by mass	160	163	159	162	164	162

(continued)

			Example 1	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
	P content	ppm by mass	458	332	460	457	461	464
	N content	mass%	0.23	0.22	0.22	0.23	0.23	0.23
	Ca content	ppm by mass	210	213	209	209	210	211
	S content	mass%	0.09	0.08	0.09	0.09	0.09	0.09
Various test results	Seizure resistance, Seizure load	N	6270	4450	6170	5820	6010	6560
	Clutch capacity μs	-	0.121	0.121	0.112	0.135	0.131	0.122
	Shudder prevention property μ ratio	-	1.015	1.036	1.015	1.064	1.037	1.023
	Copper corrosion resistance, Elution amount of copper	ppm by mass	54	64	89	52	50	115
(*1): this indicates a blending amount containing a diluent oil.								

[0251] From Table 1, the lubricating oil composition prepared in Example 1 was found to be superior in seizure resistance, clutch characteristics, and copper corrosion resistance in a balanced manner because it contained the components (A) to (F). In contrast, the lubricating oil compositions prepared in Comparative Examples 1 to 5 did not contain any one of the components (B) to (F), and the results were inferior in at least one of seizure resistance, clutch characteristics, and copper corrosion resistance. For example, from comparison between Example 1 and Comparative Example 2, it can be seen that Example 1 containing a non-boron modified succinimide was improved in clutch capacity and was also improved in copper corrosion resistance while favorably maintaining seizure resistance as compared with Comparative Example 2 containing no non-boron modified succinimide.

Claims

1. A lubricating oil composition comprising a base oil (A), a phosphorous acid ester (B), a non-boron modified imide-based compound (C), an amide-based compound (D), an amine-based compound (E), and a benzotriazole-based compound (F), wherein
a content of the component (F) is 0.005 to 1.00 mass% based on the total amount of the lubricating oil composition.

2. The lubricating oil composition according to claim 1, wherein a content of the component (B) is 0.01 to 3.00 mass% based on the total amount of the lubricating oil composition.

3. The lubricating oil composition according to claim 1 or 2, wherein a content ratio [(F)/(B)] by mass of the component (F) to the component (B) is 0.01 to 0.50.

4. The lubricating oil composition according to any one of claims 1 to 3, wherein the component (C) comprises a non-boron modified alkenyl succinimide (C1).

5. The lubricating oil composition according to any one of claims 1 to 4, wherein the component (D) comprises a fatty acid amide (D1).

6. The lubricating oil composition according to claim 5, wherein a content of the fatty acid amide (D1) is 0.04 mass% or more based on the total amount of the lubricating oil composition.

7. The lubricating oil composition according to any one of claims 1 to 6, wherein the component (E) comprises a monoamine (E1).

8. The lubricating oil composition according to any one of claims 1 to 7, wherein the component (E) comprises one or more selected from a primary monoamine (E11) and a secondary monoamine (E12).

9. The lubricating oil composition according to any one of claims 1 to 8, wherein a content ratio [(E)/(D)] by mass of the component (E) to the component (D) is 0.05 to 0.90.

10. The lubricating oil composition according to any one of claims 1 to 9, wherein a content of a fatty acid partial ester compound is less than 0.05 mass% based on the total amount of the lubricating oil composition.

11. The lubricating oil composition according to any one of claims 1 to 10, being used for a transmission equipped with a clutch mechanism.

12. A transmission filled with the lubricating oil composition according to any one of claims 1 to 11.

13. A method for using a lubricating oil composition, wherein the lubricating oil composition according to any one of claims 1 to 11 is applied to lubrication of a transmission equipped with a clutch mechanism.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/004483

A. CLASSIFICATION OF SUBJECT MATTER

C10M 141/10(2006.01)i; *C10M 129/76*(2006.01)n; *C10M 133/04*(2006.01)n; *C10M 133/16*(2006.01)n; *C10M 133/44*(2006.01)n; *C10M 137/02*(2006.01)n; *C10N 30/00*(2006.01)n; *C10N 30/06*(2006.01)n; *C10N 30/12*(2006.01)n; *C10N 40/04*(2006.01)n; *C10N 40/08*(2006.01)n; *C10N 40/25*(2006.01)n; *C10N 40/30*(2006.01)n
FI: C10M141/10; C10M129/76; C10M133/04; C10M133/16; C10M133/44; C10M137/02; C10N30:00 Z; C10N30:06; C10N30:12; C10N40:04; C10N40:08; C10N40:25; C10N40:30

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)

C10M141/10; C10M129/76; C10M133/04; C10M133/16; C10M133/44; C10M137/02; C10N30/00; C10N30/06; C10N30/12; C10N40/04; C10N40/08; C10N40/25; C10N40/30

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.
X	WO 2020/095968 A1 (JXTG NIPPON OIL & ENERGY CORP.) 14 May 2020 (2020-05-14) claims 1-12, paragraphs [0071]-[0084], examples 24-26	1-10, 12
A		11, 13
A	JP 2001-506302 A (EXXON CHEMICAL PATENTS INC.) 15 May 2001 (2001-05-15) claims 1-11	1-13
A	JP 2001-262176 A (NIPPON MITSUBISHI OIL CORP.) 26 September 2001 (2001-09-26) claims 1-5	1-13
A	JP 7-258677 A (COSMO SOGO KENKYUSHO KK) 09 October 1995 (1995-10-09) claim 1	1-13
A	JP 1-282296 A (ETHYL PETROLEUM ADDITIVES, INC.) 14 November 1989 (1989-11-14) claims 1-5	1-13

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 February 2023	**14 March 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
Information on patent family members

International application No.
PCT/JP2023/004483

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2020/095968 A1	14 May 2020	US 2021/0395634 A1 claims 1-12, paragraphs [0078]-[0094], examples 24-26 EP 3878928 A1 CN 112912477 A	
JP 2001-506302 A	15 May 2001	WO 1998/027187 A1 claims 1-11 US 5840663 A EP 956330 A1 AU 4758897 A CA 2275402 A1	
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