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(54) **LUBRICANT COMPOSITION**

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(57) **ABSTRACT**

Provided is a lubricating oil composition containing a base oil (A), a hindered amine compound (B), and an organic zinc dithiophosphate (C) having at least one primary alkyl group.

LUBRICANT COMPOSITION

TECHNICAL FIELD

[0001] The present invention relates to a lubricating oil composition, an internal combustion engine filled with the lubricating oil composition, and a method for using the lubricating oil composition.

BACKGROUND ART

[0002] In recent years, environmental regulations on a global scale have become increasingly strict, particularly the situation surrounding automobiles, with increasingly stringent fuel economy regulations, exhaust gas regulations, and the like. The background to this is environmental issues such as global warming and resource conservation due to concerns about the depletion of oil resources. Under these recent circumstances, the production ratio of hybrid vehicles, which are powered by an internal combustion engine in combination with an electromotor, has been increasing in order to reduce air pollution caused by exhaust gases from vehicles.

[0003] Incidentally, while the same engine oils as the lubricating oils for the internal combustion engine of conventional vehicles powered solely by an internal combustion engine have been used as lubricating oils for the internal combustion engine of hybrid vehicles, the development of lubricating oils for internal combustion engines adapted to the use environment of hybrid vehicles is being pursued.

[0004] For example, Patent Literature 1 discloses a lubricating oil composition for internal combustion engines of hybrid vehicles wherein a 100N hydro-refined mineral oil contains a hindered amine compound, an amine antioxidant, a metal-based detergent, and an organic zinc dithiophosphate, and the hindered amine compound and the amine antioxidant are contained at a predetermined ratio.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: Japanese Patent Laid-Open No. 2016-180069

SUMMARY OF INVENTION

Technical Problem

[0006] Under these circumstances, there is a need for a lubricating oil composition that can be suitably used for the internal combustion engine of hybrid systems having an internal combustion engine and an electromotor as power sources, with improved copper elution suppressing effect, for example.

Solution to Problem

[0007] As a result of extensive studies, the present inventors have found that the above problem can be solved by preparing a lubricating oil composition comprising a hindered amine compound and an organic zinc dithiophosphate having at least one primary alkyl group, together with a base oil. Specifically, the present invention discloses the following embodiments.

[0008] [1] A lubricating oil composition comprising a base oil (A), a hindered amine compound (B), and an organic zinc dithiophosphate (C) having at least one primary alkyl group.

[0009] [2] An internal combustion engine, which is installed in a hybrid system, and is filled with the lubricating oil composition according to the above [1].

[0010] [3] A method for lubricating an internal combustion engine, wherein the lubricating oil composition according to the above [1] is applied to an internal combustion engine installed in a hybrid system.

Advantageous Effects of Invention

[0011] The lubricating oil composition of a preferred embodiment of the present invention has an excellent copper elution suppressing effect, and can retain good long-drain properties over a long period of time. In the lubricating oil composition of a more preferred embodiment of the present invention, high temperature detergency is also excellent together with the copper elution suppressing effect. Due to these characteristics, the lubricating oil composition of one embodiment of the present invention can be preferably used for lubrication of the internal combustion engine of a hybrid system. Hereafter, the performance of exhibiting a copper elution suppressing effect may be expressed as copper elution resistance.

DESCRIPTION OF EMBODIMENTS

[0012] 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.

[0013] 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)".

[0014] Furthermore, in defining the upper limit values and lower limit values described in the present specification, the numerical range from the lower limit value to the upper limit value can be defined by appropriately selecting from each option and combining them arbitrarily.

[0015] In addition, the various requirements described in the present specification as preferred embodiments can be combined in multiple combinations.

[0016] In the present specification, the kinematic viscosity and the viscosity index mean values measured and calculated in accordance with JIS K2283:2000.

[0017] The contents of alkali metals, alkaline earth metals, zinc atoms (Zn), molybdenum atoms (Mo), phosphorus atoms (P) and boron atoms (B) mean the values measured in accordance with JPI-5S-38-92.

[0018] The content of nitrogen atoms (N) means a value measured in accordance with JIS K2609:1998.

[0019] The "base number" means a base number measured by hydrochloric acid method in accordance with JIS K2501 "Petroleum products and lubricants-Determination of neutralization number", 7.

[Constitution of Lubricating Oil Composition]

[0020] The lubricating oil composition of one embodiment of the present invention comprises a base oil (A), a hindered amine compound (B), and an organic zinc dithiophosphate (C) having at least one primary alkyl group.

[0021] Compared to the internal combustion engines of conventional vehicles, the internal combustion engines of hybrid vehicles, which are powered by an internal combustion engine in combination with an electromotor, spend more time stopped, even when the vehicle is in use, which can cause condensation to form inside the crankcase. Therefore, the lubricating oil compositions used in hybrid systems such as hybrid vehicles are prone to water contamination, and the water can cause a decrease in long-drain properties.

[0022] Meanwhile, alloys containing copper may also be used in various components making up the internal combustion engine. The study by the present inventors demonstrated that the elution of copper from the alloys that make up the various components into the lubricating oil composition may cause corrosion wear.

[0023] In order to suppress the elution of copper, the present inventors have conducted extensive studies and have acquired knowledge that the above problem can be solved by preparing a lubricating oil composition that combines a hindered amine compound (B) with an organic zinc dithiophosphate (C) having at least one primary alkyl group. The lubricating oil composition of one embodiment of the present invention has been completed based on this knowledge.

[0024] The lubricating oil composition of one embodiment of the present invention may further contain molybdenum dithiocarbamate (D).

[0025] The lubricating oil composition of one embodiment of the present invention may further contain an antioxidant (E) that does not correspond to the component (B).

[0026] The lubricating oil composition of one embodiment of the present invention may further contain an imide compound (F).

[0027] The lubricating oil composition of one embodiment of the present invention may further contain a metal-based detergent (G).

[0028] The lubricating oil composition of one embodiment of the present invention may further contain a lubricating oil additive other than the above components (B) to (G) as long as the effects of the present invention are not impaired.

[0029] In the lubricating oil composition of one embodiment of the present invention, the total content of the components (A), (B), and (C) is preferably 50 mass % or more, more preferably 60 mass % or more, still more preferably 65 mass % or more, still much more preferably 70 mass % or more, and particularly preferably 75 mass; or more, and may be 100 mass % or less, 99.99 mass % or less, 99.90 mass % or less, 99.50 mass % or less, 99.0 mass % or less, 98.0 mass % or less, 97.0 mass % or less, 95.0 mass % or less, 92.0 mass % or less, or 91.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0030] In the lubricating oil composition of one embodiment of the present invention, the total content of the components (A), (B), (C), (D), (E), (F), and (G) is preferably 60 mass % or more, more preferably 65 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 may be 100 mass % or less, 99.99 mass % or less, 99.90 mass % or less, 99.50 mass % or less, or 99.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0031] 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>

[0032] In the lubricating oil composition of one embodiment of the present invention, examples of the base oil used as the component (A) include one or more selected from mineral oils and synthetic oils.

[0033] 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; and 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.

[0034] 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; alkylnaphthalene; and synthetic oil (GTL) obtained by isomerizing wax (GTL WAX (Gas To Liquids WAX)) produced from natural gas through Fischer-Tropsch process or the like.

[0035] The component (A) used in one embodiment of the present invention is preferably 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.

[0036] The kinematic viscosity of the component (A) used in one embodiment of the present invention at 40° C. is preferably 3.0 to 120 mm^2/s, more preferably 3.5 to 100 mm^2/s, still more preferably 4.0 to 70 mm^2/s, still much more preferably 4.5 to 50 mm^2/s, and particularly preferably 5.0 to 30 mm^2/s.

[0037] The viscosity index of the component (A) used in one embodiment of the present invention is preferably 70 or more, more preferably 90 or more, still more preferably 100 or more, still much more preferably 110 or more, and particularly preferably 120 or more.

[0038] 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.

[0039] In the lubricating oil composition of one embodiment of the present invention, the content of the component (A) is preferably 40 mass % or more, more preferably 50 mass % or more, still more preferably 60 mass % or more, still much more preferably 65 mass % or more, and particularly preferably 70 mass % or more, and may be 75 mass % or more or 80 mass % or more, and 99.4 mass % or less, 99.0 mass % or less, 97.0 mass % or less, 95.0 mass % or less, 92.0 mass % or less, or 90.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

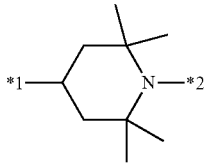
<Component (B): Hindered Amine Compound>

[0040] The lubricating oil composition of one embodiment of the present invention contains a hindered amine compound as the component (B). By containing the component (B), a lubricating oil composition with improved long-drain properties can be obtained.

[0041] The component (B) used in one embodiment of the present invention may be used singly, or may be used in combination of two or more.

[0042] In one embodiment of the present invention, the hindered amine compound used as the component (B) may be a compound containing the structure represented by the following formula (b-0).

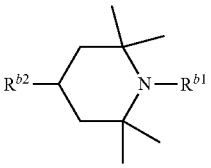
(b-0)



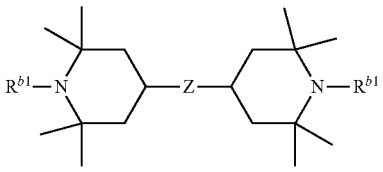
[0043] In the above formula, *1 and *2 represent a position of bonding with another atom.

[0044] The component (B) used in one embodiment of the present invention preferably contains one or more selected from a compound (B1) represented by the following general formula (b-1) and a compound (B2) represented by the following general formula (b-2).

(b-1)



(b-2)



[0045] In the above general formulae (b-1) and (b-2), R^{b1} is each independently a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, or an alkoxy group having 1 to 10 carbon atoms.

[0046] In the above general formula (b-1), R^{b2} is a hydrogen atom, an alkyl group having 1 to 20 carbon atoms, a cycloalkyl group having 3 to 18 ring-forming carbon atoms, an aryl group having 6 to 18 ring-forming carbon atoms, a hydroxyl group, an amino group, or a group represented by —O—CO—R^{b3} (R^{b3} is a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms).

[0047] In the above general formula (b-2), Z is an alkylene group having 1 to 20 carbon atoms, a cycloalkylene group having 3 to 18 ring-forming carbon atoms, an arylene group having 6 to 18 ring-forming carbon atoms, an oxygen atom, a sulfur atom, or a group represented by —O—CO—$(CH_2)_n$—CO—O— (n is an integer of 1 to 20).

[0048] Examples of the alkyl groups that can be selected as R^{b1} include a methyl group, an ethyl group, a propyl group (n-propyl group and 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, and a decyl group. These alkyl groups may be straight-chain alkyl groups or may be branched chain alkyl groups.

[0049] The number of carbon atoms of the alkyl groups that can be selected as R^{b1} is preferably 1 to 10, more preferably 1 to 6, and still more preferably 1 to 3.

[0050] Examples of the alkoxy groups that can be selected as R^{b1} include a methoxy group, an ethoxy group, a propoxy group (n-propoxy group and isopropoxy group), a butoxy group (n-butoxy group, s-butoxy group, t-butoxy group, and isobutoxy group), a pentyloxy group, a hexyloxy group, a 2-ethylhexyloxy group, a heptyloxy group, an octyloxy group, a nonyloxy group, a decyloxy group, and a group represented by —$(CH_2)_n$— (n is an integer of 1 to 20). These alkoxy groups may be straight-chain alkoxy groups or may be branched chain alkoxy groups.

[0051] The number of carbon atoms of the alkoxy groups that can be selected as R^{b1} is preferably 1 to 10, more preferably 1 to 6, and still more preferably 1 to 3.

[0052] Examples of the alkyl groups that can be selected as R^{b2} include the aforementioned alkyl groups having 1 to 10 carbon atoms that can be selected as R^{b1}, as well as an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, a hexadecyl group, and an octadecyl group. These alkyl groups may be straight-chain alkyl groups or may be branched chain alkyl groups.

[0053] The number of carbon atoms of the alkyl groups that can be selected as R^{b2} is preferably 1 to 20, more preferably 3 to 18, still more preferably 6 to 16, and still much more preferably 8 to 14.

[0054] Examples of the cycloalkyl groups that can be selected as R^{b2} include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, and an adamantyl group.

[0055] The number of ring-forming carbon atoms of the cycloalkyl groups that can be selected as R^{b2} is preferably 3 to 18, more preferably 5 to 15, and still more preferably 6 to 12.

[0056] Examples of the aryl groups that can be selected as R^{b2} include a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a biphenyl group, a terphenyl group, and a phenylnaphthyl group.

[0057] The number of ring-forming carbon atoms of the aryl groups that can be selected as R^{b2} is preferably 6 to 18, more preferably 6 to 15, and still more preferably 6 to 12.

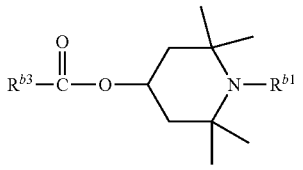
[0058] Examples of the alkylene groups that can be selected as Z include a methylene group, a 1, 1-ethylene group, a 1,2-ethylene group, various propylene groups such as 1, 3-propylene, 1,2-propylene, and 2,2-propylene, various butylene groups, various pentylene groups, various hexylene groups, various heptylene groups, various octylene groups, various nonylene groups, various decylene groups, various undecylene groups, various dodecylene groups, various tridecylene groups, various tetradecylene groups, various pentadecylene groups, various hexadecylene groups, various heptadecylene groups, and various octadecylene groups.

[0059] Examples of the cycloalkylene groups that can be selected as Z include a cyclopropylene group, a cyclobutylene group, a cyclopentylene group, a cyclohexylene group, a cycloheptylene group, a cyclooctylene group, and an adamantylene group.

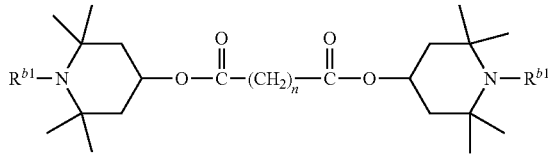
[0060] Examples of the arylene groups that can be selected as Z include a phenylene group, a naphthylene group, an anthrylene group, a phenanthrylene group, a biphenylene group, and a terphenylene group.

[0061] The component (B) used in one embodiment of the present invention more preferably contains one or more selected from a compound (B11) represented by the following general formula (b-11) and a compound (B21) represented by the following general formula (b-21).

(b-11)



(b-21)



[0062] In the above general formulae (b-11) and (b-21), R^{b1} is each independently a hydrogen atom or an alkyl group having 1 to 10 carbon atoms. Specific examples of the alkyl groups that can be selected as R^{b1} and the preferred range of the number of carbon atoms is as previously described.

[0063] In the above general formula (b-11), R^{b3} is a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms.

[0064] In the above general formula (b-21), n is an integer of 1 to 20.

[0065] Examples of the hydrocarbon groups that can be selected as R^{b3} include an alkyl group having 1 to 20 carbon atoms, an alkenyl group having 2 to 20 carbon atoms, a cycloalkyl group having 3 to 18 ring-forming carbon atoms optionally substituted with an alkyl group having 1 to 10 carbon atoms, an aryl group having 6 to 18 ring-forming carbon atoms optionally substituted with an alkyl group having 1 to 10 carbon atoms, and an arylalkyl group having 7 to 19 carbon atoms.

[0066] The alkyl groups may be straight-chain alkyl groups or may be branched chain alkyl groups. The alkenyl groups may be straight-chain alkenyl groups or may be branched chain alkenyl groups.

[0067] Examples of the alkyl groups, cycloalkyl groups and aryl groups that can be selected as R^{b3} include the same groups as the alkyl groups, cycloalkyl groups and aryl groups that can be selected as R^{b2}.

[0068] Examples of the alkenyl groups that can be selected as R^{b3} 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).

[0069] Examples of the arylalkyl groups that can be selected as R^{b3} include a phenylmethyl group, a phenylethyl group, a naphthylmethyl group, and a naphthylethyl group.

[0070] Of these, R^{b3} is preferably an alkyl group having 1 to 20 carbon atoms or an alkenyl group having 2 to 20 carbon atoms, and more preferably an alkyl group having 1 to 20 carbon atoms.

[0071] The number of carbon atoms of the alkyl groups that can be selected as R^{b3} is preferably 3 to 20, more preferably 4 to 18, still more preferably 6 to 16, and still much more preferably 8 to 14.

[0072] The number of carbon atoms of the alkenyl groups that can be selected as R^{b3} is preferably 2 to 20, more preferably 3 to 18, and still more preferably 6 to 16.

[0073] From the viewpoint of obtaining a lubricating oil composition having improved high temperature detergency, the component (B) used in one embodiment of the present invention preferably contains at least a compound (B1) represented by the general formula (b-1), and more preferably contains at least a compound (B11) represented by the general formula (b-11).

[0074] In the lubricating oil composition of one embodiment of the present invention, the content ratio of the component (B1) or (B11) in the component (B) is preferably 40 to 100 mass % or more, more preferably 50 to 100 mass %, more preferably 60 to 100 mass %, still 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 (B) contained in the lubricating oil composition, from the viewpoint of obtaining a lubricating oil composition having further improved high temperature detergency.

[0075] From the above viewpoint, the content of the component (B) in the lubricating oil composition of one embodiment of the present invention is, from the viewpoint of obtaining a lubricating oil composition with better long-drain properties, preferably 0.60 mass % or more, more preferably 0.65 mass % or more, more preferably 0.70 mass % or more, more preferably 0.85 mass % or more, more preferably 1.00 mass % or more, still more preferably 1.20 mass % or more, still more preferably 1.40 mass % or more, still more preferably 1.70 mass % or more, still more preferably 2.00 mass % or more, still more preferably 2.10 mass % or more, still much more preferably 2.20 mass % or more, still much more preferably 2.50 mass % or more, and particularly preferably 2.55 mass % or more, and from the viewpoint of obtaining a lubricating oil composition that can better retain high temperature detergency, it is preferably 10.0 mass % or less, more preferably 9.5 mass % or less, more preferably 9.0 mass % or less, still more preferably 8.5 mass % or less, still more preferably 8.0 mass % or less, still much more preferably 7.5 mass % or less, and particularly preferably 7.0 mass % or less, or may be 6.5 mass % or less, 6.0 mass % or less, 5.5 mass % or less, 5.0 mass % or less, 4.5 mass % or less, 4.0 mass % or less, less than 3.5 mass %, 3.4 mass % or less, 3.2 mass % or less, 3.0 mass % or less, or less than 3.0 mass %, based on the total amount (100 mass %) of the lubricating oil composition.

[0076] The content of the component (B) in terms of nitrogen atoms in the lubricating oil composition of one embodiment of the present invention is, from the viewpoint

of obtaining a lubricating oil composition with better long-drain properties, preferably 0.020 mass % or more, more preferably more than 0.050 mass %, more preferably 0.055 mass % or more, more preferably 0.060 mass % or more, still more preferably 0.070 mass % or more, still more preferably 0.080 mass % or more, still much more preferably 0.090 mass % or more, and particularly preferably 0.100 mass % or more, and from the viewpoint of obtaining a lubricating oil composition that can better retain high temperature detergency, it is preferably 0.60 mass % or less, more preferably 0.50 mass % or less, more preferably 0.45 mass % or less, still more preferably 0.42 mass % or less, still more preferably 0.40 mass % or less, still much more preferably 0.37 mass % or less, and particularly preferably 0.35 mass % or less, or may be 0.32 mass % or less, 0.30 mass % or less, 0.27 mass % or less, 0.25 mass % or less, 0.22 mass % or less, or 0.20 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

<Component (C): Organic Zinc Dithiophosphate>

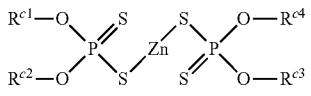
[0077] The lubricating oil composition of one embodiment of the present invention comprises an organic zinc dithiophosphate having at least one primary alkyl group (hereinafter also referred to as "ZnDTP"). By containing the component (C), a lubricating oil composition with improved copper elution resistance can be obtained.

[0078] In one embodiment of the present invention, the component (C) may be used singly, or may be used in combination of two or more.

[0079] The component (C) used in one embodiment of the present invention is any ZnDTP having at least one primary alkyl group, and may be a ZnDTP having an alkyl group other than a primary alkyl group, or a hydrocarbon group other than an alkyl group.

[0080] However, from the viewpoint of obtaining a lubricating oil composition with improved copper elution resistance, the component (C) used in one embodiment of the present invention preferably contains a compound (C1) represented by the following general formula (c-1).

(c-1)



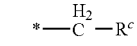
[0081] In the above general formula (c-1), R^{c1} to R^{c4} are each independently a primary alkyl group. By using a component (C1) in which all of the substituents R^{c1} to R^{c4} are primary alkyl groups, a lubricating oil composition with further improved copper elution resistance can be obtained.

[0082] From the above viewpoint, the content ratio of the component (C1) in the component (C) used in one embodiment of the present invention is preferably 60 to 100 mass %, more preferably 70 to 100 mass %, more preferably 80 to 100 mass %, still more preferably 85 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.

[0083] From the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, the number of carbon atoms of the primary alkyl groups that can be selected as R^{c1} to R^{c4} is preferably 1 to 7, more preferably 2 to 7, still more preferably 3 to 7, and still much more preferably 4 to 7.

[0084] Examples of the primary alkyl groups that can be selected as R^{c1} to R^{c4} include a group represented by the following general formula (c-i).

(c-i)



[0085] In the above formula (c-i), R^c is a hydrogen atom or an alkyl group, and the alkyl group may be a straight-chain alkyl group or may be a branched chain alkyl group.

[0086] The number of carbon atoms of the alkyl groups that can be selected as R^c is preferably 1 to 6, more preferably 2 to 6, and still more preferably 3 to 5.

[0087] Examples of the alkyl groups that can be selected as Re include a methyl group, an ethyl group, a propyl group (n-propyl group and isopropyl group), a butyl group (n-butyl group, s-butyl group, t-butyl group, and isobutyl group), a pentyl group (n-pentyl group, 1-methylbutyl group, 2-methylbutyl group, 3-methylbutyl group, 1-ethylpropyl group, 1,1-dimethylpropyl group, 1,2-dimethylpropyl group, and 2,2-dimethylpropyl group), and a hexyl group (n-hexyl group, 2-methylpentyl group, 3-methylpentyl group, 2,2-dimethylbutyl group, and 2,3-dimethylbutyl group).

[0088] The content of the component (C) in the lubricating oil composition of one embodiment of the present invention is, from the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, preferably 0.01 mass % or more, more preferably 0.05 mass % or more, more preferably 0.10 mass % or more, still more preferably 0.30 mass % or more, still more preferably 0.50 mass % or more, still much more preferably 0.70 mass % or more, still much more preferably 0.80 mass % or more, and particularly preferably 0.90 mass % or more, and from the viewpoint of obtaining a lubricating oil composition with good high temperature detergency, it is preferably 7.0 mass % or less, more preferably 6.0 mass % or less, more preferably 5.0 mass % or less, still more preferably 4.0 mass % or less, still much more preferably 3.0 mass % or less, and particularly preferably 2.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0089] The content of the component (C) in terms of zinc atoms in the lubricating oil composition of one embodiment of the present invention is, from the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, preferably 0.005 mass % or more, more preferably 0.01 mass % or more, still more preferably 0.03 mass % or more, still much more preferably 0.05 mass % or more, and particularly preferably 0.07 mass % or more, and from the viewpoint of obtaining a lubricating oil composition with good high temperature detergency, it is preferably 0.70 mass % or less, more preferably 0.50 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.

[0090] In the lubricating oil composition of one embodiment of the present invention, from the viewpoint of obtaining a lubricating oil composition with further improved high

temperature detergency, as well as further improved copper elution resistance, the content ratio by mass of the compound (B) to the compound (C), [(B)/(C)], is preferably 0.5 or more, more preferably 0.7 or more, more preferably 1.0 or more, still more preferably 1.2 or more, still more preferably 1.5 or more, still much more preferably 1.7 or more, still much more preferably 2.0 or more, and particularly preferably 2.2 or more, and it is preferably 10.00 or less, more preferably 8.00 or less, more preferably 7.00 or less, more preferably 6.00 or less, still more preferably 5.50 or less, still more preferably 5.00 or less, still much more preferably 4.50 or less, still much more preferably 4.00 or less, and particularly preferably 3.50 or less.

<Organic Zinc Dithiophosphate that does not Correspond to the Component (C)>

[0091] The lubricating oil composition of one embodiment of the present invention may contain an organic zinc dithiophosphate that does not correspond to the component (C) as long as the effects of the present invention are not impaired.

[0092] The organic zinc dithiophosphate that does not correspond to the component (C) is a ZnDTP free of primary alkyl groups, such as a ZnDTP in which all substituents are secondary alkyl groups.

[0093] However, from the viewpoint of obtaining a lubricating oil composition with better copper elution resistance, the content of the organic zinc dithiophosphate that does not correspond to the component (C) is preferably as small as possible, and it is more preferably substantially free of the organic zinc dithiophosphate that does not correspond to the component (C).

[0094] In the present specification, "substantially free of the organic zinc dithiophosphate that does not correspond to component (C)" is a provision that rules out any embodiment in which the organic zinc dithiophosphate is contained by blending it for a given purpose, and is not a provision that rules out embodiments in which the organic zinc dithiophosphate is unintentionally or unavoidably mixed or present.

[0095] The content of the organic zinc dithiophosphate that does not correspond to the component (C) in the lubricating oil composition of one embodiment of the present invention is preferably less than 0.001 mass %, more preferably less than 0.0001 mass %, and still more preferably less than 0.00001 mass %, based on the total amount (100 mass %) of the lubricating oil composition.

[0096] The content of the organic zinc dithiophosphate that does not correspond to the component (C) in the lubricating oil composition of one embodiment of the present invention is preferably less than 10 parts by mass, more preferably less than 5 parts by mass, more preferably less than 1 part by mass, still more preferably less than 0.1 parts by mass, still more preferably less than 0.01 parts by mass, still much more preferably less than 0.001 parts by mass, and particularly preferably less than 0.0001 parts by mass, based on the total 100 parts by mass of the component (C) contained in the lubricating oil composition.

<Component (D): Molybdenum Dithiocarbamate>

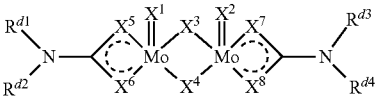
[0097] The lubricating oil composition of one embodiment of the present invention may contain molybdenum dithiocarbamate as the component (D). By containing the component (D), a lubricating oil composition with further improved copper elution resistance can be obtained.

[0098] In one embodiment of the present invention, the component (D) may be used singly, or may be used in combination of two or more.

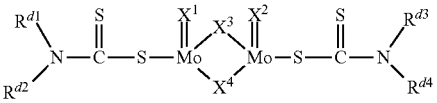
[0099] Examples of the component (D) used in one embodiment of the present invention include dinuclear molybdenum dithiocarbamate containing two molybdenum atoms per molecule and trinuclear molybdenum dithiocarbamate containing three molybdenum atoms per molecule, with dinuclear molybdenum dithiocarbamate being preferable.

[0100] The component (D) used in one embodiment of the present invention preferably contains one or more selected from a compound (D1) represented by the following general formula (d-1) and a compound (D2) represented by the following general formula (d-2).

(d-1)



(d-2)



[0101] In the above general formulae (d-1) and (d-2), R^{d1} to R^{d4} each independently represent a hydrocarbon group, and may be the same as one another, or may be different from one another.

[0102] X^1 to X^8 each independently represent an oxygen atom or a sulfur atom, and may be the same as one another, or may be different from one another.

[0103] However, at least one of X^1 to X^8 in the formula (d-1) is a sulfur atom.

[0104] In one embodiment of the present invention, X^1 and X^2 in the formula (d-1) are preferably oxygen atoms, and X^3 to X^8 sulfur atoms.

[0105] In addition, X^1 to X^4 in the formula (d-2) are preferably oxygen atoms.

[0106] In the general formula (d-1), from the viewpoint of improving solubility, the molar ratio of sulfur atoms to oxygen atoms in X^1 to X^8, [sulfur atoms/oxygen atoms], is preferably ¼ to 4/1, and more preferably 1/3 to 3/1.

[0107] Examples of the hydrocarbon groups that can be selected as R^{d1} to R^{d4} in the above general formulae (d-1) and (d-2) include alkyl groups, such as a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, an isooctyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, an isotridecyl group, a tetradecyl group, a pentadecyl group, a hexadecyl group, a heptadecyl group and an octadecyl group; alkenyl groups, such as an octenyl group, a nonenyl group, a decenyl group, an undecenyl group, a dodecenyl group, a tridecenyl group, a tetradecenyl group and a pentadecenyl group; cycloalkyl groups, such as a cyclohexyl group, a dimethylcyclohexyl group, an ethylcyclohexyl group, a methylcyclohexylmethyl group, a cyclohexylethyl group, a propylcyclohexyl group, a butylcyclohexyl group and a heptylcyclohexyl group; aryl groups, such as a phenyl group, a naphthyl group, an anthracenyl group, a biphenyl group and a terphenyl group; alkylaryl groups, such as a tolyl group, a dimethylphenyl

group, a butylphenyl group, a nonylphenyl group, a methylbenzyl group, and a dimethylnaphthyl group; and arylalkyl groups, such as a phenylmethyl group, a phenylethyl group and a diphenylmethyl group.

[0108] Of these, the hydrocarbon group that can be selected as R^{d1} to R^{d4} is preferably an alkyl group or an alkenyl group, and more preferably an alkyl group.

[0109] From the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, the number of carbon atoms of the hydrocarbon groups that can be selected as R^{d1} to R^{d4} is preferably 1 to 20, more preferably 3 to 18, still more preferably 5 to 16, still much more preferably 8 to 14, and particularly preferably 8 or 13.

[0110] From the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, in the compound in which R^{d1} to R^{d4} in the above general formulae (d-1) and (d-2) are alkyl groups, used as the component (D) in one embodiment of the present invention, the molar ratio of alkyl groups (x) having 10 carbon atoms or less (preferably 3 to 10, more preferably 5 to 10, and still more preferably 7 to 10) to alkyl groups (β) having 11 carbon atoms or more (preferably 11 to 20, more preferably 11 to 16, and still more preferably 12 to 14), [(a)/(B)], is preferably 1/7 to 7/1, more preferably 1/6 to 6/1, more preferably 1/5 to 5/1, still more preferably ¼ to 4/1, still much more preferably 1/3 to 3/1, and particularly preferably 1/2 to

[0111] From the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, the content of the component (D) in the lubricating oil composition of one embodiment of the present invention is preferably 0.05 mass % or more, more preferably 0.10 mass % or more, still more preferably 0.20 mass % or more, still much more preferably 0.30 mass % or more, and particularly preferably 0.50 mass % or more, and may be 5.0 mass % or less, 4.0 mass % or less, 3.0 mass % or less, 2.0 mass % or less, 1.5 mass % or less, or 1.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

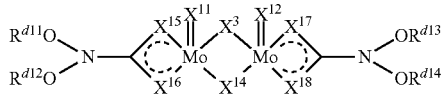
[0112] From the viewpoint of obtaining a lubricating oil composition with further improved copper elution resistance, the content of the component (D) in terms of molybdenum atoms in the lubricating oil composition of one embodiment of the present invention is preferably 0.01 mass % or more, more preferably 0.02 mass % or more, still more preferably 0.03 mass % or more, still much more preferably 0.04 mass % or more, and particularly preferably 0.05 mass % or more, and may be 0.70 mass % or less, 0.50 mass % or less, 0.30 mass % or less, 0.20 mass % or less, or 0.10 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

<Molybdenum Dithiophosphate>

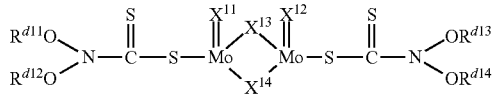
[0113] The lubricating oil composition of one embodiment of the present invention may contain molybdenum dithiophosphate as long as the effects of the present invention are not impaired.

[0114] Examples of the molybdenum dithiophosphate include a compound represented by the following general formula (d'-i) and a compound represented by the following general formula (d'-ii).

(d'-i)



(d'-ii)



[0115] In the above general formulae (d'-i) and (d'-ii), R^{d11} to R^{d14} each independently represent a hydrocarbon group, and may be the same as one another, or may be different from one another. X^{11} to X^{18} each independently represent an oxygen atom or a sulfur atom, and may be the same as one another, or may be different from one another. However, at least two of X^{11} to X^{18} in the formula (d'-i) are sulfur atoms.

[0116] From the viewpoint of obtaining a lubricating oil composition with better copper elution resistance, the content of molybdenum dithiophosphate is preferably as small as possible, and it is more preferably substantially free of molybdenum dithiophosphate.

[0117] In the present specification, "substantially free of molybdenum dithiophosphate" is a provision that rules out any embodiment in which molybdenum dithiophosphate is contained by blending it for a given purpose, and is not a provision that rules out embodiments in which molybdenum dithiophosphate is unintentionally or unavoidably mixed or present.

[0118] The content of molybdenum dithiophosphate in the lubricating oil composition of one embodiment of the present invention is preferably less than 0.001 mass %, more preferably less than 0.0001 mass %, and still more preferably less than 0.00001 mass %, based on the total amount (100 mass %) of the lubricating oil composition.

[0119] The content of molybdenum dithiophosphate in the lubricating oil composition of one embodiment of the present invention is preferably less than 10 parts by mass, more preferably less than 5 parts by mass, more preferably less than 1 part by mass, still more preferably less than 0.1 parts by mass, still more preferably less than 0.01 parts by mass, still much more preferably less than 0.001 parts by mass, and particularly preferably less than 0.0001 parts by mass, based on the total 100 parts by mass of the component (C) contained in the lubricating oil composition.

<Component (E): Antioxidant that does not Correspond to the Component (B)>

[0120] From the viewpoint of obtaining a lubricating oil composition having further improved high temperature detergency, the lubricating oil composition of one embodiment of the present invention may contain an antioxidant that does not correspond to the component (B) as the component (E).

[0121] Examples of the component (E) used in one embodiment of the present invention include an amine antioxidant other than a hindered amine compound, a phenolic antioxidant, a sulfur antioxidant, and a phosphorus antioxidant.

[0122] In one embodiment of the present invention, the component (E) may be used singly, or may be used in combination of two or more.

[0123] The component (E) used in one embodiment of the present invention preferably contains one or more selected from an amine antioxidant (El) that does not correspond to the component (B) and a phenolic antioxidant (E2), and more preferably contains both component (E1) and component (E2).

[0124] The total content ratio of the component (E1) and the component (E2) in the component (E) used in one embodiment of the present invention is preferably 60 to 100 mass %, more preferably 70 to 100 mass %, more preferably 80 to 100 mass %, still more preferably 85 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.

[0125] When the component (E) used in one embodiment of the present invention contains both components (E1) and (E2), the content ratio by mass of the component (E1) to the component (E2), [(E1)/(E2)], is preferably 0.10 to 5.0, more preferably 0.30 to 4.5, more preferably 0.50 to 4.0, still more preferably 0.75 to 3.5, still much more preferably 1.0 to 3.0, and particularly preferably 1.2 to 2.7.

[0126] Examples of the component (E1) used in one embodiment of the present invention include a diphenylamine antioxidant, such as diphenylamine, and alkylated diphenylamine having an alkyl group with 3 to 20 (preferably 6 to 16, more preferably 8 to 12) carbon atoms; and a naphthylamine antioxidant such as α-naphthylamine, phenyl-α-naphthylamine, and substituted phenyl-α-naphthylamine having an alkyl group with 3 to 20 (preferably 6 to 16, more preferably 8 to 12) carbon atoms.

[0127] Examples of the component (E2) used in one embodiment of the present invention include a monophenolic antioxidant such as 2, 6-di-t-butylphenol, 2, 6-di-t-butyl-4-methylphenol, 2, 6-di-t-butyl-4-ethylphenol, isooctyl-3-(3,5-di-t-butyl-4-hydroxyphenyl) propionate, octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl) propionate, and benzenepropanoic acid-3,5-bis (1,1-dimethylethyl)-4-hydroxyalkyl ester; and a diphenolic antioxidant such as 4,4'-methylenebis (2, 6-di-t-butylphenol), 2,2'-methylenebis (4-ethyl-6-t-butylphenol) and thiodiethylenebis [3-(3,5-di-t-butyl-4-hydroxyphenyl) propionate].

[0128] In the lubricating oil composition of one embodiment of the present invention, the content of the component (E) is preferably 0.01 mass % or more, more preferably 0.05 mass % or more, more preferably 0.10 mass % or more, still more preferably 0.30 mass % or more, still more preferably 0.50 mass % or more, still much more preferably 0.70 mass % or more, and particularly preferably 1.00 mass % or more, and may be 10.0 mass % or less, 8.0 mass % or less, 6.0 mass % or less, 5.0 mass % or less, 4.0 mass % or less, 3.0 mass % or less, or 2.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0129] In the lubricating oil composition of one embodiment of the present invention, the ratio by mass of the component (E) to the component (B), [(E)/(B)], is preferably 0.10 or more, more preferably 0.20 or more, still more preferably 0.30 or more, still much more preferably 0.40 or more, and particularly preferably 0.45 or more, and preferably 6.0 or less, more preferably 5.0 or less, still more preferably 4.0 or less, still much more preferably 3.0 or less, and particularly preferably 2.0 or less.

[0130] In the lubricating oil composition of one embodiment of the present invention, the content of the component (E1) is preferably 0.01 mass % or more, more preferably 0.05 mass % or more, more preferably 0.10 mass % or more, still more preferably 0.20 mass % or more, still more preferably 0.30 mass % or more, still much more preferably 0.50 mass % or more, and particularly preferably 0.70 mass % or more, and may be 5.0 mass % or less, 4.0 mass % or less, 3.0 mass % or less, 2.0 mass % or less, or 1.5 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0131] In the lubricating oil composition of one embodiment of the present invention, the ratio by mass of the component (E1) to the component (B), [(E1)/(B)], is preferably 0.05 or more, more preferably 0.10 or more, still more preferably 0.20 or more, still much more preferably 0.25 or more, and particularly preferably 0.30 or more, and preferably 5.0 or less, more preferably 4.0 or less, still more preferably 3.0 or less, still much more preferably 2.0 or less, and particularly preferably 1.0 or less.

[0132] In the lubricating oil composition of one embodiment of the present invention, the content of the component (E2) is preferably 0.01 mass % or more, more preferably 0.05 mass % or more, more preferably 0.10 mass % or more, still more preferably 0.20 mass % or more, still much more preferably 0.30 mass % or more, and particularly preferably 0.40 mass % or more, and may be 5.0 mass % or less, 4.0 mass % or less, 3.0 mass % or less, 2.0 mass % or less, or 1.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0133] In the lubricating oil composition of one embodiment of the present invention, the ratio by mass of the component (E2) to the component (B), [(E2)/(B)], is preferably 0.01 or more, more preferably 0.05 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 preferably 3.0 or less, more preferably 2.0 or less, still more preferably 1.0 or less, still much more preferably 0.70 or less, and particularly preferably 0.50 or less.

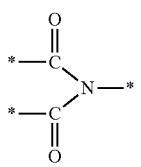
<Component (F): Imide Compound>

[0134] The lubricating oil composition of one embodiment of the present invention may contain an imide compound as the component (F). By containing the component (F), a lubricating oil composition that can suppress sludge deposition can be obtained.

[0135] In one embodiment of the present invention, the component (F) may be used singly, or may be used in combination of two or more.

[0136] In the present specification, the "imide compound" means a compound having an imide structure represented by the following formula (f-0), and includes chain compounds having this imide structure and cyclic compounds having this imide structure.

(f-0)



wherein, * represents a bonding position.

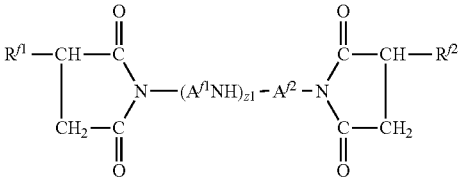
[0137] The component (F) used in one embodiment of the present invention may be a modified imide compound reacted with one or more selected from a boron compound, an alcohol, an aldehyde, a ketone, an alkylphenol, a cyclic carbonate, an epoxy compound, an organic acid, and the like, or may be a non-modified imide compound.

[0138] The component (F) used in one embodiment of the present invention preferably contains one or more selected from an alkenyl succinimide and the modified products thereof, more preferably one or more selected from a non-boron modified alkenyl succinimide (F1) and a boron-modified alkenyl succinimide (F2), and still more preferably both components (F1) and (F2).

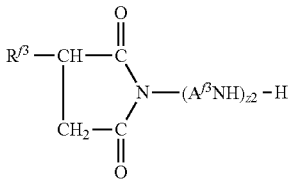
[0139] The total content ratio of the component (F1) and the component (F2) in the component (F) used in one embodiment of the present invention is preferably 60 to 100 mass %, more preferably 70 to 100 mass %, more preferably 80 to 100 mass %, still more preferably 85 to 100 mass %, still much more 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.

[0140] The non-boron modified alkenyl succinimide (F1) is preferably one or more selected from an alkenyl bis-succinimide (F11) represented by the following general formula (f-1) and an alkenyl monosuccinimide (F12) represented by the following general formula (f-2).

(f-1)



(f-2)



[0141] In the above general formulae (f-1) and (f-2), R^{f1}, R^{f2} and R^{f3} are each independently an alkenyl group having a mass-average molecular weight (Mw) of 500 to 3000 (preferably 900 to 2500).

[0142] Examples of the alkenyl groups that can be selected as R^{f1}, R^{f2} and R^{f3} include a polybutenyl group, a polyisobutenyl group, and an ethylene-propylene copolymer, and among these, a polybutenyl group or a polyisobutenyl group is preferable.

[0143] A^{f1}, A^{f2} and A^{f3} are each independently an alkylene group having 2 to 5 carbon atoms.

[0144] z1 is an integer of 0 to 10, preferably an integer of 1 to 4, and more preferably 2 or 3.

[0145] z2 is an integer of 1 to 10, preferably an integer of 2 to 5, and more preferably 3 or 4.

[0146] Examples of the boron-modified alkenyl succinimide (F2) used in one embodiment of the present invention include a boron-modified product of an alkenyl bis-succinimide represented by the aforementioned general formula (f-1) and a boron-modified product of an alkenyl monosuccinimide represented by the aforementioned general formula (f-2).

[0147] In one embodiment of the present invention, the ratio of boron atoms to nitrogen atoms constituting the component (F2), [B/N], is preferably 0.1 or more, more preferably 0.2 or more, still more preferably 0.3 or more, still much more preferably 0.5 or more, and particularly preferably 0.7 or more.

[0148] In the lubricating oil composition of one embodiment of the present invention, from the viewpoint of high temperature detergency, the content ratio by mass of the component (F1) to the component (F2), [(F1)/(F2)], is preferably 0.10 or more, more preferably 0.50 or more, still more preferably 0.70 or more, still much more preferably 1.00 or more, and particularly preferably 1.20 or more, and preferably less than 5.00, more preferably less than 4.00, still more preferably less than 3.00, still much more preferably less than 2.50, and particularly preferably less than 2.00.

[0149] In the lubricating oil composition of one embodiment of the present invention, the content ratio by mass of boron atoms derived from the component (F2) to nitrogen atoms derived from the component (F), [B/N], is preferably 0.01 or more, more preferably 0.05 or more, still more preferably 0.10 or more, still much more preferably 0.20 or more, and particularly preferably 0.30 or more, and 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 0.55 or less.

[0150] The content of the component (F) in the lubricating oil composition of one embodiment of the present invention is preferably 0.50 mass % or more, more preferably 1.0 mass % or more, still more preferably 2.0 mass % or more, still much more preferably 3.0 mass % or more, and particularly preferably 4.0 mass % or more, and it is preferably 12.0 mass % or less, more preferably 10.0 mass % or less, still more preferably 9.0 mass % or less, still much more preferably 8.5 mass % or less, and particularly preferably 8.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0151] In the lubricating oil composition of one embodiment of the present invention, the content of the component (F) in terms of nitrogen atoms is preferably 0.010 to 0.200 mass %, more preferably 0.020 to 0.170 mass %, still more preferably 0.030 to 0.130 mass %, still much more preferably 0.040 to 0.100 mass %, and particularly preferably 0.050 to 0.090 mass %, based on the total amount (100 mass %) of the lubricating oil composition.

[0152] The content of the component (F1) in the lubricating oil composition of one embodiment of the present invention is preferably 0.10 mass % or more, more preferably 0.50 mass % or more, still more preferably 1.0 mass % or more, still much more preferably 1.5 mass % or more, and particularly preferably 2.0 mass % or more, and it is preferably 10.0 mass % or less, more preferably 8.0 mass % or less, still more preferably 7.0 mass % or less, still much more preferably 6.5 mass % or less, and particularly preferably 6.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0153] In the lubricating oil composition of one embodiment of the present invention, the content of the component (F1) in terms of nitrogen atoms is preferably 0.005 to 0.150 mass %, more preferably 0.010 to 0.120 mass %, still more

preferably 0.015 to 0.100 mass %, still much more preferably 0.020 to 0.080 mass %, and particularly preferably 0.025 to 0.070 mass %, based on the total amount (100 mass %) of the lubricating oil composition.

[0154] The content of the component (F2) in the lubricating oil composition of one embodiment of the present invention is preferably 0.10 mass % or more, more preferably 0.30 mass % or more, still more preferably 0.50 mass % or more, still much more preferably 1.0 mass % or more, and particularly preferably 1.5 mass % or more, and it is preferably 8.0 mass % or less, more preferably 7.0 mass % or less, still more preferably 6.0 mass % or less, still much more preferably 5.0 mass % or less, and particularly preferably 4.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0155] In the lubricating oil composition of one embodiment of the present invention, the content of the component (F2) in terms of boron atoms is preferably 0.001 to 0.100 mass %, more preferably 0.005 to 0.090 mass %, still more preferably 0.010 to 0.080 mass %, still much more preferably 0.015 to 0.070 mass %, and particularly preferably 0.020 to 0.060 mass %, based on the total amount (100 mass %) of the lubricating oil composition.

<Component (G): Metal-Based Detergent>

[0156] The lubricating oil composition of one embodiment of the present invention may contain a metal-based detergent as the component (G). By containing the component (G), a lubricating oil composition with better high temperature detergency can be obtained.

[0157] In one embodiment of the present invention, the component (G) may be used singly, or may be used in combination of two or more.

[0158] Examples of the component (G) 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 atom 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.

[0159] The component (G) used in one embodiment of the present invention preferably contains one or more selected from calcium sulfonate, calcium salicylate and calcium phenate, and more preferably contains calcium salicylate.

[0160] The content ratio of the calcium salicylate 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.

[0161] The base number of the metal-based detergent is preferably 0 to 600 mg KOH/g.

[0162] The component (G) used in one embodiment of the present invention may be a neutral metal-based detergent, or an overbased metal-based detergent.

[0163] A neutral metal-based detergent means a metal-based detergent with a base number of 0 to 100 mg KOH/g, whereas an overbased metal-based detergent means a metal-based detergent with a base number of more than 100 mg KOH/g.

[0164] The content of the component (G) in the lubricating oil composition of one embodiment of the present invention is preferably 0.10 mass % or more, more preferably 0.30 mass % or more, more preferably 0.50 mass % or more, more preferably 0.70 mass % or more, still more preferably 1.00 mass % or more, still more preferably 1.20 mass % or more, still more preferably 1.50 mass % or more, still much more preferably 1.70 mass % or more, and particularly preferably 1.90 mass % or more, and it is preferably 10.0 mass % or less, more preferably 8.0 mass % or less, more preferably 7.0 mass % or less, still more preferably 6.0 mass % or less, still much more preferably 5.0 mass % or less, and particularly preferably 4.0 mass % or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0165] The content of the component (G) in terms of calcium atoms in the lubricating oil composition of one embodiment of the present invention is preferably 50 ppm by mass or more, more preferably 100 ppm by mass or more, more 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 more preferably 300 ppm by mass or more, still more preferably 350 ppm by mass or more, still much more preferably 400 ppm by mass or more, and particularly preferably 450 ppm by mass or more, and it is preferably 3000 ppm by mass or less, more preferably 2500 ppm by mass or less, more preferably 2000 ppm by mass or less, still more preferably 1500 ppm by mass or less, still much more preferably 1000 ppm by mass or less, and particularly preferably 800 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

<Lubricating Oil Additive>

[0166] The lubricating oil composition of one embodiment of the present invention may further contain a lubricating oil additive other than the components (B) to (G) when needed as long as the effects of the present invention are not impaired.

[0167] Examples of such lubricating oil additives include a pour point depressant, a viscosity index improver, a friction modifier, an anti-wear agent, an extreme pressure agent, a metal deactivator, an oil agent, an anti-rust agent, and an anti-foaming agent.

[0168] These lubricating oil additives may be each used singly, or may be each used in combination of two or more.

[0169] 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]

[0170] 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.

[0171] 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.

[0172] 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 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]

[0173] 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.

[0174] Examples of the viscosity index improvers used in one embodiment of the present invention include polymers such as non-dispersed polymethacrylate, dispersed polymethacrylate, an olefin copolymer (e.g., ethylene-propylene copolymer), a dispersed olefin copolymer, and a styrene copolymer (e.g., styrene-diene copolymer and styrene-isoprene copolymer).

[0175] 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 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.

[Friction Modifier and Anti-Wear Agent]

[0176] The lubricating oil composition of one embodiment of the present invention may further contain a friction modifier or an anti-wear agent. The friction modifier or anti-wear agent may be used singly, or may be used in combination of two or more.

[0177] Examples of the friction modifiers and anti-wear agents used in one embodiment of the present invention include sulfur compounds such as a sulfurized olefin, a dialkyl polysulfide, a diarylalkyl polysulfide, and a diaryl polysulfide; phosphorous compounds such as a phosphoric acid ester, a thiophosphoric acid ester, a phosphorous acid ester, an alkylhydrogen phosphite, an amine salt of phosphoric acid ester, and an amine salt of phosphorous acid ester; and ashless friction modifiers such as a fatty acid ester, a fatty acid amide, a fatty acid, an aliphatic alcohol, an aliphatic ether, an urea compound, and a hydrazide compound.

[Extreme Pressure Agent]

[0178] The lubricating oil composition of one embodiment of the present invention may further contain an extreme pressure agent. The extreme pressure agent may be used singly, or may be used in combination of two or more.

[0179] Examples of the extreme pressure agents used in one embodiment of the present invention include sulfur compounds such as a sulfurized olefin, a dialkyl polysulfide, a diarylalkyl polysulfide, and a diaryl polysulfide; and phosphorous compounds such as a phosphoric acid ester, a thiophosphoric acid ester, a phosphorous acid ester, an alkylhydrogen phosphite, an amine salt of phosphoric acid ester, and an amine salt of phosphorous acid ester.

[Metal Deactivator]

[0180] The lubricating oil composition of one embodiment of the present invention may further contain a metal deactivator. The metal deactivator may be used singly, or may be used in combination of two or more.

[0181] Examples of the metal deactivators used in one embodiment of the present invention include benzotriazole, a triazole derivative, a benzotriazole derivative, and a thiadiazole derivative.

[Oil Agent]

[0182] The lubricating oil composition of one embodiment of the present invention may further contain an oil agent. The oil agent may be used singly, or may be used in combination of two or more.

[0183] Examples of the oil agents used in one embodiment of the present invention include aliphatic saturated and unsaturated monocarboxylic acids such as stearic acid and oleic acid; polymerized fatty acids such as a dimer acid and a hydrogenated dimer acid; hydroxy fatty acids such as ricinoleic acid and 12-hydroxystearic acid; aliphatic saturated and unsaturated monoalcohols such as a lauryl alcohol and an oleyl alcohol; aliphatic saturated and unsaturated monoamines such as a stearylamine and an oleylamine; and aliphatic saturated and unsaturated monocarboxylic acid amides such as a lauramide and an oleamide.

[Anti-Rust Agent]

[0184] 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.

[0185] 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]

[0186] 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.

[0187] Examples of the anti-foaming agents used in one embodiment of the present invention include an alkyl silicone anti-foaming agent, a fluorosilicone anti-foaming agent, and a fluoroalkyl ether anti-foaming agent.

<Method for Producing Lubricating Oil Composition>

[0188] 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 is preferably a method having a step of adding the aforementioned components (B) and (C), and if needed, the components (D) to (G) and the other lubricating oil additives, to the base oil (A).

[Properties of Lubricating Oil Composition]

[0189] The kinematic viscosity of the lubricating oil composition of one embodiment of the present invention at 40° C. is preferably 10 to 120 mm^2/s, more preferably 15 to 100 mm^2/s, still more preferably 20 to 80 mm^2/s, still much more preferably 25 to 70 mm^2/s, and particularly preferably 27 to 60 mm^2/s.

[0190] The kinematic viscosity of the lubricating oil composition of one embodiment of the present invention at 100°

C. is preferably 2.5 to 20.0 mm^2/s, more preferably 4.0 to 18.0 mm^2/s, still more preferably 5.0 to 15.0 mm^2/s, still much more preferably 6.0 to 12.0 mm^2/s, and particularly preferably 7.0 to 10.0 mm^2/s.

[0191] 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, more preferably 120 or more, still more preferably 150 or more, still much more preferably 170 or more, and particularly preferably 200 or more.

[0192] The content of calcium atoms in the lubricating oil composition of one embodiment of the present invention is preferably 50 ppm by mass or more, more preferably 100 ppm by mass or more, more 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 more preferably 300 ppm by mass or more, still more preferably 350 ppm by mass or more, still much more preferably 400 ppm by mass or more, and particularly preferably 450 ppm by mass or more, and it is preferably 3000 ppm by mass or less, more preferably 2500 ppm by mass or less, more preferably 2000 ppm by mass or less, still more preferably 1500 ppm by mass or less, still much more preferably 1000 ppm by mass or less, and particularly preferably 800 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0193] The content of zinc atoms in the lubricating oil composition of one embodiment of the present invention is preferably 50 ppm by mass or more, more preferably 100 ppm by mass or more, still more preferably 300 ppm by mass or more, still much more preferably 500 ppm by mass or more, and particularly preferably 700 ppm by mass or more, and it is preferably 7000 ppm by mass or less, more preferably 5000 ppm by mass or less, still more preferably 3000 ppm by mass or less, still much more preferably 2000 ppm by mass or less, and particularly preferably 1500 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0194] The content of molybdenum atoms in the lubricating oil composition of one embodiment of the present invention is preferably 100 ppm by mass or more, more preferably 200 ppm by mass or more, still more preferably 300 ppm by mass or more, still much more preferably 400 ppm by mass or more, and particularly preferably 500 ppm by mass or more, and it is preferably 7000 ppm by mass or less, more preferably 5000 ppm by mass or less, still more preferably 3000 ppm by mass or less, still much more preferably 2000 ppm by mass or less, and particularly preferably 1000 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0195] The content of phosphorus atoms in the lubricating oil composition of one embodiment of the present invention is preferably 50 ppm by mass or more, more preferably 100 ppm by mass or more, still more preferably 200 ppm by mass or more, still much more preferably 300 ppm by mass or more, and particularly preferably 400 ppm by mass or more, and it is preferably 1000 ppm by mass or less, more preferably 950 ppm by mass or less, still more preferably 900 ppm by mass or less, still much more preferably 850 ppm by mass or less, and particularly preferably 750 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0196] The content of boron atoms in the lubricating oil composition of one embodiment of the present invention is preferably 10 ppm by mass or more, more preferably 50 ppm by mass or more, still more preferably 100 ppm by mass or more, still much more preferably 150 ppm by mass or more, and particularly preferably 200 ppm by mass or more, and it is preferably 1000 ppm by mass or less, more preferably 900 ppm by mass or less, still more preferably 800 ppm by mass or less, still much more preferably 700 ppm by mass or less, and particularly preferably 600 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0197] The content of nitrogen atoms in the lubricating oil composition of one embodiment of the present invention is preferably 100 ppm by mass or more, more preferably 500 ppm by mass or more, still more preferably 1000 ppm by mass or more, still much more preferably 1500 ppm by mass or more, and particularly preferably 1800 ppm by mass or more, and it is preferably 8000 ppm by mass or less, more preferably 6000 ppm by mass or less, still more preferably 5000 ppm by mass or less, still much more preferably 4000 ppm by mass or less, and particularly preferably 3000 ppm by mass or less, based on the total amount (100 mass %) of the lubricating oil composition.

[0198] The elution amount of copper for the lubricating oil composition of one embodiment of the present invention, as measured by performing the copper elution resistance test described in Examples described later, is preferably less than 250 ppm by mass, more preferably less than 220 ppm by mass, more preferably less than 200 ppm by mass, still more preferably less than 185 ppm by mass, still more preferably less than 170 ppm by mass, still much more preferably less than 120 ppm by mass, and particularly preferably less than 100 ppm by mass.

[0199] The merit rating for the lubricating oil composition of one embodiment of the present invention, obtained by performing a hot tube test as described in Examples described later and evaluating the degree of color change, is preferably 7.0 or more, more preferably 7.5 or more, still more preferably 8.0 or more, still much more preferably 8.5 or more, and particularly preferably 9.0 or more.

[Use Application of Lubricating Oil Composition]

[0200] The lubricating oil composition of one embodiment of the present invention has an excellent copper elution resistance, and can retain good long-drain properties over a long period of time.

[0201] Therefore, the lubricating oil composition of one embodiment of the present invention can be applied to various apparatuses that can exhibit the above characteristics, but it can be suitably used for lubrication between parts in an internal combustion engine, and particularly for lubrication between parts in an internal combustion engine of a hybrid system having an internal combustion engine and an electromotor as power sources.

[0202] 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 [I] and [II].

[0203] [I] An internal combustion engine, which is installed in a hybrid system, and is filled with the aforementioned lubricating oil composition of one embodiment of the present invention.

[0204] [II] A method for lubricating an internal combustion engine, wherein the aforementioned lubricating oil composition of one embodiment of the present

invention is applied to an internal combustion engine installed in a hybrid system.

[0205] The hybrid system described in the above [I] and [II] is a mechanism having an internal combustion engine and an electromotor as power sources.

[0206] Examples of the hybrid system described in the above [I] and [II] include hybrid vehicles, hybrid motorcycles, hybrid trains, and hybrid ships.

[0207] The internal combustion engine of the above [I] is filled with the aforementioned lubricating oil composition of one embodiment of the present invention, and is an apparatus installed in a hybrid system together with an electric motor, which is an electromotor.

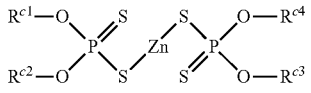
[0208] In addition, the method for lubricating an internal combustion engine of the above [II] specifies the application of the aforementioned lubricating oil composition of one embodiment of the present invention to an internal combustion engine installed in a hybrid system, but the lubricating oil composition may also be applied to an electric motor, which is an electromotor.

[0209] As described above, the present invention discloses the following embodiments.

[0210] [1] A lubricating oil composition comprising a base oil (A), a hindered amine compound (B), and an organic zinc dithiophosphate (C) having at least one primary alkyl group.

[0211] [2] The lubricating oil composition according to the above [1], wherein the component (C) comprises a compound (C1) represented by the following general formula (c-1):

(c-1)



wherein R^{c1} to R^{c4} are each independently a primary alkyl group.

[0212] [3] The lubricating oil composition according to the above [2], wherein the number of carbon atoms of the primary alkyl group is 1 to 7.

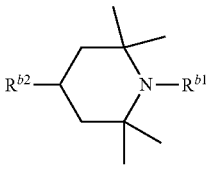
[0213] [4] The lubricating oil composition according to any one of the above [1] to [3], wherein a content of the component (C) is 0.01 to 7.0 mass % based on the total amount of the lubricating oil composition.

[0214] [5] The lubricating oil composition according to any one of the above [1] to [4], wherein a content of the component (B) is 0.60 to 10.0 mass % based on the total amount of the lubricating oil composition.

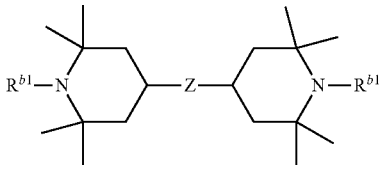
[0215] [6] The lubricating oil composition according to any one of the above [1] to [5], wherein a content ratio by mass of the compound (B) to the compound (C), [(B)/(C)], is 0.5 to 10.0.

[0216] [7] The lubricating oil composition according to any one of the above [1] to [6], wherein the component (B) comprises one or more selected from a compound (B1) represented by the following general formula (b-1) and a compound (B2) represented by the following general formula (b-2):

(b-1)



(b-2)



[0217] wherein R^{b1} is each independently a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, or an alkoxy group having 1 to 10 carbon atoms;

[0218] R^{b2} is a hydrogen atom, an alkyl group having 1 to 20 carbon atoms, a cycloalkyl group having 3 to 18 ring-forming carbon atoms, an aryl group having 6 to 18 ring-forming carbon atoms, a hydroxyl group, an amino group, or a group represented by —O—CO—R^{b3}, wherein R^{b3} is a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms; and

[0219] Z is an alkylene group having 1 to 20 carbon atoms, a cycloalkylene group having 3 to 18 ring-forming carbon atoms, an arylene group having 6 to 18 ring-forming carbon atoms, an oxygen atom, a sulfur atom, or a group represented by —O—CO—$(CH_2)_n$—CO—O—, wherein n is an integer of 1 to 20.

[0220] [8] The lubricating oil composition according to any one of the above [1] to [7], further comprising molybdenum dithiocarbamate (D).

[0221] [9] The lubricating oil composition according to any one of the above [1] to [8], further comprising an antioxidant (E) that does not correspond to the component (B),

[0222] wherein the component (E) comprises one or more selected from an amine antioxidant (E1) that does not correspond to the component (B) and a phenolic antioxidant (E2).

[0223] [10] The lubricating oil composition according to any one of the above [1] to [9], further comprising an imide compound (F),

[0224] wherein the component (F) comprises one or more selected from a non-boron modified alkenyl succinimide (F1) and a boron-modified alkenyl succinimide (F2).

[0225] [11] The lubricating oil composition according to the above [10],

[0226] wherein the component (F) comprises the component (F1) and the component (F2), and

[0227] a content ratio by mass of the component (F1) to the component (F2), [(F1)/(F2)], is less than 5.00.

[0228] [12] The lubricating oil composition according to any one of the above [1] to [11], being used for lubrication of an internal combustion engine of a hybrid system.

[0229] [13] An internal combustion engine, which is installed in a hybrid system, and is filled with the lubricating oil composition according to any one of the above [1] to [12].

[0230] [14] A method for lubricating an internal combustion engine, wherein the lubricating oil composition according to any one of the above [1] to [12] is applied to an internal combustion engine installed in a hybrid system.

EXAMPLES

[0231] 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.

[0232] (1) Contents of calcium atoms (Ca), zinc atoms (Zn), molybdenum atoms (Mo), phosphorus atoms (P) and boron atoms (B)

[0233] The contents were measured in accordance with JPI-5S-38-92.

[0234] (2) Content of nitrogen atoms (N)

[0235] The content was measured in accordance with JIS K2609:1998.

[0236] (3) Weight-average molecular weight (Mw)

[0237] Measurements were made using a gel permeation chromatograph (HPLC Model 1260 manufactured by Agilent) under the following conditions and the values measured in terms of standard polystyrene were used.

(Measurement Conditions)

[0238] Column: Two serially connected "Shodex LF404." Column temperature: 35° C.

[0239] Developing solvent: Chloroform

[0240] Flow rate: 0.3 mL/min

Examples 1 to 7 and Comparative Examples 1 to 2

[0241] A base oil and various additives were added and mixed in amounts shown in Table 1, thereby preparing each lubricating oil composition.

[0242] Details of each component used in the preparation of the lubricating oil composition are as follows.

<Component (A): Base Oil>

[0243] "100N mineral oil": Paraffinic mineral oil classified in Group III of the API base oil categories, kinematic viscosity at 40° C.=20 mm^2/s, viscosity index=122, corresponds to the component (A).

<Component (B): Hindered Amine Compound>

[0244] "Hindered amine compound": 2, 2, 6, 6-Tetramethylpiperidin-4-yl dodecanoate, compound in which R^{b1}=hydrogen atom and R^{b3}=—$C_{11}H_{23}$ in the aforementioned general formula (b-11), nitrogen atom content=4.13 mass %, corresponds to the component (B11).

<Component (C): ZnDTP>

[0245] "Primary zinc dialkyl dithiophosphate": Compound in which R^{c1} to R^{c4} in the aforementioned general formula (c-1) are all primary alkyl groups having 6 carbon atoms, phosphorus atom content=7.5 mass %, zinc atom content=8.5 mass %, corresponds to the component (C).

<ZnDTP that does not Correspond to the Component (C)>

[0246] "Secondary zinc dialkyl dithiophosphate": Compound in which R^{c1} to R^{c4} in the aforementioned general formula (c-1) are all secondary alkyl groups. Phosphorus atom content=7.1 mass %, zinc atom content=8.2 mass %.

<Component (D): Molybdenum Dithiocarbamate>

[0247] "Molybdenum dithiocarbamate (1)": Mixture of compounds in which R^{d1} to R^{d4} in the aforementioned general formula (d-2) are all alkyl groups having 8 or 13 carbon atoms (alkyl groups (α) of 8 carbon atoms/alkyl groups (β) of 13 carbon atoms=1/1 (molar ratio), corresponds to the component (D2).

[0248] "Molybdenum dithiocarbamate (2)": Compound in which R^{d1} to R^{d4} in the aforementioned general formula (d-2) are all alkyl groups having 14 carbon atoms, corresponds to the component (D2).

<Component (E): Antioxidant that does not Correspond to the Component (B)>

[0249] "Amine antioxidant that does not correspond to the component (B)": Dinonyldiphenylamine, nitrogen atom content=3.6 mass %, corresponds to the component (E1). "Phenolic antioxidant": Benzene propanoic acid-3, 5-bis (1,1-dimethylethyl)-4-hydroxyalkyl ester, corresponds to the component (E2).

<Component (F): Imide Compound>

[0250] "Non-boron modified alkenyl succinimide": Polybutenyl bis-succinimide, content of nitrogen atoms (N): 1.0 mass %, corresponds to the component (F1).

[0251] "Boron-modified alkenyl succinimide": Boron-modified product of polybutenyl monosuccinimide, content of boron atoms (B): 1.3 mass %, content of nitrogen atoms (N): 1.2 mass %, B/N=1.08, corresponds to the component (F2).

<Metal-Based Detergent>

[0252] "Neutral Ca salicylate": Calcium salicylate with base number=64 mg KOH/g, Ca content=2.3 mass %.

<Other Additives>

[0253] "Additive mixture": Additive mixture consisting of a viscosity index improver (Mw=400, 000), pour point depressant (Mw=70, 000), glyceryl monooleate, and a silicone anti-foaming agent.

[0254] Regarding the lubricating oil compositions prepared, the content of each atom was measured, and the following evaluation tests were carried out. The results of them are set forth in Table 1.

(1) Copper Elution Resistance Test

[0255] To a glass test tube (40 mm diameter x 300 mm long) was added 100 mL of the prepared lubricating oil composition as a test oil, and then a polished copper plate (25 mm×25 mm×1 mm) was also added and immersed in the test oil. The copper plate immersed in the test oil was allowed to stand for 62 hours at an oil temperature of 140° C. while injecting 2000 ppm by volume of NOx gas based on the total amount of supplied gas at a flow rate of 12 L/h, and then the amount (unit: mass ppm) of copper eluted in the test oil was measured in accordance with JPI-5S-38-2003. It can be said that the smaller the elution amount of copper is, the better the copper elution resistance of the lubricating oil

composition becomes. In the present Example, the lubricating oil composition was considered to have good copper elution resistance when the elution amount of copper was less than 250 ppm by mass.

(2) Hot Tube Test

[0256] The prepared lubricating oil compositions were used to perform an ISOT test for 168 hours with the addition of pure water while injecting NOx gas under the following test conditions, and thereby prepared degraded oils.

<Test Conditions>

[0257] Testing machine: ISOT TESTER manufactured by Yoshida Kagaku Kikai Co., Ltd.

[0258] Internal volume of test container: 500 mL

[0259] Amount of lubricating oil composition used: 300 mL

[0260] Amount of NOx gas: 2, 000 ppm by volume based on the total amount of supplied gas

[0261] Amount of pure water added: 5 vol % based on the total amount of the lubricating oil composition, added every 24 hours

[0262] Agitation speed: 800 r/min

[0263] Test temperature (cycle): (1) 4 hours at 60° C., (2) 2 hours at 95° C., (3) 12 hours at 120° C., and (4) 6 hours at 60° C. was counted as one cycle and repeated.

[0264] The degraded oils prepared as described above were used to perform a hot tube test in accordance with JPI-5S-55-99 at a test temperature of 240° C. The degree of color change of the glass tube after the test was evaluated on a 21-point scale from 0 (black) to 10 (colorless) (merit rating) in 0.5 increments. It can be said that the higher the score is, the better the high temperature detergency of the lubricating oil composition becomes. In the present Example, the lubricating oil composition was considered to have good high temperature detergency when the score was 7.0 or more.

TABLE 1

				Example 1	Example 2	Example 3	Example 4	Example 5
Composition of lubricating oil composition	Component (A)	100N base oil	mass %	85.15	83.15	83.40	85.22	84.15
	Component (B)	Hindered amine compound	mass %	2.80	2.80	2.80	2.80	2.80
	Component (C)	Primary zinc dialkyl dithiophosphate	mass %	1.10	1.10	0.85	1.03	1.10
	ZnDTP that does not correspond to component (C)	Secondary zinc dialkyl dithiophosphate	mass %	—	—	—	—	—
	Component (D)	Molybdenum dithiocarbamate (1)	mass %	0.70	0.70	0.70	0.70	0.70
		Molybdenum dithiocarbamate (2)	mass %	—	—	—	—	—
	Component (E)	Amine antioxidant that does not correspond to component (B)	mass %	1.00	1.00	1.00	1.00	1.00
		Phenolic antioxidant	mass %	0.50	0.50	0.50	0.50	0.50
	Component (F)	Non-boron modified alkenyl succinimide	mass %	3.00	4.00	4.00	3.00	4.00
		Boron-modified alkenyl succinimide	mass %	2.00	3.00	3.00	2.00	2.00
	Component (G)	Neutral Ca salicylate	mass %	2.16	2.16	2.16	2.16	2.16
	Other additives	Additive mixture	mass %	1.59	1.59	1.59	1.59	1.59
	Total		mass %	100.00	100.00	100.00	100.00	100.00
	Component (B)/Component (C)		—	2.55	2.55	3.29	2.72	2.55
	Content of N derived from component (B)		mass %	0.12	0.12	0.12	0.12	0.12
Properties of lubricating oil composition	Content of each atom in lubricating oil composition	Ca	ppm by mass	502	516	515	507	521
		Zn	ppm by mass	936	986	761	907	982
		Mo	ppm by mass	671	679	680	665	687
		P	ppm by mass	781	805	624	748	809
		B	ppm by mass	285	410	410	282	274
		N	ppm by mass	2100	2100	2100	2100	2200
Evaluation points	Copper elution resistance test Elution amount of copper		ppm by mass	104	57	109	113	178
	Hot tube test (240° C.) Score		—	7.0	8.0	9.0	7.0	7.0

				Example 6	Example 7	Comparative Example 1	Comparative Example 2
Composition of lubricating oil composition	Component (A)	100N base oil	mass %	83.15	85.22	85.15	85.15
	Component (B)	Hindered amine compound	mass %	2.80	2.80	2.80	2.80
	Component (C)	Primary zinc dialkyl dithiophosphate	mass %	1.10	1.03	—	—
	ZnDTP that does not correspond to component (C)	Secondary zinc dialkyl dithiophosphate	mass %	—	—	1.10	1.10
	Component (D)	Molybdenum dithiocarbamate (1)	mass %	0.70		0.70	—
		Molybdenum dithiocarbamate (2)	mass %	—	0.70	—	0.70
	Component (E)	Amine antioxidant that does not correspond to component (B)	mass %	1.00	1.00	1.00	1.00
		Phenolic antioxidant	mass %	0.50	0.50	0.50	0.50
	Component (F)	Non-boron modified alkenyl succinimide	mass %	5.00	3.00	3.00	3.00
		Boron-modified alkenyl succinimide	mass %	2.00	2.00	2.00	2.00

TABLE 1-continued

	Component (G)	Neutral Ca salicylate	mass %	2.16	2.16	2.16	2.16
	Other additives	Additive mixture	mass %	1.59	1.59	1.59	1.59
	Total		mass %	100.00	100.00	100.00	100.00
	Component (B)/Component (C)		—	2.55	2.72	—	—
	Content of N derived from component (B)		mass %	0.12	0.12	0.12	0.12
Properties of lubricating oil composition	Content of each atom in lubricating oil composition	Ca	ppm by mass	520	516	516	516
		Zn	ppm by mass	980	922	905	905
		Mo	ppm by mass	689	699	684	698
		P	ppm by mass	808	741	783	785
		B	ppm by mass	274	279	280	279
		N	ppm by mass	2300	2100	2400	2400
Evaluation points	Copper elution resistance test Elution amount of copper		ppm by mass	181	154	290	558
	Hot tube test (240° C.) Score		—	8.0	8.0	8.0	7.0

[0265] Table 1 indicates that the lubricating oil compositions prepared in Examples 1 to 7 have excellent copper elution resistance, and can retain good long-drain properties over a long period of time because they contain the components (A) to (C). The results for the lubricating oil compositions prepared in Examples 1 to 7 were also superior in high temperature detergency. On the other hand, the lubricating oil compositions prepared in Comparative Examples 1 and 2 contained secondary zinc dialkyl dithiophosphate instead of primary zinc dialkyl dithiophosphate, but the elution amount of copper was more than 250 ppm by mass, resulting in problems with copper elution resistance.

1: A lubricating oil composition, comprising:

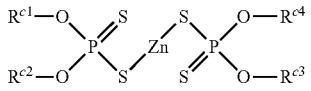
a base oil;

a hindered amine compound; and

an organic zinc dithiophosphate having at least one primary alkyl group.

2: The lubricating oil composition according to claim **1**, wherein the organic zinc dithiophosphate comprises a compound of formula (c-1)

(c-1)



where R^{c1} to R^{c4} are each independently a primary alkyl group.

3: The lubricating oil composition according to claim **2**, wherein a number of carbon atoms of the primary alkyl group is 1 to 7.

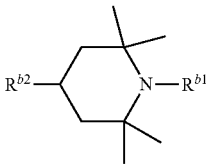
4: The lubricating oil composition according to claim **1**, wherein a content of the organic zinc dithiophosphate is in a range of 0.01 to 7.0 mass % based on a total amount of the lubricating oil composition.

5: The lubricating oil composition according to claim **1**, wherein a content of the hindered amine compound is in a range of 0.60 to 10.0 mass % based on a total amount of the lubricating oil composition.

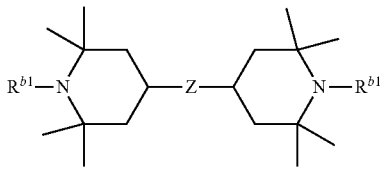
6: The lubricating oil composition according to claim **1**, wherein a content ratio by mass of the hindered amine compound to the organic zinc dithiophosphate is in a range of 0.5 to 10.0.

7: The lubricating oil composition according to claim **1**, wherein the hindered amine compound comprises at least one selected from a compound of formula (b-1) and a compound of formula (b-2)

(b-1)



(b-2)



where R^{b1} is each independently a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, or an alkoxy group having 1 to 10 carbon atoms, R^{b2} is a hydrogen atom, an alkyl group having 1 to 20 carbon atoms, a cycloalkyl group having 3 to 18 ring-forming carbon atoms, an aryl group having 6 to 18 ring-forming carbon atoms, a hydroxyl group, an amino group, or a group of —O—CO—R^{b3}, R^{b3} is a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms, and Z is an alkylene group having 1 to 20 carbon atoms, a cycloalkylene group having 3 to 18 ring-forming carbon atoms, an arylene group having 6 to 18 ring-forming carbon atoms, an oxygen atom, a sulfur atom, or a group of —O—CO—$(CH_2)_n$—CO—O— where n is an integer of 1 to 20.

8: The lubricating oil composition according to claim **1**, further comprising:

molybdenum dithiocarbamate.

9: The lubricating oil composition according to claim **1**, further comprising:

an antioxidant that does not correspond to the hindered amine compound,

wherein the antioxidant component (E) comprises at least one selected from an amine antioxidant that does not correspond to the hindered amine compound and a phenolic antioxidant.

10: The lubricating oil composition according to claim **1**, further comprising:

an imide compound comprising at least one selected from a non-boron modified alkenyl succinimide and a boron-modified alkenyl succinimide.

11: The lubricating oil composition according to claim **10**, wherein the imide compound comprises the non-boron modified alkenyl succinimide and the boron-modified alkenyl succinimide, and a content ratio by mass of the non-boron modified alkenyl succinimide to the boron-modified alkenyl succinimide is less than 5.00.

12: A lubricating oil composition for an internal combustion engine of a hybrid system, comprising:

the lubricating oil composition of claim **1**.

13: An internal combustion engine, wherein the internal combustion engine is installed in a hybrid system and is filled with the lubricating oil composition of claim **1**.

14: A method for lubricating an internal combustion engine, comprising:

applying the lubricating oil composition of claim **1** to an internal combustion engine installed in a hybrid system.

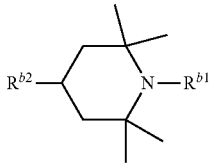
15: The lubricating oil composition according to claim **2**, wherein a content of the organic zinc dithiophosphate is in a range of 0.01 to 7.0 mass % based on a total amount of the lubricating oil composition.

16: The lubricating oil composition according to claim **2**, wherein a content of the hindered amine compound is in a range of 0.60 to 10.0 mass % based on a total amount of the lubricating oil composition.

17: The lubricating oil composition according to claim **2**, wherein a content ratio by mass of the hindered amine compound to the organic zinc dithiophosphate is in a range of 0.5 to 10.0.

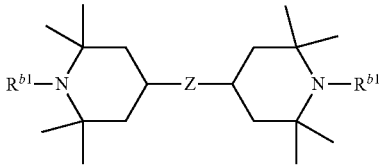
18: The lubricating oil composition according to claim **2**, wherein the hindered amine compound comprises at least one selected from a compound of formula (b-1) and a compound of formula (b-2)

(b-1)



-continued

(b-2)



where R^{b1} is each independently a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, or an alkoxy group having 1 to 10 carbon atoms, R^{b2} is a hydrogen atom, an alkyl group having 1 to 20 carbon atoms, a cycloalkyl group having 3 to 18 ring-forming carbon atoms, an aryl group having 6 to 18 ring-forming carbon atoms, a hydroxyl group, an amino group, or a group of —O—CO—R^{b3}, R^{b3} is a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms, and Z is an alkylene group having 1 to 20 carbon atoms, a cycloalkylene group having 3 to 18 ring-forming carbon atoms, an arylene group having 6 to 18 ring-forming carbon atoms, an oxygen atom, a sulfur atom, or a group of —O—CO—$(CH_2)_n$—CO—O— where n is an integer of 1 to 20.

19: The lubricating oil composition according to claim **2**, further comprising:

molybdenum dithiocarbamate.

20: The lubricating oil composition according to claim **2**, further comprising:

an antioxidant that does not correspond to the hindered amine compound,

wherein the antioxidant comprises at least one selected from an amine antioxidant that does not correspond to the hindered amine compound and a phenolic antioxidant.

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