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(54) **LUBRICATING OIL COMPOSITION**

(57) A lubricating oil composition according to one embodiment of the present invention contains an oxygen-containing synthetic base oil having an oxygen content (A) of from 15 to 40 mass% and a kinetic viscosity at 100°C of from 0.5 to 50 mm²/s, and a viscosity index improver that is an oxygen-containing compound having an oxygen content (B) of from 15 to 40 mass% and a kinetic viscosity at 100°C of 11,000 mm²/s or more, a mass ratio of the oxygen-containing synthetic base oil and the viscosity index improver being from 99.5:0.5 to 75:25, and a ratio (A/B) of the oxygen content (A) of the oxygen-containing synthetic base oil to the oxygen content (B) of the viscosity index improver being in a range of from 0.5 to 2.

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Description

Technical Field

5 **[0001]** The present invention relates to a lubricating oil composition which can be applied to a refrigerator oil and various purposes.

Background Art

10 **[0002]** In recent years, as a base oil of a lubricating oil, an oxygen-containing synthetic base oil, such as a polyalkylene glycol, a polyvinyl ether, and a polyol ester, is being used in various fields including a refrigerator oil, a hydraulic oil, and the like.

[0003] The base oil used for a refrigerator oil, a hydraulic oil, and the like has been variously improved, and for example, it has been known in PTL 1 that for improving the lubrication capability and the like, a high-viscosity base oil having a kinetic viscosity at 100°C of from 300 to 10,000 mm²/s selected from polyvinyl ether, a polycarbonate derivative, polyether ketone, and polyalkylene glycol is blended with a low-viscosity base oil having a kinetic viscosity at 100°C of from 1 to 100 mm²/s. It has also been known in PTL 2 that for improving the low-temperature fluidity, the wear resistance, and the like, a high-viscosity polyalkylene glycol having a viscosity at 40°C of from 170 to 30,000 cSt is blended with a base oil having a viscosity at 40°C of from 170 to 1,000 cSt.

20 **[0004]** As for a lubricating oil used in fields including an engine oil and the like, it has been widely known that a viscosity index improver is used for the purpose of improving the viscosity index. As the viscosity index improver, polymer materials, such as a polymethacrylate (PMA) and an olefin copolymer (OCP), have been widely known as one that improves the viscosity index of a mineral oil.

25 Citation List

Patent Literatures

[0005]

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PTL 1: Japanese Patent No. 3,983,328

PTL 2: Japanese Patent No. 2,952,044

Summary of Invention

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Technical Problem

[0006] In the case where an oxygen-containing synthetic base oil is used, there is a demand for improving the viscosity index, as similar to the mineral oil. The viscosity index is generally improved by blending the high-viscosity base oil components described in PTLs 1 and 2, with an oxygen-containing synthetic base oil, but these high-viscosity base oil components may not sufficiently exhibit the effect of improving the viscosity index in some cases.

[0007] Furthermore, in the case where PMA or OCP which is conventionally used as the viscosity index improver is blended with an oxygen-containing synthetic base oil having a large oxygen content, PMA or OCP may be separated from the base oil and may not sufficiently exhibit the performance as the viscosity index improver in some cases. In particular, PMA and OCP having a large molecular weight have a large effect of improving the viscosity index, but have insufficient compatibility with an oxygen-containing synthetic base oil, resulting in a tendency of separation from the base oil. Moreover, a viscosity index improver having a large molecular weight may raise the pour point of the lubricating oil, resulting in decrease of the low-temperature fluidity in some cases.

50 **[0008]** The present invention has been made in view of the aforementioned problems, and an object thereof is to provide a lubricating oil composition, in which even though a viscosity index improver having a large effect of improving a viscosity index is applied to an oxygen-containing synthetic base oil, the viscosity index improver is hardly separated from the base oil while retaining a good low-temperature fluidity.

Solution to Problem

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[0009] As a result of earnest investigations made by the present inventors, it has been found that the problem can be solved by blending a viscosity index improver having an oxygen content and a kinetic viscosity that are in prescribed ranges with an oxygen-containing synthetic base oil having a certain oxygen content, and thus the present invention

shown below has been completed. Accordingly, one embodiment of the present invention provides the following.

(1) A lubricating oil composition containing an oxygen-containing synthetic base oil having an oxygen content (A) of from 15 to 40 mass% and a kinetic viscosity at 100°C of from 0.5 to 50 mm²/s, and a viscosity index improver that is an oxygen-containing compound having an oxygen content (B) of from 15 to 40 mass% and a kinetic viscosity at 100°C of 11,000 mm²/s or more, a mass ratio of the oxygen-containing synthetic base oil and the viscosity index improver being from 99.5:0.5 to 75:25, and a ratio (A/B) of the oxygen content (A) of the oxygen-containing synthetic base oil to the oxygen content (B) of the viscosity index improver being in a range of from 0.5 to 2.

(2) A method for producing a lubricating oil composition, including: blending a viscosity index improver that is an oxygen-containing compound having an oxygen content (B) of from 15 to 40 mass% and a kinetic viscosity at 100°C of 11,000 mm²/s or more, with an oxygen-containing synthetic base oil having an oxygen content (A) of from 15 to 40 mass% and a kinetic viscosity at 100°C of from 0.5 to 50 mm²/s, a mass ratio of the oxygen-containing synthetic base oil and the viscosity index improver being from 99.5:0.5 to 75:25, and a ratio (A/B) of the oxygen content (A) of the oxygen-containing synthetic base oil to the oxygen content (B) of the viscosity index improver being in a range of from 0.5 to 2.

Advantageous Effects of Invention

[0010] According to the present invention, a lubricating oil composition can be provided, in which even though a viscosity index improver having a large effect of improving a viscosity index is applied to an oxygen-containing synthetic base oil, the viscosity index improver is hardly separated from the base oil while retaining a good low-temperature fluidity.

Description of Embodiments

[0011] The present invention will be described with reference to embodiments below.

[0012] A lubricating oil composition according to one embodiment of the present invention contains an oxygen-containing synthetic base oil, and a viscosity index improver that is an oxygen-containing compound. The components contained in the lubricating oil composition will be described in more detail below.

[Oxygen-containing Synthetic Base Oil]

[0013] The oxygen-containing synthetic base oil has an oxygen content (A) of from 15 to 40 mass% and a kinetic viscosity at 100°C of from 0.5 to 50 mm²/s.

[0014] When the oxygen-containing synthetic base oil has a kinetic viscosity at 100°C within the range, a good lubrication performance is exhibited. When the oxygen content (A) is 40 mass% or less, the base oil is prevented from being solidified, and when it is 15 mass% or more, the ratio (A/B) described later can be easily within the prescribed range, thereby facilitating the improvement of the solubility of the viscosity index improver. Furthermore, when the oxygen content (A) is within the range, the compatibility with a refrigerant can be easily ensured in the case where the lubricating oil composition is used as a refrigerator oil, for example.

[0015] In these points of view, the oxygen content (A) is preferably from 16 to 38 mass%, and more preferably from 19 to 32 mass%.

[0016] The kinetic viscosity at 100°C of the oxygen-containing synthetic base oil is preferably from 1.0 to 30 mm²/s, and more preferably from 1.0 to 15 mm²/s. When the kinetic viscosity at 100°C of the base oil is thus lowered, the pour point can be decreased to improve the low-temperature fluidity and the energy saving property, and thus the lubricating oil composition can be favorably applied to various purposes.

[0017] For example, the oxygen-containing synthetic base oil used is selected from a polyvinyl ether compound (PVE), a polyoxyalkylene glycol compound (PAG), a copolymer having a structure of a poly(oxy)alkylene glycol or a monoether thereof and a polyvinyl ether (ECP), and a polyol ester compound (POE). The use of these base oils as the oxygen-containing synthetic base oil may facilitate the improvement of the lubrication capability of the lubricating oil composition. In the present embodiment, among these, PVE, PAG, and POE are preferred, and PVE and PAG are more preferred. The oxygen-containing synthetic base oil may be used solely or as a combination of two or more kinds thereof. These compounds, which can be used as the oxygen-containing synthetic base oil, will be described in detail later.

[0018] The number average molecular weight (Mn) of the oxygen-containing synthetic base oil is not particularly limited, as far as the kinetic viscosity thereof is in the range, may be 100 or more, and is more preferably 150 or more. The upper limit of the number average molecular weight is also not particularly limited, but it is generally approximately 6,000 or less.

[0019] The oxygen-containing synthetic base oil preferably has a volume resistivity of 10⁶ Ω · m or more, more preferably 10⁷ Ω · m or more, and further preferably 10⁸ Ω · m or more. When the volume resistivity of the base oil is increased as above, good electric insulation property thereof may be obtained to facilitate the application of the lubricating oil com-

position to the purposes including an electric car air-conditioner and the like. The upper limit of the volume resistivity of the base oil is not particularly limited, but it is generally $10^{15} \text{ } \Omega \cdot \text{m}$ or less. The volume resistivity is measured at room temperature of 25°C according to JIS C2101-24 (volume resistivity test).

[0020] The saturated water content of the oxygen-containing synthetic base oil is preferably 5 mass% or less, more preferably 3 mass% or less, and further preferably 1 mass% or less. When the saturated water content is decreased in this way, the hygroscopicity of the lubricating oil composition may be decreased, and the electric insulation property and the thermal stability thereof can be retained good for a prolonged period of time.

[0021] The saturated water content is measured in such a manner that a specimen oil and water are mixed at a mass ratio of 1/1 and shaken for 5 minutes, the mixture is separated to a specimen oil layer and an aqueous layer by centrifugal separation, and the specimen oil layer is measured for the water content by the Karl Fischer titration method according to JIS K0113-2005.

[0022] The content of the oxygen-containing synthetic base oil in the lubricating oil composition is preferably 70 mass% or more, more preferably from 80 to 99.5 mass%, and further preferably from 85 to 99.5 mass%, based on the total amount of the lubricating oil composition.

[0023] The base oil contained in the lubricating oil composition may consist of the oxygen-containing synthetic base oil, but a mineral oil or a synthetic base oil other than the oxygen-containing synthetic base oil may be contained in such a range that does not impair the effects of the present invention. The content of mineral oil and the synthetic base oil other than the oxygen-containing synthetic base oil is generally 10 mass% or less, preferably 5 mass% or less, and more preferably 3 mass% or less, based on the total amount of the lubricating oil composition. Examples of the mineral oil include a paraffin mineral oil, a naphthene mineral oil, and an intermediate base mineral oil, and examples of the synthetic base oil include a poly- α -olefin, an α -olefin copolymer, a polybutene, an alkylbenzene, and a GTL by-product wax isomerized oil.

[Viscosity Index Improver]

[0024] In the present embodiment, the oxygen-containing compound used as the viscosity index improver has an oxygen content (B) of from 15 to 40 mass% and a kinetic viscosity at 100°C of 11,000 mm^2/s or more. When the oxygen content (B) of the viscosity index improver is in such a range, a ratio (A/B) described later can be easily adjusted in the prescribed range, and thus the viscosity index improver can be easily dissolved in the base oil. When the oxygen content is 40 mass% or less, the viscosity index improver can be prevented from precipitating in the lubricating oil composition. When the kinetic viscosity is 11,000 mm^2/s or more, the viscosity index of the lubricating oil composition can be sufficiently improved.

[0025] In these points of view, the oxygen content (B) is preferably from 16 to 38 mass%, and more preferably from 19 to 32 mass%.

[0026] The kinetic viscosity at 100°C of the viscosity index improver is preferably from 11,000 to 120,000 mm^2/s , and more preferably from 11,000 to 100,000 mm^2/s .

[0027] The number average molecular weight (Mn) of the oxygen-containing compound used as the viscosity index improver is appropriately determined to provide the aforementioned kinetic viscosity range, and is generally appropriately selected from 70,000 to 1,000,000, and preferably appropriately selected from 100,000 to 1,000,000. The degree of dispersion (Mw/Mn) of the oxygen-containing compound used as the viscosity index improver is not particularly limited, and is generally approximately from 1.0 to 6.

[0028] For example, the oxygen-containing compound used as the viscosity index improver is selected from a polyvinyl ether compound (PVE), a polyoxyalkylene glycol compound (PAG), and a copolymer having a structure of a poly(oxy)alkylene glycol or a monoether thereof and a polyvinyl ether (ECP). The use of these compounds may facilitate the improvement of the solubility in the oxygen-containing synthetic base oil. Among these, PAG and PVE are preferred, and PAG is most preferred from the standpoint that the viscosity index can be further easily improved. The oxygen-containing compound may be used solely or as a combination of two or more kinds thereof. The oxygen-containing compound that can be used as the viscosity index improver will be described in detail later.

[0029] In the lubricating oil composition, the mass ratio of the oxygen-containing synthetic base oil and the viscosity index improver (oxygen-containing synthetic base oil : viscosity index improver) is 99.5:0.5 to 75:25. In the present embodiment, when the mass ratio is 99.5:0.5 or over, i.e., the viscosity index improver is contained in an amount of 0.5 part by mass or more per 99.5 parts by mass of the oxygen-containing synthetic base oil, the viscosity index of the lubricating oil composition can be sufficiently improved. When the mass ratio is 75:25 or below, the pour point of the lubricating oil composition can be decreased to improve the low-temperature fluidity. In these points of view, the mass ratio is preferably from 99.5:0.5 to 80:20, and more preferably from 99.5:0.5 to 88:12.

[0030] The ratio (A/B) of the oxygen content (A) of the oxygen-containing synthetic base oil to the oxygen content (B) of the viscosity index improver is in a range of from 0.5 to 2. When the ratio (A/B) is 0.5 or more and 2 or less, the viscosity index improver can be prevented from being separated from the base oil, and the viscosity index improver

having a large molecular weight can sufficiently exhibit the capability thereof.

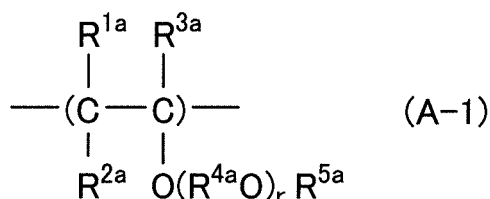
[0031] In these points of view, the ratio (A/B) is preferably from 0.55 to 1.7, and more preferably from 0.65 to 1.4.

[0032] The oxygen content (A) and the oxygen content (B) are values that are calculated from the molecular formulae of each compound.

[0033] The compounds used in the oxygen-containing synthetic base oil will be described in more detail below.

<Polyvinyl Ether Compound (PVE)>

[0034] The polyvinyl ether compound (PVE) used in the oxygen-containing synthetic base oil is a polymer having a vinyl ether-derived constituent unit, and specifically, examples thereof include a polyvinyl-based compound having a constituent unit represented by the following general formula (A-1).



[0035] In the general formula (A-1), R^{1a}, R^{2a}, and R^{3a} each independently represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, and they may be the same as or different from each other. Here, specifically, examples of the hydrocarbon group include an alkyl group, such as a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group of every kind, a hexyl group of every kind, a heptyl group of every kind, an octyl group of every kind, etc.; a cycloalkyl group, such as a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group of every kind, an ethylcyclohexyl group of every kind, a dimethylcyclohexyl group of every kind, etc.; an aryl group, such as a phenyl group, a methylphenyl group of every kind, an ethylphenyl group of every kind, a dimethylphenyl group of every kind, etc.; and an arylalkyl group, such as a benzyl group, a phenylethyl group, a methylbenzyl group of every kind, etc. Of those, an alkyl group is preferred. In addition, R^{1a}, R^{2a}, and R^{3a} are each more preferably a hydrogen atom or an alkyl group having 3 or less carbon atoms, and for making the oxygen content (A) within the aforementioned range, all R^{1a}, R^{2a}, and R^{3a} are further preferably hydrogen atoms. In the general formula (2), r represents a repeating number, and an average value thereof is a number ranging from 0 to 10, and preferably from 0 to 5.

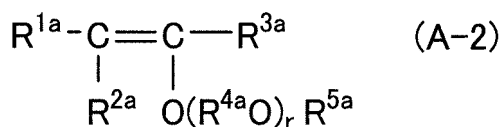
[0036] R^{4a} represents a divalent hydrocarbon group having 2 to 10 carbon atoms. Here, specifically, examples of the divalent hydrocarbon group having 2 to 10 carbon atoms include a divalent aliphatic hydrocarbon group, such as an ethylene group, a phenylethylene group, a 1,2-propylene group, a 2-phenyl-1,2-propylene group, a 1,3-propylene group, a butylene group of every kind, a pentylene group of every kind, a hexylene group of every kind, a heptylene group of every kind, an octylene group of every kind, a nonylene group of every kind, a decylene group of every kind, etc.; an alicyclic hydrocarbon group having two bonding sites in an alicyclic hydrocarbon such as cyclohexane, methylcyclohexane, ethylcyclohexane, dimethylcyclohexane, propylcyclohexane, etc.; a divalent aromatic hydrocarbon group, such as a phenylene group of every kind, a methylphenylene group of every kind, an ethylphenylene group of every kind, a dimethylphenylene group of every kind, a naphthylene group of every kind, etc.; an alkyl aromatic hydrocarbon group having a monovalent bonding site in each of an alkyl group moiety and an aromatic moiety of an alkyl aromatic hydrocarbon such as toluene, ethylbenzene, etc.; an alkyl aromatic hydrocarbon group having bonding sites in an alkyl group moiety of a polyalkyl aromatic hydrocarbon, such as xylene, diethylbenzene, etc.; and the like. Of those, the aliphatic hydrocarbon group having 2 to 4 carbon atoms is more preferred. Plural R^{4a}Os may be the same as or different from each other.

[0037] Furthermore, in the general formula (A-1), R^{5a} represents a hydrocarbon group having 1 to 10 carbon atoms. Specifically, this hydrocarbon group represents an alkyl group, such as a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group of every kind, a hexyl group of every kind, a heptyl group of every kind, an octyl group of every kind, a nonyl group of every kind, a decyl group of every kind, etc.; a cycloalkyl group, such as a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group of every kind, an ethylcyclohexyl group of every kind, a propylcyclohexyl group of every kind, a dimethylcyclohexyl group of every kind, etc.; an aryl group, such as a phenyl group, a methylphenyl group of every kind, an ethylphenyl group of every kind, a dimethylphenyl group of every kind, a propylphenyl group of every kind, a trimethylphenyl group of every kind, a butylphenyl group of every kind, a naphthyl group of every kind, etc.; or an arylalkyl group, such as a benzyl group, a phenylethyl group, a methylbenzyl group of every kind, a phenylpropyl group of every kind, a phenylbutyl group of every kind, etc. Of those, a hydrocarbon group having 1 to 8 carbon atoms is preferred, and for making the oxygen content within the aforementioned range, an alkyl group having 2 to 4 carbon atoms is more preferred.

The alkyl groups may be any of straight-chain, branched, and cyclic groups.

[0038] In the polyvinyl-based compound having a constituent unit represented by the general formula (A-1), a compound containing a constituent unit, in which all R^{1a} , R^{2a} , and R^{3a} represent hydrogen atoms, R^{5a} represents an alkyl group having 2 to 4 carbon atoms, and r represents 0, in an amount of 80 mol% or more is preferred, and in an amount of 100 mol% is more preferred. Examples of the alkyl group of R^{5a} include an ethyl group, a *n*-propyl group, an isopropyl group, a *n*-butyl group, an isobutyl group, a *sec*-butyl group, and a *tert*-butyl group. Furthermore, a polymer or a copolymer containing from 50 to 100 mass% of a constituent unit in which R^{5a} represents an ethyl group, and from 0 to 50 mass% of a constituent unit in which R^{5a} represents an alkyl group having 3 or 4 carbon atoms, is preferred.

[0039] The polyvinyl ether compound is a polymer having the constituent unit represented by the general formula (A-1), and the repeating number thereof may be properly chosen according to a desired kinematic viscosity, and is generally from 3 to 80. The aforementioned polyvinyl ether compound can be produced through polymerization of a corresponding vinyl ether-based monomer. The vinyl ether-based monomer that can be used herein is one represented by the following general formula (A-2).



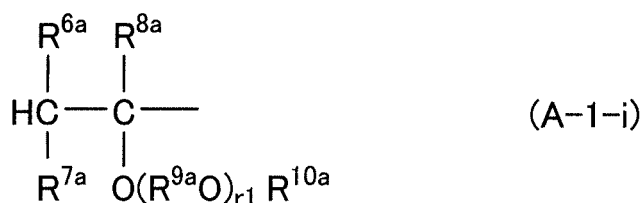
In the formula, R^{1a} , R^{2a} , R^{3a} , R^{4a} , R^{5a} , and r are the same as those mentioned above.

[0040] As this vinyl ether-based monomer, there are various monomers corresponding to the aforementioned polyvinyl ether compounds. Examples thereof include vinyl methyl ether, vinyl ethyl ether, vinyl *n*-propyl ether, vinyl isopropyl ether, vinyl *n*-butyl ether, vinyl isobutyl ether, vinyl *sec*-butyl ether, vinyl *tert*-butyl ether, vinyl *n*-pentyl ether, vinyl *n*-hexyl ether, vinyl 2-methoxyethyl ether, vinyl 2-ethoxyethyl ether, vinyl 2-methoxy-1-methylethyl ether, vinyl 2-methoxypropyl ether, vinyl 3,6-dioxaheptyl ether, vinyl 3,6,9-trioxadecyl ether, vinyl 1,4-dimethyl-3,6-dioxaheptyl ether, vinyl 1,4,7-trimethyl-3,6,9-trioxadecyl ether, vinyl 2,6-dioxa-4-heptyl ether, vinyl 2,6,9-trioxa-4-decyl ether, 1-methoxypropene, 1-ethoxypropene, 1-*n*-propoxypropene, 1-isopropoxypropene, 1-*n*-butoxypropene, 1-isobutoxypropene, 1-*sec*-butoxypropene, 1-*tert*-butoxypropene, 2-methoxypropene, 2-ethoxypropene, 2-*n*-propoxypropene, 2-isopropoxypropene, 2-*n*-butoxypropene, 2-isobutoxypropene, 2-*sec*-butoxypropene, 2-*tert*-butoxypropene, 1-methoxy-1-butene, 1-ethoxy-1-butene, 1-*n*-propoxy-1-butene, 1-isopropoxy-1-butene, 1-*n*-butoxy-1-butene, 1-isobutoxy-1-butene, 1-*sec*-butoxy-1-butene, 1-*tert*-butoxy-1-butene, 2-methoxy-1-butene, 2-ethoxy-1-butene, 2-*n*-propoxy-1-butene, 2-isopropoxy-1-butene, 2-*n*-butoxy-1-butene, 2-isobutoxy-1-butene, 2-*sec*-butoxy-1-butene, 2-*tert*-butoxy-1-butene, 2-methoxy-2-butene, 2-ethoxy-2-butene, 2-*n*-propoxy-2-butene, 2-isopropoxy-2-butene, 2-*n*-butoxy-2-butene, 2-isobutoxy-2-butene, 2-*sec*-butoxy-2-butene, 2-*tert*-butoxy-2-butene, and the like. These vinyl ether-based monomers can be produced by a known method.

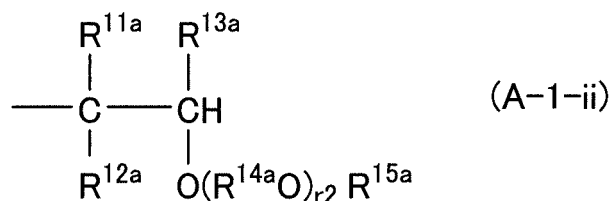
[0041] In an end moiety of the polymer represented by the general formula (A-1), a monovalent group derived from a saturated hydrocarbon, an ether, an alcohol, a ketone, an amide, a nitrile, or the like may be introduced by a known method.

[0042] Above all, as the polyvinyl ether compound, those having an end structure of each of the following (1) to (4) are suitable.

(1) A compound in which one end thereof is represented by the following general formula (A-1-i), and the remaining end is represented by the following general formula (A-1-ii).

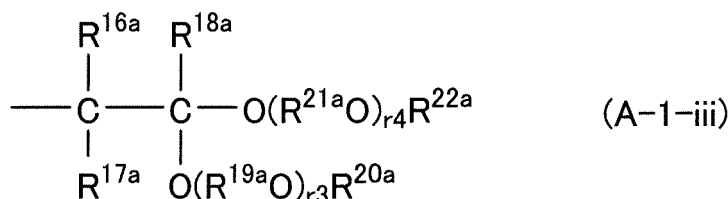


In the formula, R^{6a} , R^{7a} , and R^{8a} each independently represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, and they may be the same as or different from each other; R^{9a} represents a divalent hydrocarbon group having 2 to 10 carbon atoms; R^{10a} represents a hydrocarbon group having 1 to 10 carbon atoms; $r1$ represents a number of 0 to 10 in terms of an average value thereof; and in the case where plural R^{9a} O's are present, the plural R^{9a} O's may be the same as or different from each other.



In the formula, R^{11a} , R^{12a} , and R^{13a} each independently represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, and they may be the same as or different from each other; R^{14a} represents a divalent hydrocarbon group having 2 to 10 carbon atoms; R^{15a} represents a hydrocarbon group having 1 to 10 carbon atoms; r_2 represents a number of 0 to 10 in terms of an average value thereof; and in the case where plural R^{14a} Os are present, the plural R^{14a} Os may be the same as or different from each other.

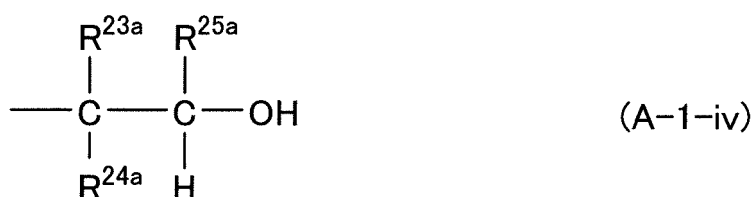
(2) A compound in which one end thereof is represented by the foregoing general formula (A-1-i), and the remaining end is represented by the following general formula (A-1-iii):



In the formula, R^{16a} , R^{17a} , and R^{18a} each independently represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, and they may be the same as or different from each other; R^{19a} and R^{21a} each independently represent a divalent hydrocarbon group having 2 to 10 carbon atoms, and they may be the same as or different from each other; R^{20a} and R^{22a} each independently represent a hydrocarbon group having 1 to 10 carbon atoms, and they may be the same as or different from each other; r_3 and r_4 each represent a number of 0 to 10 in terms of an average value thereof, they may be the same as or different from each other; in the case where plural R^{19a} Os are present, the plural R^{19a} Os may be the same as or different from each other; and in the case where plural R^{21a} Os are present, the plural R^{21a} Os may be the same as or different from each other.

(3) A compound in which one end thereof is represented by the foregoing general formula (A-1-i), and the remaining end has an olefinic unsaturated bond:

(4) A compound in which one end thereof is represented by the foregoing general formula (A-1-i), and the remaining end is represented by the following general formula (A-1-iv):



[0043] In the formula, R^{23a} , R^{24a} , and R^{25a} each represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, and they may be the same as or different from each other.

[0044] The polyvinyl ether compound may also be a mixture of two or more selected from those having an end structure of each of the foregoing (1) to (4). Suitable examples of such a mixture may include a mixture of the compound having the end structure of the foregoing (1) and the compound having the end structure of the foregoing (4); and a mixture of the compound having the end structure of the foregoing (2) and the compound having the end structure of the foregoing (3).

[0045] As for the polyvinyl ether compound, it is preferred to choose a degree of polymerization, an end structure, and so on so as to have a desired viscosity range. The polyvinyl ether compound may be used solely, or it may be used in combination of two or more thereof.

[0046] Among the polyvinyl-based compounds having the constituent unit represented by the general formula (A-1), a compound in which one end thereof is represented by the general formula (A-1-i), and the remaining end is represented by the general formula (A-1-ii) is preferred.

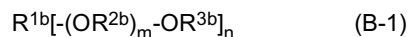
[0047] Above all, it is more preferred that in the formulae (A-1-i) and (A-1-ii), all of R^{6a} , R^{7a} , R^{8a} , R^{11a} , R^{12a} , and R^{13a}

are a hydrogen atom, all of r_1 and r_2 are 0, and R^{10a} and R^{15a} are each an alkyl group having 1 to 4 carbon atoms.

[0048] Particularly preferred specific examples of the PVE include a polyisobutyl vinyl ether, a polyethyl vinyl ether, an isobutyl vinyl ether-ethyl vinyl ether copolymer, and mixtures of two or more kinds thereof.

<Polyoxyalkylene Glycol Compound (PAG)>

[0049] Examples of the polyoxyalkylene glycol compound (PAG) used in the oxygen-containing synthetic base oil include a compound represented by the following general formula (B-1). The PAG may be used either solely or in combination of two or more kinds thereof.



[0050] In the formula, R^{1b} represents a hydrogen atom, a monovalent hydrocarbon group having 1 to 10 carbon atoms, an acyl group having 2 to 10 carbon atoms, a hydrocarbon group having 2 to 6 bonding sites and having 1 to 10 carbon atoms, or an oxygen-containing hydrocarbon group having 1 to 10 carbon atoms; R^{2b} represents an alkylene group having 2 to 4 carbon atoms; R^{3b} represents a hydrogen atom, a hydrocarbon group having 1 to 10 carbon atoms, an acyl group having 2 to 10 carbon atoms, or an oxygen-containing hydrocarbon group having 1 to 10 carbon atoms; n represents an integer of 1 to 6; and m represents a number of 6 to 80 in terms of an average value of $(m \times n)$.

[0051] In the general formula (B-1), the monovalent hydrocarbon group having 1 to 10 carbon atoms in each of R^{1b} and R^{3b} may be any of straight-chain, branched, and cyclic groups. The hydrocarbon group is preferably an alkyl group, and specific examples thereof may include a methyl group, an ethyl group, an n-propyl group, an isopropyl group, a butyl group of every kind, a pentyl group of every kind, a hexyl group of every kind, a heptyl group of every kind, an octyl group of every kind, a nonyl group of every kind, a decyl group of every kind, a cyclopentyl group, a cyclohexyl group, and the like. As for the aforementioned monovalent hydrocarbon group, when the number of carbon atoms is 10 or less, the oxygen content (A) can be easily within the prescribed range, and the compatibility with the refrigerant becomes good when the lubricating oil composition is used as a refrigerator oil. From such a viewpoint, the number of carbon atoms of the monovalent hydrocarbon group is more preferably 1 to 4.

[0052] The hydrocarbon group moiety which the acyl group having 2 to 10 carbon atoms in each of R^{1b} and R^{3b} has may be any of straight-chain, branched, and cyclic groups. The hydrocarbon group moiety of the acyl group is preferably an alkyl group, and specific examples thereof include those having 1 to 9 carbon atoms among the alkyl groups which may be chosen as the aforementioned R^{1b} and R^{3b} . When the number of carbon atoms of the acyl group is 10 or less, the oxygen content (A) can be easily within the prescribed range, and the compatibility with the refrigerant becomes good when the lubricating oil composition is used in a refrigerator oil. The number of carbon atoms of the acyl group is preferably 2 to 4.

[0053] In the case where all of R^{1b} and R^{3b} are a hydrocarbon group or an acyl group, R^{1b} and R^{3b} may be the same as or different from each other.

[0054] In the case where R^{1b} is the hydrocarbon group having 2 to 6 bonding sites and having 1 to 10 carbon atoms, this hydrocarbon group may be either linear or cyclic. The hydrocarbon group having 2 bonding sites is preferably an aliphatic hydrocarbon group, and examples thereof include an ethylene group, a propylene group, a butylene group, a pentylene group, a hexylene group, a heptylene group, an octylene group, a nonylene group, a decylene group, a cyclopentylene group, a cyclohexylene group, and the like. Examples of the other hydrocarbon groups may include residues resulting from removing a hydroxyl group from a bisphenol compound such as bisphenol, bisphenol F, bisphenol A, etc. The hydrocarbon group having 3 to 6 bonding sites is preferably an aliphatic hydrocarbon group, and examples thereof may include residues resulting from removing a hydroxyl group from a polyhydric alcohol, such as trimethylolpropane, glycerin, pentaerythritol, sorbitol, 1,2,3-trihydroxycyclohexane, 1,3,5-trihydroxycyclohexane, etc.

[0055] When the number of carbon atoms of this aliphatic hydrocarbon group is 10 or less, the oxygen content (A) can be easily within the prescribed range, and the compatibility with the refrigerant becomes good when the lubricating oil composition is used as a refrigerator oil. The number of carbon atoms of this aliphatic hydrocarbon group is preferably 2 to 6.

[0056] Furthermore, examples of the oxygen-containing hydrocarbon group having 1 to 10 carbon atoms in each of R^{1b} and R^{3b} may include an ether bond-containing linear or cyclic aliphatic group (for example, a tetrahydrofurfuryl group), and the like.

[0057] At least one of R^{1b} and R^{3b} is preferably an alkyl group, especially an alkyl group having 1 to 4 carbon atoms.

[0058] R^{2b} in the general formula (B-1) is an alkylene group having 2 to 4 carbon atoms, and examples of the oxyalkylene group as a repeating unit include an oxyethylene group, an oxypropylene group, and an oxybutylene group. The oxyalkylene groups in one molecule may be the same as each other, and two or more kinds of oxyalkylene groups may also be contained. It is preferred that at least an oxypropylene unit is contained in one molecule, and it is more preferred that 50 mol% or more of an oxypropylene unit is contained in the oxyalkylene unit, and it is more preferred that 70 mol%

or more of an oxypropylene unit is contained therein. When the content of the oxypropylene unit is large, for example, the saturated moisture content can be lower to decrease the hygroscopicity, and the oxygen content (A) can be easily within the prescribed range.

[0059] In the general formula (B-1), n is an integer of 1 to 6 and is determined according to the number of bonding sites of R^{1b} . For example, in the case where R^{1b} is an alkyl group or an acyl group, then n is 1; and in the case where R^{1b} is an aliphatic hydrocarbon group having 2, 3, 4, 5, or 6 bonding sites, then n is 2, 3, 4, 5, or 6, respectively.

[0060] m is a number providing an average value of $m \times n$ of 6 to 80. When the average value is 80 or less, the base oil can exhibit the lubrication performance, and the compatibility with a refrigerant may be improved when the lubricating oil composition is used as a refrigerator oil. The average value of $m \times n$ is determined in such a manner that the viscosity of the base oil is in the desired range.

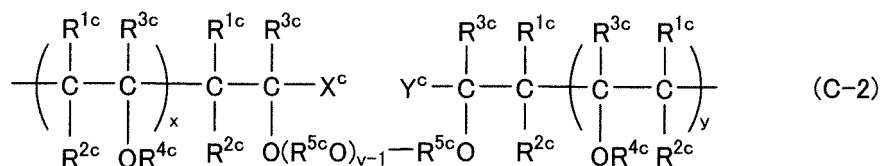
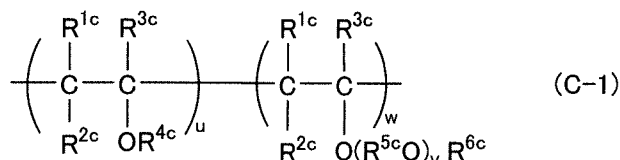
[0061] n is preferably an integer of 1 to 3, and more preferably 1. In the case where n is 1, it is preferred that any one of R^{1b} and R^{3b} represents an alkyl group, and it is more preferred that both of them each represent an alkyl group. Similarly, in the case where n is 2 or more, it is preferred that any one of plural R^{3bs} in one molecule represents an alkyl group, and it is more preferred that all of them each represent an alkyl group.

[0062] In the case where n is 2 or more, plural R^{3bs} in one molecule may be the same as or different from each other.

[0063] Preferred examples of the PAG used as the base oil include a mono- or dialkyl ether of a polyoxypropylene glycol, a mono- or dialkyl ether of a polyoxyethylene glycol polyoxypropylene glycol, and a mixture of two or more kinds of these compounds; namely ones represented by the general formula (B-1), in which R^{2b} represents a propylene group or a combination of an ethylene group and a propylene group, n is 1, and one or both of R^{1b} and R^{3b} are an alkyl group having 1 to 4 carbon atoms with the balance being a hydrogen atom, and more specifically include a polyoxypropylene glycol dimethyl ether, a polyoxypropylene glycol monobutyl ether, a polyoxyethylene glycol polyoxypropylene glycol dimethyl ether, and a mixture of two or more kinds of these compounds.

<Copolymer having Structure of Poly(oxy)alkylene Glycol or Monoether thereof and Polyvinyl Ether (ECP)>

[0064] In the lubricating oil composition according to the present embodiment, examples of the copolymer having a structure of a poly(oxy)alkylene glycol or a monoether thereof and a polyvinyl ether (ECP) that can be used as the oxygen-containing synthetic base oil include a copolymer represented by the following general formula (C-1) and a copolymer represented by the following general formula (C-2) (hereinafter referred to as "polyvinyl ether copolymer I" and "polyvinyl ether copolymer II", respectively). The poly(oxy)alkylene glycol refers to both a polyalkylene glycol and a polyoxyalkylene glycol.



[0065] In the general formula (C-1), R^{1c} , R^{2c} , and R^{3c} each independently represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, and they may be the same as or different from each other; R^{5c} represents a divalent hydrocarbon group having 2 to 4 carbon atoms; R^{6c} represents an aliphatic or alicyclic hydrocarbon group having 1 to 20 carbon atoms, an aromatic hydrocarbon group having 1 to 20 carbon atoms which may have a substituent, an acyl group having 2 to 20 carbon atoms, or an oxygen-containing hydrocarbon group having 2 to 50 carbon atoms; R^{4c} represents a hydrocarbon group having 1 to 10 carbon atoms; and in the case where a plurality of each of R^{1c} to R^{6c} are present, they may be each the same as or different from each other.

[0066] Here, specifically, the hydrocarbon group having 1 to 8 carbon atoms in R^{1c} to R^{3c} represents an alkyl group, such as a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group of every kind, a hexyl group of every kind, a heptyl group of every kind, an octyl group of every kind, etc.; a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group of every kind, an ethylcyclohexyl group of every kind, a dimethylcyclohexyl group of every kind, an aryl group such as a dimethylphenyl

group of every kind, etc.; or an arylalkyl group, such as a benzyl group, a phenylethyl group, a methylbenzyl group of every kind, etc. R^{1c} , R^{2c} , and R^{3c} are each preferably a hydrogen atom for making the oxygen content (B) within the aforementioned range.

[0067] Meanwhile, specifically, the divalent hydrocarbon group having 2 to 4 carbon atoms as represented by R^{5c} is a divalent alkylene group, such as a methylene group, an ethylene group, a propylene group of every kind, a butylene group of every kind, etc.

[0068] In the general formula (C-1), v represents a repeating number of $R^{5c}O$, and is a number ranging from 1 to 50, preferably from 1 to 20, more preferably from 1 to 10, and especially preferably from 1 to 5 in terms of an average value thereof. In the case where plural $R^{5c}O$ s are present, the plural $R^{5c}O$ s may be the same as or different from each other. v may be the same as or different from each other in every constituent unit.

[0069] w represents a number of 1 to 50, preferably 1 to 10, more preferably 1 to 2, and especially preferably 1; u represents a number of 0 to 50, preferably 2 to 25, and more preferably 5 to 15; and in the case where a plurality of each of w and u are present, they may be either block or random.

[0070] Furthermore, in the general formula (C-1), R^{6c} preferably represents an alkyl group having 1 to 10 carbon atoms, an acyl group having 2 to 10 carbon atoms, or an oxygen-containing hydrocarbon group having 2 to 50 carbon atoms.

[0071] Specifically, this alkyl group having 1 to 10 carbon atoms represents a methyl group, an ethyl group, an *n*-propyl group, an isopropyl group, an *n*-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group of every kind, a hexyl group of every kind, a heptyl group of every kind, an octyl group of every kind, a nonyl group of every kind, a decyl group of every kind, a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group of every kind, an ethylcyclohexyl group of every kind, a propylcyclohexyl group of every kind, a dimethylcyclohexyl group of every kind, or the like.

[0072] Examples of the acyl group having 2 to 10 carbon atoms include an acetyl group, a propionyl group, a butyryl group, an isobutyryl group, a valeryl group, an isovaleryl group, a pivaloyl group, a benzoyl group, a toluoyl group, and the like.

[0073] Furthermore, a methoxymethyl group, a methoxyethyl group, a methoxypropyl group, a 1,1-bismethoxypropyl group, a 1,2-bismethoxypropyl group, an ethoxypropyl group, a (2-methoxyethoxy)propyl group, a (1-methyl-2-methoxy)propyl group, and the like are preferably exemplified as specific examples of the oxygen-containing hydrocarbon group having 2 to 50 carbon atoms.

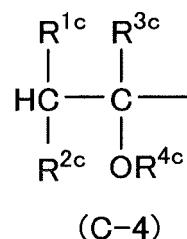
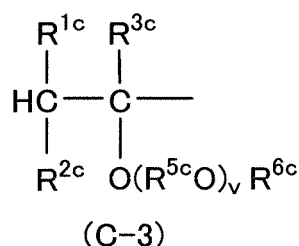
[0074] In the general formula (C-1), specifically, the hydrocarbon group having 1 to 10 carbon atoms as represented by R^{4c} represents an alkyl group, such as a methyl group, an ethyl group, an *n*-propyl group, an isopropyl group, an *n*-butyl group, an isobutyl group, a pentyl group of every kind, a hexyl group of every kind, a heptyl group of every kind, an octyl group of every kind, a nonyl group of every kind, a decyl group of every kind, etc.; a cycloalkyl group, such as a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group of every kind, an ethylcyclohexyl group of every kind, a propylcyclohexyl group of every kind, a dimethylcyclohexyl group of every kind, etc.; an aryl group, such as a phenyl group, a methylphenyl group of every kind, an ethylphenyl group of every kind, a dimethylphenyl group of every kind, a propylphenyl group of every kind, a trimethylphenyl group of every kind, a butylphenyl group of every kind, a naphthyl group of every kind, etc.; an arylalkyl group, such as a benzyl group, a phenylethyl group of every kind, a methylbenzyl group of every kind, a phenylpropyl group of every kind, a phenylbutyl group of every kind, etc.; or the like.

[0075] The polyvinyl ether copolymer I having the constituent unit represented by the general formula (C-1) is able to improve lubricating properties, insulating properties, hygroscopicity, and so on while improving the compatibility with the refrigerant when the lubricating oil composition is used in a refrigerator oil, through formation of the copolymer.

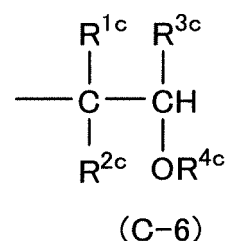
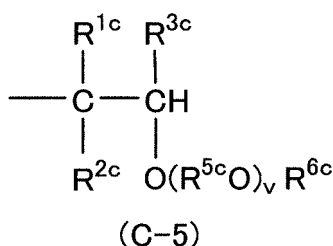
[0076] Meanwhile, in the polyvinyl ether copolymer II represented by the general formula (C-2), R^{1c} to R^{5c} and v are the same as those mentioned above. In the case where a plurality of each of R^{4c} and R^{5c} are present, they may be each the same as or different from each other. x and y each represent a number of 1 to 50, and in the case where a plurality of each of x and y are present, they may be either block or random. X^c and Y^c each independently represent a hydrogen atom, a hydroxyl group, or a hydrocarbon group having 1 to 20 carbon atoms.

[0077] It is preferred that the repeating numbers u , w , x , and y in the general formulae (C-1) and (C-2) are properly chosen such that a desired viscosity as mentioned later is obtained. A production method of each of the polyvinyl ether copolymers I and II is not particularly limited so long as it is a method for which each of the polyvinyl ether copolymers I and II is obtained.

[0078] The vinyl ether-based copolymers I and II represented by the general formulae (C-1) and (C-2) can be formed into the polyvinyl ether copolymer I having a structure in which one end thereof is represented by the following general formula (C-3) or (C-4), and the remaining end is represented by the following general formula (C-5) or (C-6).



[0079] In the aforementioned (C-3) and (C-4), R^{1c} to R^{6c} and v are the same as those as mentioned above.



[0080] In the aforementioned (C-5) and (C-6), R^{1c} to R^{6c} and v are the same as those as mentioned above.

<Polyol Ester Compound (POE)>

[0081] In the lubricating oil composition, examples of the polyol ester compound (POE) that can be used as the oxygen-containing synthetic base oil include an ester of a diol or a polyol having 3 to 20 hydroxyl groups and a fatty acid having 1 to 24 carbon atoms. However, the fatty acid for forming the polyol ester generally needs to contain a fatty acid having 12 or less carbon atoms in such a manner that the oxygen content (A) is 15 mass% or more.

[0082] Here, examples of the diol include ethylene glycol, 1,3-propanediol, propylene glycol, 1,4-butanediol, 1,2-butanediol, 2-methyl-1,3-propanediol, 1,5-pentanediol, neopentyl glycol, 1,6-hexanediol, 2-ethyl-2-methyl-1,3-propanediol, 1,7-heptanediol, 2-methyl-2-propyl-1,3-propanediol, 2,2-diethyl-1,3-propanediol, 1,8-octanediol, 1,9-nonanediol, 1,10-decanediol, 1,11-undecanediol, 1,12-dodecanediol, and the like. Examples of the polyol include a polyhydric alcohol, such as trimethylolethane, trimethylolpropane, trimethylolbutane, ditrimethylolpropane, tritrimethylolpropane, pentaerythritol, dipentaerythritol, tripentaerythritol, glycerin, a polyglycerin (e.g., dimer to icosamer of glycerin), 1,3,5-pentanetriol, sorbitol, sorbitan, a sorbitol glycerin condensate, adonitol, arabitol, xylitol, mannitol, etc.; a saccharide, such as xylose, arabinose, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose, cellobiose, maltose, isomaltose, trehalose, sucrose, raffinose, gentianose, merenditose, etc.; a partially etherified product thereof; methyl glucoside (e.g. glucosides); and the like. Above all, hindered alcohols, such as neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, ditrimethylolpropane, tritrimethylolpropane, pentaerythritol, dipentaerythritol, tripentaerythritol, etc., are preferred as the polyol.

[0083] As for the fatty acid, those having 1 to 24 carbon atoms are used as described above, and those having 3 or more carbon atoms are preferred, those having 4 or more carbon atoms are more preferred, and those having 5 or more carbon atoms are still more preferred from standpoint of lubricating properties. For the fatty acid for making the oxygen content (A) of 15 mass% or more, those having 12 or less carbon atoms are preferred, and those having 9 or less carbon atoms are more preferred.

[0084] The fatty acid may be any of a straight-chain fatty acid and a branched fatty acid, a straight-chain fatty acid is preferred from the standpoint of lubricating properties, and a branched fatty acid is preferred from the standpoint of hydrolysis stability. Furthermore, the fatty acid may be any of a saturated fatty acid and an unsaturated fatty acid.

[0085] Examples of the fatty acid include a straight-chain or branched fatty acid, such as isobutyric acid, pentanoic acid, hexanoic acid, heptanoic acid, octanoic acid, nonanoic acid, decanoic acid, undecanoic acid, dodecanoic acid, etc.; a so-called neo acid in which an α -carbon atom is quaternary; and the like. More specifically, isobutyric acid, valeric acid (n-pentanoic acid), caproic acid (n-hexanoic acid), enanthic acid (n-heptanoic acid), caprylic acid (n-octanoic acid), pelargonic acid (n-nonanoic acid), capric acid (n-decanoic acid), isopentanoic acid (3-methylbutanoic acid), 2-methylhexanoic acid, 2-ethylpentanoic acid, 2-ethylhexanoic acid, 3,5,5-trimethylhexanoic acid, and the like are preferred.

[0086] The polyol ester may be a partial ester in which some of the hydroxyl groups of a polyol remain without being esterified, may be a complete ester in which all of the hydroxyl groups of the polyol are esterified, or may be a mixture of the partial ester and the complete ester, but the polyol ester is preferably the complete ester.

[0087] Among the polyol esters, due to the excellent hydrolysis stability, esters of a hindered alcohol, such as neopentyl

glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, ditrimethylolpropane, tritrimethylolpropane, pentaerythritol, dipentaerythritol, and tripentaerythritol, are preferred, and esters of neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, and pentaerythritol are more preferred.

[0088] Specific examples of the preferred polyol ester include a diester of neopentyl glycol and one or more kinds of fatty acids selected from isobutyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, isopentanoic acid, 2-methylhexanoic acid, 2-ethylpentanoic acid, 2-ethylhexanoic acid, and 3,5,5-trimethylhexanoic acid; a triester of trimethylolethane and one or more kinds of fatty acids selected from isobutyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, isopentanoic acid, 2-methylhexanoic acid, 2-ethylpentanoic acid, 2-ethylhexanoic acid, and 3,5,5-trimethylhexanoic acid; a triester of trimethylolpropane and one or more kinds of fatty acids selected from isobutyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, isopentanoic acid, 2-methylhexanoic acid, 2-ethylpentanoic acid, 2-ethylhexanoic acid, and 3,5,5-trimethylhexanoic acid; a triester of trimethylolbutane and one or more kinds of fatty acids selected from isobutyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, isopentanoic acid, 2-methylhexanoic acid, 2-ethylpentanoic acid, 2-ethylhexanoic acid, and 3,5,5-trimethylhexanoic acid; and a tetraester of pentaerythritol and one or more kinds of fatty acids selected from isobutyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, isopentanoic acid, 2-methylhexanoic acid, 2-ethylpentanoic acid, 2-ethylhexanoic acid, and 3,5,5-trimethylhexanoic acid. As a more preferred specific example among the above, pentaerythritol tetra-2-ethylhexyl ester is particularly preferred.

[0089] The ester of two or more kinds of fatty acids may be a mixture of two or more kinds of esters, each of which is an ester of one kind of fatty acid and a polyol; or may be an ester of a mixed fatty acid of two or more kinds thereof and a polyol. Particularly, an ester of a mixed fatty acid and a polyol is excellent in low-temperature properties, and is excellent in compatibility with the refrigerant when the lubricating oil composition is used as a refrigerator oil.

[0090] The compound used as the viscosity index improver will be described in detail.

[0091] A polyvinyl ether compound (PVE) used as the viscosity index improver is a polymer having a vinyl ether-derived constituent unit, and specifically, examples thereof include a polyvinyl-based compound having a constituent unit represented by the general formula (A-1), as similar to the oxygen-containing synthetic base oil. However, the repeating number of the constituent unit represented by the general formula (A-1) is appropriately selected depending on the desired kinetic viscosity, and the repeating number is sufficiently larger than that used as the oxygen-containing synthetic base oil, and is generally approximately from 1,000 to 14,000. The detailed explanations of the PVE used as the viscosity index improver are same as those for the PVE used in the oxygen-containing synthetic base oil, except for the repeating number, and the explanations thereof are omitted herein.

[0092] Incidentally, specific examples of the PVE used as the viscosity index improver include the same kinds as for the oxygen-containing synthetic base oil, and among them, a polyethyl vinyl ether is most preferred.

[0093] Examples of the polyoxyalkylene glycol compound (PAG) used as the viscosity index improver include a compound represented by the general formula (B-1), as similar to the oxygen-containing synthetic base oil. The detailed explanations of R^{1b} , R^{2b} , n , and R^{3b} in the general formula (B-1) are the same as above except for the following differences. Only the differences are described below, but the others are the same and not described herein.

[0094] Specifically, while m in the general formula (B-1) for the oxygen-containing synthetic base oil is a number providing an average value of $m \times n$ of 6 to 80, m for the viscosity index improver is a number providing an average value of $m \times n$ of approximately 1,800 to 20,000. However, m is appropriately changed corresponding to the kinetic viscosity and the number average molecular weight of the viscosity index improver described above.

[0095] Moreover, in the viscosity index improver, at least one of R^{1b} and R^{3b} preferably represents a hydrogen atom. For example, in the case where n is 1, any one of R^{1b} and R^{3b} preferably represents a hydrogen atom, and in the case where n is 2 or more, any one of plural R^{3b} s in one molecule preferably represents a hydrogen atom.

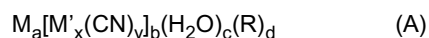
[0096] In the case where both the oxygen-containing synthetic base oil and the viscosity index improver are PAG, both the oxygen-containing synthetic base oil and the viscosity index improver used are generally ones represented by the general formula (B-1), and in both the compounds, n in the general formula (B-1) is preferably an integer of from 1 to 3, and more preferably 1. By using the oxygen-containing synthetic base oil and the viscosity index improver having structures of the same kind, the aforementioned various effects can be easily obtained.

[0097] Specific particularly preferred examples of the PAG used as the viscosity index improver include a polyoxypropylene glycol, a polyoxyethylene glycol, polyoxypropylene glycol, polyoxybutylene glycol, and monoalkyl ethers of these compounds; namely, ones represented by the general formula (B-1), in which R^{2b} represents a propylene group, a butylene group, or a combination of an ethylene group and a propylene group, n is 1, and one or both of R^{1b} and R^{3b} are a hydrogen atom with the balance being an alkyl group having 1 to 4 carbon atoms, and more specifically include a polyoxypropylene glycol diol (both ends are hydroxyl groups), a polyoxypropylene glycol monobutyl ether, a polyoxyethylene glycol, polyoxypropylene glycol diol (both ends are hydroxyl groups), and a polyoxybutylene glycol monobutyl ether.

[0098] While the production method of the PAG used as the viscosity index improver is not particularly limited, the

PAG is preferably produced, for example, by polymerizing an alkylene oxide by using a composite metal catalyst, from the standpoint of easily producing one having a large viscosity.

[0099] The composite metal catalyst is preferably a composite metal cyanide complex catalyst. Specific examples of the composite metal cyanide complex catalyst include a compound having a structure represented by the following general formula (A).



[0100] In the general formula, M represents Zn(II), Fe(II), Fe(III), Co(II), Ni(II), Al(III), Sr(II), Mn(II), Cr(III), Cu(II), Sn(II), Pb(II), Mo(IV), Mo(VI), W(IV), W(VI), or the like; M' represents Fe(II), Fe(III), Co(II), Co(III), Cr(II), Cr(III), Mn(II), Mn(III), Ni(II), V(IV), V(V), or the like; R represents an organic ligand; a, b, x, and y each are a positive integer that vary depending on the valency and the coordination number of the metal; and c and d each are a positive number that vary depending on the coordination number of the metal.

[0101] In the general formula (A), M preferably represents Zn(II), and M' preferably represents Fe(II), Fe(III), Co(II), Co(III), or the like. Examples of the organic ligand include a ketone, an ether, an aldehyde, an ester, an alcohol, and an amide, and an alcohol is preferred.

[0102] The composite metal cyanide complex represented by the general formula (A) may be produced in such a manner that: a metal salt MX_a (wherein M and a are the same as above, and X represents an anion forming a salt with M); and a polycyanometallate (salt) $Z_e[M'_x(CN)_y]_f$ (wherein M', x, and y are the same as above, Z represents hydrogen, an alkali metal, an alkaline earth metal, or the like, and e and f each represent a positive integer determined by the valency and the coordination number of M'), each of which is in aqueous solution or mixed solvent solution of water and an organic solvent, are mixed to obtain a composite metal cyanide complex, the organic ligand R is made contact with the obtained composite metal cyanide complex, and then the excessive solvent and the excessive organic ligand R are removed.

[0103] In the polycyanometallate (salt) $Z_e[M'_x(CN)_y]_f$, hydrogen and various metals, such as an alkali metal, can be used as Z, and a lithium salt, a sodium salt, a potassium salt, a magnesium salt, and a calcium salt are preferred. What are particularly preferred are normal alkali metal salts, i.e., a sodium salt and a potassium salt.

[0104] The PAG used as the viscosity index improver is generally produced by making a mixture of the alkylene oxide and an initiator in contact with the catalyst, and a particular amount of an organic solvent is preferably present in the reaction. The presence of an organic solvent may increase the molecular weight of the PAG. The reaction may also be performed by adding the alkylene oxide gradually to the reaction system, and an organic solvent may be added along with the alkylene oxide. While the reaction may occur under ordinary temperature, the reaction system may be heated or cooled, and a large molecular weight can be easily obtained by cooling. The specific reaction temperature is preferably from -20 to 100°C. The amount of the catalyst used is not particularly limited, and is suitably from 1 to 5,000 ppm based on the initiator used. The catalyst may be introduced to the reaction system at one time at the beginning of the reaction or may be divided and introduced sequentially.

[0105] The amount of the organic solvent present in the reaction is preferably 10 to 90 mass% based on the amount of the PAG finally obtained. When the amount of the organic solvent is 10 mass% or more, the molecular weight of the PAG can be further increased. When the amount thereof is 90 mass% or less, the PAG can be produced with good economic efficiency.

[0106] The organic solvent used may be various organic solvents, and is preferably an ether compound. Examples of the ether compound include a monoether, a diether, a polyether compound, a polyvinyl ether compound, and a polyalkylene glycol compound.

[0107] Examples of the monoether include a dialkyl ether, in which the alkyl group is a branched or straight-chain alkyl group having 1 to 12 carbon atoms, and specific examples thereof include a symmetrical ether, such as di-2-ethylhexyl ether and di-3,5,5-trimethylhexyl ether, and an asymmetrical ether, such as 2-ethylhexyl n-octyl ether and 3,5,5-trimethylhexyl n-nonyl ether.

[0108] The diether used may be, for example, a dialkyl ether of various diols. Examples of the diol used include a straight-chain-alkane diol, such as an alkylene glycol, e.g., ethylene glycol, propylene glycol, and butylene glycol, 1,3-propanediol, and 1,4-butanediol; and a branched-alkene diol, such as neopentyl glycol. Examples of the polyether used include alkyl ethers of a polyhydric alcohol, such as glycerin, tetramethylethane, tetramethylolpropane, pentaerythritol, and dipentaerythritol.

[0109] The alkyl group used in the dialkyl ether and the alkyl ether of a polyhydric alcohol may be a branched or straight-chain alkyl group having 1 to 12 carbon atoms. The alkyl group of the diether and the polyether may be used solely, or it may be used in combination of two or more thereof.

[0110] The polyvinyl ether compound and the polyalkylene glycol compound used as the organic solvent can be similar to those used as the oxygen-containing synthetic base oil. However, the polyalkylene glycol compound that has a -OH group at the end thereof may have a possibility of reaction with a monomer, and therefore the compound having the

end that is etherified with an alkyl group having 1 to 4 carbon atoms can be used. Specifically, in the case where n in the formula (B-1) is 1, the compound in which both R^{1b} and R^{3b} each represent an alkyl group having 1 to 4 carbon atoms can be used. Similarly, in the case where n is 2 or more, the compound in which all of plural R^{3b} s in one molecule each represent an alkyl group having 1 to 4 carbon atoms can be used. Similarly, as the polyvinyl ether compound, the compound having the end that has no -OH group may be used.

[0111] After completing the reaction, the organic solvent may be removed partially or entirely, and may not be removed. In the case where at least a part of the organic solvent is not removed after the reaction, the organic solvent is contained in the lubricating oil composition along with the viscosity index improver (PAG), and used as at least a part of the oxygen-containing synthetic base oil. Accordingly, in the case where the organic solvent is used as at least a part of the base oil, the organic solvent used is preferably a polyvinyl ether compound or a polyalkylene glycol compound capable of being used as the oxygen-containing synthetic base oil.

[0112] The initiator may be appropriately selected depending on the structure of the PAG to be produced, and in the case where the resulting PAG is represented by the general formula (B-1), the initiator is preferably an alcohol compound represented by the general formula, $R^{1b}(OH)_n$ or $HO-R^{2b}-OH$ (wherein R^{1b} , n , and R^{2b} are the same as above).

[0113] The alkylene oxide may be appropriately selected corresponding to R^{2b} in the general formula (B-1), and examples thereof include ethylene oxide, propylene oxide, and a butylene oxide.

[0114] The PAG thus obtained after the reaction contains the catalyst and the organic solvent, and thus at least the catalyst is necessarily removed. The processing method therefor is preferably, for example, such a method that a catalyst deactivator, such as an alkali metal compound, is added to deactivate the catalyst, and then the compound is purified.

[0115] Examples of the copolymer having a structure of a poly(oxy)alkylene glycol or a monoether thereof and a polyvinyl ether (ECP) used as the viscosity index improver include a copolymer represented by the general formula (C-1) and a copolymer represented by the general formula (C-2). However, in the ECP used as the viscosity index improver, the repeating number of the constituent unit is larger than that of the ECP used as the base oil, and w , u , v , x , and y in the general formulae (C-1) and (C-2) are not limited to the aforementioned ranges, and are appropriately determined corresponding to the viscosity of the viscosity index improver. The detailed explanations of ECP used as the viscosity index improver are the same as the oxygen-containing synthetic base oil except for the repeating numbers, and the explanations thereof are omitted herein.

[Other Additives]

[0116] The lubricating oil composition according to the present embodiment may further contain various additives. The additives are contained preferably in an amount of about 20 mass% or less, and more preferably about 0 to 10 mass%, based on the total amount of the lubricating oil composition. Various materials may be used as the additives, and examples thereof include an antioxidant, an acid scavenger, an oxygen scavenger, an extreme pressure agent, an oiliness agent, a copper deactivator, a rust preventive, and a defoaming agent.

[0117] Examples of the antioxidant include a phenol-based antioxidant, such as 2,6-di-tert-butyl-4-methylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,2'-methylenebis(4-methyl-6-tert-butylphenol), etc.; and an amine type antioxidant, such as phenyl- α -naphthylamine, N,N' -di-phenyl- p -phenylenediamine, etc., and a phenol-based antioxidant is preferred. From the standpoints of effects and economy, and so on, the content of the antioxidant is typically 0.01 to 5 mass%, and preferably 0.05 to 3 mass%, based on the total amount of the lubricating oil composition.

[0118] Examples of the acid scavenger may include an epoxy compound, such as phenyl glycidyl ether, an alkyl glycidyl ether, an alkylene glycol glycidyl ether, cyclohexene oxide, an α -olefin oxide, an epoxidized soybean oil, etc. Above all, from the standpoint of compatibility, phenyl glycidyl ether, an alkyl glycidyl ether, an alkylene glycol glycidyl ether, cyclohexene oxide, and an α -olefin oxide are preferred.

[0119] Regarding the alkyl group in the alkyl glycidyl ether and the alkylene group in the alkylene glycol glycidyl ether, the branched is also acceptable, and the number of carbon atoms thereof is typically 3 to 30, preferably 4 to 24, and especially preferably 6 to 16. As for the α -olefin oxide, one having a total number of carbon atoms of generally 4 to 50, preferably 4 to 24, and especially 6 to 16 is used. In the present embodiment, the acid scavenger may be used solely, or may be used in combination of two or more thereof. The content thereof is typically 0.005 to 5 mass%, and preferably 0.05 to 3 mass%, based on the total amount of the lubricating oil composition, from the standpoints of effects and inhibition of sludge generation. The lubricating oil composition may be improved in stability by containing the acid scavenger.

[0120] Examples of the oxygen scavenger include a sulfur-containing aromatic compound, such as 4,4'-thiobis(3-methyl-6- t -butylphenol), diphenyl sulfide, dioctyldiphenyl sulfide, a dialkyldiphenylene sulfide, benzothiophene, dibenzothiophene, phenothiazine, benzothiapyrane, thiapyrane, thianthrene, dibenzothiapyrane, diphenylene disulfide, etc.; an aliphatic unsaturated compound, such as various olefins, dienes, and trienes, etc.; a terpene compound having a double bond; and the like.

[0121] Examples of the extreme pressure agent may include a phosphorus-based extreme pressure agent, such as

a phosphate ester, an acidic phosphate ester, a phosphite ester, an acidic phosphite ester, and an amine salt thereof, etc.

[0122] As such a phosphorus-based extreme pressure agent, tricresyl phosphate, trithiophenyl phosphate, tri(nonyl-phenyl) phosphite, dioleoyl hydrogenphosphite, 2-ethylhexyldiphenyl phosphite, and the like are exemplified from the standpoint of the extreme pressure property, the frictional characteristics, and the like.

[0123] In addition, examples of the extreme pressure agent include a metal salt of a carboxylic acid. The metal salt of a carboxylic acid as referred to herein is preferably a metal salt of a carboxylic acid having 3 to 60 carbon atoms, and more preferably a metal salt of a fatty acid having 3 to 30 carbon atoms, and especially preferably 12 to 30 carbon atoms. In addition, examples thereof may include a metal salt of a dimer acid or a trimer acid of the aforementioned fatty acid, and a dicarboxylic acid having 3 to 30 carbon atoms. Of those, a metal salt of a fatty acid having 12 to 30 carbon atoms and a dicarboxylic acid having 3 to 30 carbon atoms is especially preferred.

[0124] Meanwhile, the metal constituting the metal salt is preferably an alkali metal or an alkaline earth metal, and in particular, an alkali metal is optimum.

[0125] In addition, examples of the extreme pressure agent other than those as mentioned above may include a sulfur-based extreme pressure agent, such as sulfurized fats and oils, a sulfurized fatty acid, a sulfurized ester, a sulfurized olefin, a dihydrocarbyl polysulfide, a thiocarbamate compound, a thioterpene compound, a dialkyl thiodipropionate compound, etc.

[0126] The content of the extreme pressure agent is typically 0.001 to 5 mass%, and especially preferably 0.005 to 3 mass% on the basis of the whole amount of the lubricating oil composition from the standpoints of lubricating properties and stability.

[0127] The extreme pressure agent may be used solely, or may be used in combination of two or more thereof.

[0128] Examples of the oiliness agent include an aliphatic saturated or unsaturated monocarboxylic acid, such as stearic acid, oleic acid, etc.; a polymerized fatty acid, such as a dimer acid, a hydrogenated dimer acid, etc.; a hydroxy fatty acid, such as ricinoleic acid, 12-hydroxystearic acid, etc.; an aliphatic saturated or unsaturated monoalcohol, such as lauryl alcohol, oleyl alcohol, etc.; an aliphatic saturated or unsaturated monoamine, such as stearylamine, oleylamine, etc.; an aliphatic saturated or unsaturated monocarboxylic acid amide, such as lauric acid amide, oleic acid amide, etc.; a partial ester of a polyhydric alcohol, such as glycerin, sorbitol, etc., and an aliphatic saturated or unsaturated monocarboxylic acid; and the like.

[0129] Such an oiliness agent may be used solely, or may be used in combination of two or more thereof. The content thereof is chosen within the range of typically from 0.01 to 10 mass%, and preferably from 0.1 to 5 mass%, on the basis of the whole amount of the lubricating oil composition.

[0130] Examples of the copper deactivator may include an N-[N,N'-dialkyl(alkyl group having 3 to 12 carbon atoms)aminomethyl]triazole, and the like.

[0131] Examples of the defoaming agent may include a silicone oil, a fluorinated silicone oil, and the like. The content of the defoaming agent is typically 0.005 to 2 mass%, and preferably 0.01 to 1 mass%, relative to the whole amount of the lubricating oil composition.

[0132] Examples of the rust preventive may include a metal sulfonate, an aliphatic amine compound, an organic phosphite ester, an organic phosphate ester, an organic sulfonic acid metal salt, an organic phosphoric acid metal salt, an alkenyl succinate ester, a polyhydric alcohol ester, and the like.

[0133] The lubricating oil composition according to the present embodiment may further contain various other known additives within the range where the object of the present invention is not impaired.

[0134] The lubricating oil composition according to the present embodiment can be used as a hydraulic oil, a turbine oil, a compressor oil, a bearing gear oil, an engine oil, a refrigerator oil, and the like, and among these, is preferably used as a refrigerator oil.

[0135] The lubricating oil composition used as a refrigerator oil is used under a refrigerant environment, and specifically used by filling in a refrigerator along with a refrigerant. The refrigerator as referred to herein has a refrigeration cycle constituted of a compressor, a condenser, an expansion mechanism (e.g., an expansion valve, etc.), and an evaporator as the essential components, or constituted of a compressor, a condenser, an expansion mechanism, a dryer, and an evaporator as essential components. The lubricating oil composition is used, for example, for lubricating a sliding portion provided in a compressor, etc.

[0136] More specifically, the lubricating oil composition used as a refrigerator oil can be used for, for example, various refrigerator systems, hot water systems, and heating systems, such as various car air conditioners, e.g., an open type car air-conditioner and an electric car air-conditioner, a gas heat pump (GHP), an air conditioner, a fridge, an automatic vending machine, a showcase, a hot water supply machine, a floor heater, and the like.

[Method for producing Lubricating Oil Composition]

[0137] The method for producing a lubricating oil composition according to the present embodiment includes: blending a viscosity index improver with an oxygen-containing synthetic base oil, so as to provide a lubricating oil composition.

In the production method, various additives may be blended with the oxygen-containing synthetic base oil in addition to the viscosity index improver. The details of the oxygen-containing synthetic base oil, the viscosity index improver, and the additives, and the details of the lubricating oil composition are the same as above, and the detailed explanations are omitted herein.

Examples

[0138] The present invention will be described more specifically with reference to examples below, but the present invention is not limited to the examples.

[0139] The properties and the evaluation of the lubricating oil compositions were obtained by the procedures shown below.

(1) Kinetic viscosity (40°C, 100°C)

[0140] The kinematic viscosity was measured with a glass capillary viscometer according to JIS K2283.

(2) Number average molecular weight (Mn) and Weight average molecular weight (Mw)

[0141] The number average molecular weight (Mn) and the weight average molecular weight (Mw) were measured with gel permeation chromatography (GPC). In the GPC, the measurement was performed by using two columns of Shodex KF-402HQ and chloroform as an eluent with an RI detector, and the number average molecular weight (Mn) and the weight average molecular weight (Mw) were obtained with the standard polystyrene.

(3) Storage Stability Test

[0142] 100 mL of the lubricating oil composition was stirred with a magnetic stirrer at 60°C for 30 minutes, and after allowing to stand at room temperature (23°C) for 1 day, it was visually observed whether or not the viscosity index improver was dissolved in the base oil.

(4) Pour Point

[0143] The pour point was measured according to JIS K2269.

Examples 1 to 14 and Comparative Examples 1 to 7

[0144] The base oils shown in Table 1 and the viscosity index improvers shown in Table 2 were blended in the blending amounts shown in Table 3, so as to provide lubricating oil compositions of Examples and Comparative Examples. The properties and the results of the evaluation tests of the lubricating oil compositions of Examples and Comparative Examples are shown in Table 3.

Table 1

Base oil		40°C Kinetic viscosity (mm ² /s)	100°C Kinetic viscosity (mm ² /s)	Oxygen content	Number average molecular weight	Weight average molecular weight
A1	Polyoxypropylene glycol dimethyl ether	3.72	1.5	28%	250	270
A2	Polyoxypropylene glycol dimethyl ether	46.1	10	28%	1,200	1,300
A3	Polyoxypropylene glycol monobutyl ether	125	20	28%	2,800	3,000
A4	Polyoxyethylene glycol polyoxypropylene glycol dimethyl ether	12.2	3.5	32%	550	600
A5	Polyisobutyl vinyl ether	11.1	2.7	16%	300	350

(continued)

Base oil		40°C Kinetic viscosity (mm ² /s)	100°C Kinetic viscosity (mm ² /s)	Oxygen content	Number average molecular weight	Weight average molecular weight
A6	Polyethyl vinyl ether	41.5	6.3	22%	650	710
A7	Pentaerythritol tetra-2-ethylhexyl ester	39.5	6.1	20%	640	700
A8	Paraffin mineral oil	42.3	6.5	0	580	630
A9	Alkylbenzene	25.4	3.8	0	430	470
* The molar ratio of the oxypropylene unit and the oxyethylene unit in A4 was 5:5.						
* The number average molecular weight of A7 shows the molecular weight calculated from the chemical formula (formula weight).						

Table 2

Viscosity index improver		40°C Kinetic viscosity (mm ² /s)	100°C Kinetic viscosity (mm ² /s)	Oxygen content	Number average molecular weight	Weight average molecular weight
B1	Polyoxypropylene glycol diol (hydroxyl groups at both ends)	45,000	11,000	28%	150,000	345,000
B2	Polyoxypropylene glycol monobutyl ether	100,000 <	36,000	28%	460,000	1,932,000
B3	Polyoxyethylene glycol polyoxypropylene glycol diol (hydroxyl groups at both ends)	100,000 <	23,000	32%	300,000	1,110,000
B4	Polyoxybutylene glycol monobutyl ether	87,000	18,000	22%	210,000	546,000
B5	Polyethyl vinyl ether	100,000 <	35,000	22%	320,000	1,280,000
B6	PMA (polymethacrylate, polymer of alkyl methacrylate, alkyl group: C ₁₂ H ₂₅)	100,000 <	33,000	13%	470,000	2,162,000
B7	OCP (olefin copolymer)	100,000 <	27,000	0	200,000	560,000
B8	PIB (polyisobutylene)	100,000 <	19,000	0	250,000	750,000
B9	SDC (hydride of styrene-isoprene block polymer)	100,000 <	37,000	0	280,000	980,000
* The molar ratio of the oxypropylene unit and the oxyethylene unit in B3 was 5:5.						

Table 3

		Example										
		1	2	3	4	5	6	7	8	9	10	11
Base oil	A1	95										11
	A2		95					95	95	95	95	95
	A3			95								
	A4				95							
	A5					95						
	A6						95					
	A7							95				
	A8											
	A9											
Viscosity index improver	B1	5	5	5	5	5	5	5				
	B2							5				
	B3								5			
	B4									5		
	B5										5	
	B6											
	B7											
	B8											
	B9											
Oxygen content ratio (A/B)		1.0	1.0	1.0	1.3	0.6	0.8	0.8	1.0	0.7	1.2	1.2
100°C Kinetic viscosity (mm²/s)		1.7	12	24	4.1	3.2	7.1	7.3	12	12	12	12
Storage stability		dissolved	dissolved	dissolved	dissolved	dissolved	dissolved	dissolved	dissolved	dissolved	dissolved	dissolved
Pour point (°C)		-50 >	-45	-40	-50 >	-50 >	-50 >	-50 >	-45	-45	-45	-45

(continued)

Table 3 (continued)

	Example			Comparative Example						
	12	13	14	1	2	3	4	5	6	7
Base oil	A1									
	A2	99.5	90	80		95	95	95	95	70
	A3									
	A4									
	A5									
	A6									
	A7									
	A8					95				
	A9				95					
Viscosity index improver	B1				5	5				
	B2									
	B3	0.5	10	20						30
	B4									
	B5									
	B6					5				
	B7						5			
	B8							5		
	B9								5	
Oxygen content ratio (A/B)	1.0	1.0	1.0	0.0	0.0	2.2				1.0
100°C Kinetic viscosity (mm ² /s)	10	15	23.6	7.3	3.5	12	12	12	12	38
Storage stability	dissolved	dissolved	dissolved	separated	separated	separated	separated	separated	separated	dissolved
Pour point (°C)	-50 >	-45	-40	-	-	-	-	-	-	-15

* In Table 3, "-50 >" shows that the pour point is lower than -50°C.

[0145] As shown by Examples, even though a viscosity index improver having a large molecular weight and thus

having a large effect of improving a viscosity index was used, a good low-temperature fluidity could be obtained, and the viscosity index improver was hard to be separated from the base oil, by making the oxygen contents (A) and (B) and the ratio (A/B) within the prescribed ranges.

[0146] In Comparative Examples 1, 2, and 4 to 6, on the other hand, since a base oil or a viscosity index improver containing no oxygen was used, the base oil and the viscosity improver were separated from each other to fail to exhibit a sufficient effect of improving a viscosity index. Similarly, in Comparative Example 3, since the viscosity index improver had a low oxygen content and the ratio (A/B) exceeded 2, the base oil and the viscosity improver were separated from each other to fail to exhibit a sufficient effect of improving a viscosity index. In Comparative Example 7, furthermore, since the viscosity index improver was blended in a large amount outside the mass ratio of from 99.5:0.5 to 75:25, the pour point was increased and the low-temperature fluidity could not be improved.

Claims

1. A lubricating oil composition comprising an oxygen-containing synthetic base oil having an oxygen content (A) of from 15 to 40 mass% and a kinetic viscosity at 100°C of from 0.5 to 50 mm²/s, and a viscosity index improver that is an oxygen-containing compound having an oxygen content (B) of from 15 to 40 mass% and a kinetic viscosity at 100°C of 11,000 mm²/s or more,
a mass ratio of the oxygen-containing synthetic base oil and the viscosity index improver being from 99.5:0.5 to 75:25, and
a ratio (A/B) of the oxygen content (A) of the oxygen-containing synthetic base oil to the oxygen content (B) of the viscosity index improver being in a range of from 0.5 to 2.
2. The lubricating oil composition according to claim 1, wherein the viscosity index improver is at least one oxygen-containing compound selected from a polyvinyl ether compound, a polyoxyalkylene glycol compound, and a copolymer having a structure of a poly(oxy)alkylene glycol or a monoether thereof and a polyvinyl ether.
3. The lubricating oil composition according to claim 2, wherein the viscosity index improver is selected from a polyoxyalkylene glycol compound.
4. The lubricating oil composition according to any one of claims 1 to 3, wherein the oxygen-containing synthetic base oil is at least one selected from a polyvinyl ether compound, a polyoxyalkylene glycol compound, a polyol ester compound, and a copolymer having a structure of a poly(oxy)alkylene glycol or a monoether thereof and a polyvinyl ether.
5. The lubricating oil composition according to any one of claims 1 to 4, wherein the lubricating oil composition is selected from a hydraulic oil, a turbine oil, a compressor oil, a bearing gear oil, an engine oil, and a refrigerator oil.
6. A method for producing a lubricating oil composition, comprising: blending a viscosity index improver that is an oxygen-containing compound having an oxygen content (B) of from 15 to 40 mass% and a kinetic viscosity at 100°C of 11,000 mm²/s or more, with an oxygen-containing synthetic base oil having an oxygen content (A) of from 15 to 40 mass% and a kinetic viscosity at 100°C of from 0.5 to 50 mm²/s,
a mass ratio of the oxygen-containing synthetic base oil and the viscosity index improver being from 99.5:0.5 to 75:25, and
a ratio (A/B) of the oxygen content (A) of the oxygen-containing synthetic base oil to the oxygen content (B) of the viscosity index improver being in a range of from 0.5 to 2.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/050404

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C10M169/04, C10M105/08, C10M105/18, C10M105/38, C10M107/20, C10M107/24, C10M107/34, C10M145/00, C10M145/04, C10M145/26, C10N20/02, C10N30/00, C10N30/02, C10N40/00, C10N40/04, C10N40/08, C10N40/12, C10N40/25,

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016

Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

JSTPlus/JST7580/JSTChina(JDreamIII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 63-142098 A (Kawasaki Heavy Industries, Ltd.), 14 June 1988 (14.06.1988), (Family: none)	1-6
A	JP 2002-003874 A (Sanyo Chemical Industries, Ltd.), 09 January 2002 (09.01.2002), (Family: none)	1-6
A	JP 2001-348587 A (Sanyo Chemical Industries, Ltd.), 18 December 2001 (18.12.2001), (Family: none)	1-6

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
26 February 2016 (26.02.16)Date of mailing of the international search report
08 March 2016 (08.03.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/050404

5

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

10

15

20

25

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40

45

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2014-196503 A (Dow Global Technologies L.L.C.), 16 October 2014 (16.10.2014), & US 2010/0120639 A1 & EP 2142624 A2	1-6

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/050404

Continuation of A. CLASSIFICATION OF SUBJECT MATTER

(International Patent Classification (IPC))

C10M169/04(2006.01)i, C10M105/08(2006.01)n, C10M105/18(2006.01)n,
 C10M105/38(2006.01)n, C10M107/20(2006.01)n, C10M107/24(2006.01)n,
 C10M107/34(2006.01)n, C10M145/00(2006.01)n, C10M145/04(2006.01)n,
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 C10N30/02(2006.01)n, C10N40/00(2006.01)n, C10N40/04(2006.01)n,
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 C10N40/30(2006.01)n

(According to International Patent Classification (IPC) or to both national
 classification and IPC)

Continuation of B. FIELDS SEARCHED

Minimum documentation searched (International Patent Classification (IPC))

C10N40/30

Minimum documentation searched (classification system followed by
 classification symbols)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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