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(54) **HIGH-TEMPERATURE LUBRICANT COMPOSITION**

(57) A lubricating oil composition for high-temperature applications contains: a component (A) that is an aromatic ester; and a component (B) that is a poly-alpha-olefin having a viscosity index of 140 or more. A content of the component (A) is preferably in a range from 10

mass% to 95 mass% of a total amount of the composition. A content of the component (B) is preferably in a range from 50 mass% or less of the total amount of the composition.

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a lubricating oil composition for high-temperature applications.

BACKGROUND ART

10 **[0002]** There are a lot of sliding portions such as a chain, a gear and a bearing inside a tenter used for manufacturing an optical film, a food-packaging film, a solar panel film or the like. Since a lubricating oil used in such sliding portions is exposed to high temperatures, an amount of evaporation of the lubricating oil significantly affects a life time of a device. In other words, under high temperatures, since the lubricating oil loses an inherent viscosity to form a thin film, it is necessary to restrain the amount of evaporation of the lubricating oil in order to keep lubricity thereof.

15 **[0003]** Accordingly, in order to restrain the amount of evaporation, a high-molecular and highly viscous lubricating oil has been used for high-temperature applications.

[0004] However, such a lubricating oil causes a large power loss although having a small amount of evaporation, which makes overall performance of the lubricating oil unfavorable. Moreover, when such a lubricating oil is exposed to high temperatures while forming a thin film, the lubricating oil becomes solid though a large amount of residue remains. Thus, the lubricating oil not only loses characteristics as a liquid but also blocks a flow of the lubricating oil in a form of a solid sludge, which causes a poor lubrication of the sliding portions. Although such a disadvantage can be simply solved by increasing the amount of the lubricating oil in use, such a solution is not favorable in terms of costs and an environmental aspect. Consequently, as the lubricating oil used under high temperatures, a lubricating oil whose evaporation amount under high temperatures is restrained and whose fluidity is kept for a long time has been demanded.

25 **[0005]** Moreover, in the above tenter, since scattering of the lubricating oil on a product is extremely disfavored, reduction of the amount of the lubricating oil in use has also been demanded.

[0006] Accordingly, as such a lubricating oil for high-temperature applications, there has been proposed a lubricating oil composition that contains a polyol ester synthetic oil and a diphenylamine derivative having a C₁₂-C₇₂ fatty acid and/or an aryl alkyl group having a number average molecular weight of 400 to 800 (see Patent Literature 1).

30 CITATION LIST

PATENT LITERATURE(S)

35 **[0007]** Patent Literature 1: JP-A-2005-314650

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

40 **[0008]** However, even in the lubricating oil composition disclosed in Patent Literature 1, the lubricating oil does not always exhibit sufficient characteristics under high temperatures. For instance, the lubricating oil composition may turn sludge under high temperatures to cause an oil path to be clogged.

[0009] In the above tenter, a resin (engineering plastics) is occasionally used in the sliding portion in order to prevent wear of the sliding portion and simplify maintenance thereof.

45 **[0010]** However, use of a lubricating oil unsuitable to the resin may cause troubles such as a poor lubricity or breakage of the sliding portion, which is caused by oil film breakage, or an increase in scattering of the lubricating oil to the surroundings, which is caused by an increase in the amount of the lubricating oil to be used.

50 **[0011]** An object of the invention is to provide a lubricating oil composition for high-temperature applications, in which, under high temperatures and in a thin film, an amount of evaporation of the lubricating oil composition is restrained, fluidity thereof is kept for a long time, and lubricity thereof in a contact portion between a resin and a metal is excellent.

MEANS FOR SOLVING THE PROBLEMS

55 **[0012]** In order to solve the above problem(s), the invention provides a lubricating oil composition for high-temperature applications as follows:

(1) a lubricating oil composition for high-temperature applications in an aspect of the invention, containing a component (A) that is an aromatic ester and a component (B) that is a poly-alpha-olefin having a viscosity index of 140

or more;

(2) the lubricating oil composition in the above aspect of the invention, in which a content of the component (A) is in a range from 10 mass% to 95 mass% of a total amount of the composition, and a content of the component (B) is 50 mass% or less of the total amount of the composition;

(3) the lubricating oil composition in the above aspect of the invention, in which the content of the component (A) is in a range from 30 mass% to 80 mass% of the total amount of the composition, and the content of the component (B) is 40 mass% or less of the total amount of the composition;

(4) the lubricating oil composition in the above aspect of the invention, in which the aromatic ester of the component (A) is a pyromellitate ester or a trimellitate ester, and a content of the component (A) is 80 mass% or less of the total amount of the composition;

(5) the lubricating oil composition in the above aspect of the invention, in which the aromatic ester of the component (A) is a pyromellitate ester;

(6) the lubricating oil composition in the above aspect of the invention, in which the component (B) has a kinematic viscosity at 100 degrees C in a range from 10 mm²/s to 400 mm²/s;

(7) the lubricating oil composition in the above aspect of the invention, in which the component (B) is a poly-alpha-olefin manufactured using a metallocene catalyst;

(8) the lubricating oil composition in the above aspect of the invention, further containing a component (C) that is a thickener and has a kinematic viscosity at 40 degrees C of 100 mm²/s or more;

(9) the lubricating oil composition in the above aspect of the invention, in which the component (C) is polybutene having a mass average molecular weight of 1000 to 3000, and a content of the component (C) is 50 mass% or less of the total amount of the composition;

(10) the lubricating oil composition in the above aspect of the invention, further containing a component (D) that is a sulfur-containing triazine antioxidant;

(11) the lubricating oil composition in the above aspect of the invention, further containing a component (E) that is a thiophosphoric acid ester antioxidant;

(12) the lubricating oil composition in the above aspect of the invention, further containing a component (F) that is an amine antioxidant;

(13) the lubricating oil composition in the above aspect of the invention, in which the lubricating oil composition is used in a contact portion between a resin and a metal in use under an atmosphere of a temperature of 150 degrees C or more;

(14) the lubricating oil composition in the above aspect of the invention, in which the resin is engineering plastics; and

(15) the lubricating oil composition in the above aspect of the invention, in which the lubricating oil composition is used in one of a chain, a gear and a bearing.

[0013] According to the above aspect of the invention, a lubricating oil composition for high-temperature applications, in which, under high temperatures and in a thin film, an amount of evaporation of the lubricating oil composition is restrained, fluidity thereof is kept for a long time, and lubricity thereof in a contact portion between a resin and a metal is excellent, can be provided.

DESCRIPTION OF EMBODIMENT(S)

[0014] A lubricating oil composition for high-temperature applications according to an exemplary embodiment of the invention is provided by blending a component (A) that is an aromatic ester and a component (B) that is a poly-alpha-olefin having a viscosity index of 140 or more. The invention will be described below in detail.

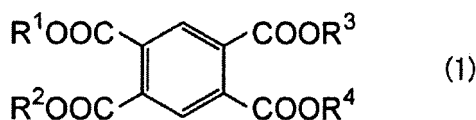
Component (A)

[0015] The component (A) of the lubricating oil composition for high-temperature applications in the exemplary embodiment (hereinafter, referred to as "the composition") is the aromatic ester and corresponds to a base oil of the composition.

[0016] Examples of the aromatic ester as the component (A) are preferably a pyromellitate ester and a trimellitate ester. Among the above examples, the pyromellitate ester is particularly preferable.

[0017] As the pyromellitate ester, a pyromellitate tetraester represented by a formula (1) below is preferably used.

[Formula 1]



[0018] In the pyromellitate tetraester represented by the formula (1), all functional groups of R¹ to R⁴ are hydrocarbyl groups, which may be mutually the same or different. Each of the hydrocarbyl groups are preferably an alkyl group having 6 to 16 carbon atoms, more preferably 6 to 10 carbon atoms, in terms of evaporativity restraint and fluidity.

[0019] Examples of the pyromellitate tetraester represented by the formula (1) include tetra-n-octyl pyromellitate, tetra-3,5,5-trimethylhexyl pyromellitate, tetra-undecyl pyromellitate, and tetraisostearyl pyromellitate. The alkyl group preferably has a linear structure in terms of evaporativity restraint.

[0020] A blending rate of the component (A) in the composition is preferably in a range from 10 mass% to 95 mass% of a total amount of the composition, more preferably in a range from 30 mass% to 80 mass%. When the blending rate falls within the above range, the composition is excellent in a balance between evaporativity restraint and fluidity.

[0021] In the above range, when the aromatic ester of the component (A) is a pyromellitate ester or a trimellitate ester, the blending rate is particularly preferably 80 mass% or less of the total amount of the composition.

Component (B)

[0022] The component (B) of the composition is a poly-alpha-olefin (hereinafter, also referred as PAO) having a viscosity index of 140 or more. When PAO having a viscosity index of 140 or more is blended, an oil film breakage on a resin surface is restrained while an evaporation amount is restrained, so that a surface pressure at which a resin is broken (hereinafter, referred to as a breakage surface pressure) can be improved. The viscosity index is preferably 145 or more, more preferably 150 or more. Note that the viscosity index can be measured in accordance with JIS K 2283.

[0023] PAO (the component (B)) having a viscosity index of 140 or more is preferably exemplified by PAO manufactured using a metallocene catalyst.

[0024] PAO is a polymer (oligomer) of an alpha-olefin. As PAO, such an alpha-olefin oligomer can be used as it is, or can be used after hydrogenation. The alpha-olefin in a form of a monomer preferably has 6 to 20 carbon atoms in terms of the viscosity index and evaporativity. For instance, 1-octene, 1-decene, 1-dodecene and 1-tetradecene are usable as the alpha-olefin. The alpha-olefin more preferably has 8 to 16 carbon atoms, further preferably 10 to 14 carbon atoms. PAO is preferably a dimer, trimer, tetramer and pentamer of the alpha-olefin in terms of a low evaporativity and energy-saving. However, the number of carbon atoms, the blending rate and a polymerization degree of the alpha-olefin are adjustable depending on desired characteristics. As a polymerization catalyst of the alpha-olefin, a metallocene catalyst is used in terms of a low evaporativity and energy-saving.

[0025] For hydrogenating the oligomer, a typical nickel catalyst such as sponge nickel and nickel diatomite and a noble metal catalyst such as palladium activated carbon or ruthenium activated carbon are preferable.

[0026] A kinematic viscosity at 100 degrees C of the component (B) in the composition is preferably in a range from 10 mm²/s to 400 mm²/s.

[0027] A blending rate of the component (B) in the composition is preferably in a range from 5 mass% to 50 mass% of the total amount of the composition, more preferably in a range from 10 mass% to 40 mass%. When the blending rate falls within this range, since an oil film breakage on a contact portion between a resin and a metal is restrained while an evaporation amount is restrained, a breakage surface pressure of the composition can be improved.

Component (C)

[0028] The composition is preferably further blended with a thickener as a component (C).

[0029] Examples of the thickener include polybutene, highly viscous PAO having a kinematic viscosity at 100 degrees C of 100 mm²/s or more, dipentaerythritol ester, tripentaerythritol ester, tetrapentaerythritol ester, ester (polyester) of pentaerythritol partial ester or pentaerythritol and fatty acid, complex ester (obtained by reacting a linear saturated aliphatic carboxylic acid, a linear aliphatic dicarboxylic acid and polyhydric alcohol), polymethacrylate, polyoxyalkylene, and aromatic polyester (polyester of phthalic acid, trimellitic acid and pyromellitic acid).

[0030] Among the above, polybutene is preferable since the composition blended with polybutene can be effectively prevented from dropping off a chain and a gear even under high temperatures.

[0031] Polybutene is exemplified by a mixture of polyisobutylene and poly-n-butene formed by polymerization of olefins having 4 carbon atoms, preferably having a mass average molecular weight (Mw) of 1000 to 3000. Polybutene or

polyisobutylene having a mass average molecular weight (Mw) of 1300 to 2500 is particularly preferable. A polymer formed by 100mass% polyisobutylene or 100 mass% poly-n-butene may be used as polybutene.

[0032] A kinematic viscosity at 100 degrees C of the component (C) in the composition is preferably 100 mm²/s or more.

[0033] A blending rate of the component (C) in the composition is preferably 50 mass% or less of the total amount of the composition, more preferably 30 mass% or less. In the above arrangement, when the component (C) is a polybutene having a mass average molecular weight of 1000 to 3000, the blending rate is particularly preferably 50 mass% or less of the total amount of the composition.

Component (D)

[0034] The composition is preferably further blended with a sulfur-containing triazine antioxidant as a component (D). The component (D) exhibits a low evaporativity, and also exhibits excellent anti-oxidation effect and sludge formation prevention effect even under high temperatures by being contained together with a later-described component (E). The sulfur-containing triazine antioxidant is preferably exemplified by 2,6-di-tert-butyl-4-(4,6-bis(octylthio)-1,3,5-triazine-2-ylamino)phenol.

[0035] A blending rate of the component (D) in the composition is preferably in a range from 0.01 mass% to 5 mass% of the total amount of the composition, more preferably in a range from 0.1 mass% to 3 mass%, in terms of the above effects.

Component (E)

[0036] The composition is preferably further blended with a thiophosphoric acid ester antioxidant as the component (E). The component (E) exhibits a low evaporativity, and also exhibits excellent anti-oxidation effect and wear resistance even under high temperatures by being contained together with the aforementioned component (D). Examples of the thiophosphoric acid ester include a thiophosphite and a thiophosphate, particularly preferably, an alkyl thiophosphite and an aryl thiophosphate, examples of which include trilauryl trithiophosphite, triphenyl thiophosphate, trinonylphenyl thiophosphate and triphenyl phosphorothioate.

[0037] A blending rate of the component (E) in the composition is preferably in a range from 0.01 mass% to 10 mass% of the total amount of the composition, more preferably in a range from 0.5 mass% to 5 mass%, in terms of the above effects.

Component (F)

[0038] The composition is preferably further blended with an amine antioxidant as the component (F). By blending the component (F) in the composition, the anti-oxidation effect and the sludge formation prevention effect can be enhanced. The amine antioxidant is exemplified by a diphenylamine antioxidant, examples of which include diphenylamine, mono-octyl diphenylamine, monononyl diphenylamine, 4,4'-dibutyl diphenylamine, 4,4'-dihexyl diphenylamine, 4,4'-dioctyl diphenylamine, 4,4'-dinonyl diphenylamine, tetrabutyl diphenylamine, tetrahexyl diphenylamine, tetraoctyl diphenylamine, tetranonyl diphenylamine, and 4,4'-bis(α,α -dimethylbenzyl)diphenylamine. The amine antioxidant is also exemplified by a naphthylamine antioxidant, examples of which include α -naphthylamine, phenyl- α -naphthylamine, butylphenyl- α -naphthylamine, hexylphenyl- α -naphthylamine, octylphenyl- α -naphthylamine, and nonylphenyl- α -naphthylamine. Among the above, the diphenylamine antioxidant is preferred to the naphthylamine antioxidant in terms of the effects.

[0039] A blending rate of the component (F) in the composition is preferably in a range from 0.01 mass% to 10 mass% of the total amount of the composition, more preferably in a range from 0.1 mass% to 5 mass%, in terms of the above effects.

[0040] The composition may further contain various additives such as a detergent dispersant, a metal deactivator, an antifoaming agent and a friction modifier (hereinafter, referred to as FM agent) as long as the effects of the invention are not impaired.

[0041] The detergent dispersant is classified into a metal detergent and an ashless dispersant. Examples of the ashless dispersant include polybutenyl succinimide, polybutenyl benzylamine, and polybutenyl amine, each of which has a polybutenyl group having a number average molecular weight of 900 to 3,500, and a derivative of a boron-modified substance and the like of those. One of the ashless dispersants may be contained alone or two or more thereof may be contained in combination. A content of the ashless dispersant(s) is preferably in a range from 0.01 mass% to 10 mass% of the total amount of the composition.

[0042] Examples of the metal detergent include a sulfonate, a phenate, a salicylate and a naphthenate of an alkali metal (e.g., sodium (Na) and potassium (K)) or an alkaline earth metal (e.g., calcium (Ca) and magnesium (Mg)). One of the metal detergents may be used alone, or two or more thereof may be used in combination. A total base number

and a content of the metal detergent(s) may be selected as needed depending on required performance of the lubricating oil. The total base number is 500 mgKOH/g or less according to a perchloric acid method, desirably in a range from 10 mgKOH/g to 400 mgKOH/g. A content of the metal detergent(s) is preferably in a range from 0.1 mass% to 10 mass% or more of the total amount of the composition.

[0043] Examples of the metal deactivator include benzotriazole, a triazole derivative, a benzotriazole derivative and a thiadiazole derivative. A content of the metal deactivator is preferably in a range from 0.01 mass% to 3 mass% or more of the total amount of the composition.

[0044] As the antifoaming agent, a liquid silicone is suitable, and a methylsilicone, a fluorosilicone, a polyacrylate and the like are usable. A content of the antifoaming agent is preferably in a range from 0.0005 mass% to 0.1 mass% of the total amount of the composition.

[0045] It is more preferable to add the FM agent in order to increase the breakage surface pressure. Examples of the FM agent include: sulfur-containing FM agents such as zinc dithiophosphate (ZnDTP), zinc dithiocarbamate (ZnDTC), disulfides, sulfurized olefins, sulfurized fats and oils, sulfurized esters, thiocarbonates, and thiocarbamates; phosphorus-containing FM agents such as phosphite esters, phosphate esters, phosphonate esters and amine salts or metal salts thereof; and sulfur and phosphorus-containing FM agents such as thiophosphite esters, thiophosphate esters, thiophosphonate esters, sulfurized oxymolybdenum organophosphorodithioate (MoDTP), sulfurized oxymolybdenum dithiocarbamate (MoDTC) and amine salts or metal salts thereof. One of the above oil-base agents may be used alone, or two or more thereof may be used in combination.

[0046] In the lubricating oil composition for high-temperature applications in the exemplary embodiment, the amount of evaporation can significantly be reduced and formation of sludge can be restrained, under high temperatures and in a thin film. Further, the lubricating oil composition for high-temperature applications in the exemplary embodiment exhibits an excellent lubricity on the contact portion between the resin such as engineering plastics (e.g., polyether ketone) and the metal in use under the atmosphere of a temperature of 150 degrees C or more. The lubricating oil composition is suitably applicable to a chain, a chain roller, a chain conveyor, a bearing and the like used in a high-temperature furnace, a drying furnace, panelboard manufacturing equipment, a chemical fiber tenter, a resin film tenter and the like.

Example(s)

[0047] Next, the invention will be further described in detail with reference to Examples and Comparatives, which by no means limit the invention.

Examples 1 to 5 and Comparatives 1 to 5

(1) Preparation of Sample Oil

[0048] Base oils and additives described below were mixed at a predetermined content to prepare a lubricating oil composition, which was provided as a sample oil. Blending compositions are shown in Table 1.

(1.1) Base Oil

[0049]

Base Oil 1: Pyromellitate Ester (Component A)

(a tetraester mixture containing a linear alkyl group having 6 to 10 carbon atoms)

Base Oil 2: Trimellitate Ester (Component A)

(a triester containing a linear alkyl group having 10 carbon atoms as an alcohol residue)

Base Oil 3: Pentaerythritol ester

Base Oil 4: Poly-alpha-olefin manufactured using a metallocene catalyst (Component B) (Kinematic Viscosity at 100 degrees C: 15 mm²/s, Viscosity Index: 150)

Base Oil 5: Poly-alpha-olefin manufactured using a metallocene catalyst (Component B) (Kinematic Viscosity at 100 degrees C: 50 mm²/s, Viscosity Index: 180)

Base Oil 6: Poly-alpha-olefin (Kinematic Viscosity at 100 degrees C: 10 mm²/s, Viscosity Index: 139)

Base Oil 7: Polybutene (Component C) (Mw=1400)

Base Oil 8: Polybutene (Component C) (Mw=2300)

(1.2) Additive

[0050]

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(1.2.1) Sulfur-containing Triazine Antioxidant (Component D)
2,6-di-tert-butyl-4-(4,6-bis(octylthio)-1,3,5-triazine-2-ylamino)phenol
(1.2.2) Thiophosphoric Acid Ester Antioxidant (Component E)
Tris(2,4-C₉-C₁₀ isoalkylphenol)thiophosphate
(1.2.3) Amine Antioxidant (Component F)
4-4'-bis(α,α -dimethylbenzyl)diphenylamine
(1.2.4) Other Additives
Metal deactivator: benzotriazole

FM agent 1 (zinc dithiophosphate based): ZnDTP
FM agent 2 (molybdenum based): MoDTP

Table I

		Ex.	1	Ex.	1-1	Ex.	2	Ex.	2-1	Ex.	3	Ex.	3-1	Ex.	4	Ex.	4-1	Ex.	5	Comp.	1	Comp.	2	Comp.	3	Comp.	4	Comp.	5	
Blending Composition (mass%)	Base Oil	pyromellitate ester (component A)	63.6	63.5	66.6	66.5	66.6	66.5	66.6	66.5	66.6	66.5	66.6	66.5	66.6	66.5	66.6	66.5	63.5			74.6								
		trimellitate ester (component A)																	42.5	41.6			64.6							
		pentaerythritol ester																												
		metallocene PAO (component B) (100°C kinematic viscosity: 15mm ² /s, VI: 150)	25.0	25.0								25.0	25.0	25.0	25.0	25.0	25.0	36.0	36.0	25.0										35.0
		metallocene PAO (component B) (100°C kinematic viscosity: 50mm ² /s, VI: 180)			25.0	25.0																								
		PAO(100°C kinematic viscosity: 10mm ² /s, VI: 139)																				35.0								
		Polybutene (component C)(Mw 1400)			5.0	5.0																								
		Polybutene (component C)(Mw 2300)	8.0	8.0								15.0	15.0	15.0	15.0	18.0	18.0	18.0	8.0	8.0	20.0									20.0
		Sulfur-containing triazine antioxidant (component D)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
		Thiophosphoric acid ester antioxidant (component E)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Others	Amine antioxidant (component F)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
	Metal deactivator (benzotriazole)	0.1		0.1			0.1			0.1				0.1						0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
	FM agent 1 (zinc dithiophosphate based)		0.1			0.1			0.1				0.1				0.1													
	FM agent 2 (molybdenum based)																		0.1											
Evaluation Results	Thin Film Evaporation Test	230°C, 20H	12	12	12	12	12	12	12	12	12	12	12	20	20	20	18	45	13	45	56	45								
		Fluidity after test	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	B	C	B						
		Evaporation rate after test (mass%)	22	22	23	23	24	24	24	24	24	24	24	24	44	44	44	33	64	35	70	81	64							
	Pin-on-Disk Test	Fluidity after test	A	A	A	A	A	A	A	A	A	A	A	B	B	B	A	C	A	C	C	C	C							
		Pin breakage surface pressure (Mpa)	6.5	7.0	6.5	7.0	4.5	5.0	7.5	3.5	2.5	3.0	4.0	4.5	5.0	5.0	7.5	3.5	2.5	3.0	4.0	4.5								
Kinematic Viscosity (40°C)		150	150	150	150	150	150	260	260	260	260	260	260	260	260	260	150	260	260	260	260	260	260	260	260	260	260	260	260	260

(2) Evaluation Method

[0051] The above sample oils were evaluated according to the following method. Results are shown in Table 1.

5 Thin Film Evaporation Test

Evaporation Rate

10 **[0052]** A container and a thermostat air bath for the thermal stability test of lubricating oils (JIS K 2540) were used. A sample oil (1 g) was put in the container and was left to stand still for 20 hours or 40 hours at 230 degrees C. Subsequently, an evaporation amount of the sample oil was measured. The evaporation amount was divided by the original amount of the sample oil, and the obtained value was represented in percentage to provide an evaporation rate (mass%). Note that air was arranged to flow into the thermostat air bath at a flow rate of 10 L/hr during heating.

15 Fluidity

[0053] In the above test, after calculating the evaporation rate, the container was inclined by 45 degrees. Fluidity of the residual oil (thin film residue) was evaluated based on the following scale.

- 20 A: The residual oil does not adhere and drops off the container within 15 minutes.
B: A part of the residual oil adheres while another part thereof drops off the container within 15 minutes.
C: The residual oil adheres and does not drop off the container even after the elapse of 15 minutes.

Friction/Wear Test

25 **[0054]** The friction test for the sample oils was conducted using a pin-on-disk wear tester (in accordance with JIS K7128) under the following conditions.

1) Test Piece

- 30 **[0055]** Pin material: 5.0-mm diameter, 8.0-mm height, polyether ketone (PEK) (manufactured by Victrex PLC)
[0056] Disc material: 60.0-mm diameter, 5.0-mm thickness, CrMo steel,

- 35 2) Sliding speed: 700 m/min
3) Surface pressure: started from 0.5 MPa and increased by 0.5 MPa
4) Temperature: 160 degrees C
5) Measurement method: a test pin was slid on the test piece and a surface pressure (MPa) at which the test pin was broken was obtained.

40 Kinematic Viscosity

[0057] A kinematic viscosity at 40 degrees C of each of the lubricating oil compositions was measured by a method in accordance with JIS K2283.

45 Evaluation Result

[0058] From the results of Table 1, in all the sample oils of Examples 1 to 5 according to the invention, lubricity and wear resistance at high temperatures are, of course, excellent and the amount of evaporation is restrained in a thin film and under high temperatures while fluidity is kept for a long time. Accordingly, by using the lubricating oil composition for high-temperature applications according to the invention, a life time and a maintenance interval of a high thermal device (e.g., a chain and a bearing driven in an oven) can be prolonged. Moreover, reduction of power consumption required for operating the high thermal device can contribute to cost saving and energy saving.

50 **[0059]** Since a typical PAO is used in place of the component B in Comparative 1, the evaporativity is high and the breakage surface pressure is low. In Comparative 2, the evaporativity is low due to a high blending rate of the component (A) (pyromellitate), but the breakage surface pressure is low since the component (B) is not contained. In Comparative 3, the evaporativity is low due to a high blending rate of the component (A) (trimellitate), but the breakage surface pressure is low since the component (B) is not contained. In Comparative 4, the breakage surface pressure is low since the component (B) is not contained, but the evaporativity is particularly high since an aliphatic ester is used in place of

the component (A). In Comparative 5, the breakage surface pressure is increased since the components (B) and (C) are contained, but the evaporativity is high since an aliphatic ester is used in place of the component (A).

5 Claims

1. A lubricating oil composition for high-temperature applications, comprising: a component (A) that is an aromatic ester; and
a component (B) that is a poly-alpha-olefin having a viscosity index of 140 or more.
2. The lubricating oil composition according to claim 1, wherein
a content of the component (A) is in a range from 10 mass% to 95 mass% of a total amount of the composition, and
a content of the component (B) is 50 mass% or less of the total amount of the composition.
3. The lubricating oil composition according to claim 2, wherein
the content of the component (A) is in a range from 30 mass% to 80 mass% of the total amount of the composition, and
the content of the component (B) is 40 mass% or less of the total amount of the composition.
4. The lubricating oil composition according to any one of claims 1 to 3, wherein
the aromatic ester of the component (A) is a pyromellitate ester or a trimellitate ester, and
a content of the component (A) is 80 mass% or less of the total amount of the composition.
5. The lubricating oil composition according to claim 4, wherein
the aromatic ester of the component (A) is a pyromellitate ester.
6. The lubricating oil composition according to any one of claims 1 to 5, wherein
the component (B) has a kinematic viscosity at 100 degrees C in a range from 10 mm²/s to 400 mm²/s.
7. The lubricating oil composition according to any one of claims 1 to 6, wherein the component B is a poly-alpha-olefin manufactured using a metallocene catalyst.
8. The lubricating oil composition according to any one of claims 1 to 7, further comprising:
a component (C) that is a thickener and has a kinematic viscosity at 40 degrees C of 100 mm²/s or more.
9. The lubricating oil composition according to claim 8, wherein
the component (C) is polybutene having a mass average molecular weight of 1000 to 3000, and
a content of the component (C) is 50 mass% or less of the total amount of the composition.
10. The lubricating oil composition according to any one of claims 1 to 9, further comprising:
a component (D) that is a sulfur-containing triazine antioxidant.
11. The lubricating oil composition according to any one of claims 1 to 10, further comprising:
a component (E) that is a thiophosphoric acid ester antioxidant.
12. The lubricating oil composition according to any one of claims 1 to 11, further comprising:
a component (F) that is an amine antioxidant.
13. The lubricating oil composition according to any one of claims 1 to 12, wherein
the lubricating oil composition is used in a contact portion between a resin and a metal in use under an atmosphere
of a temperature of 150 degrees C or more.
14. The lubricating oil composition according to claim 13, wherein
the resin is engineering plastics.

- 15.** The lubricating oil composition according to any one of claims 1 to 14, wherein the lubricating oil composition is used in one of a chain, a gear and a bearing.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/056451

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)

C10M111/04, C10M169/04, C10M105/32, C10M105/36, C10M107/02, C10M133/12, C10M133/42, C10M137/10, C10M143/06, C10N20/02, C10N20/04, C10N30/08, C10N40/02, C10N40/04, C10N40/32

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/115193 A1 (Idemitsu Kosan Co., Ltd.), 22 September 2011 (22.09.2011), claims 1 to 8; paragraphs [0008], [0011] to [0019]; examples 1 to 5 & US 2013/0012417 A1 & EP 2548940 A1 & WO 2011/115193 A1 & CN 102791842 A	1-15
Y	JP 2000-192071 A (Idemitsu Kosan Co., Ltd.), 11 July 2000 (11.07.2000), claims 1 to 7; paragraphs [0001], [0003]; examples 1 to 6 & US 6465400 B1 & EP 1154011 A1 & WO 2000/039256 A1 & TW 531559 B & CN 1332784 A	1-15

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

* Special categories of cited documents:

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search
16 June, 2014 (16.06.14)Date of mailing of the international search report
24 June, 2014 (24.06.14)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/056451

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2010/084966 A1 (Idemitsu Kosan Co., Ltd.), 29 July 2010 (29.07.2010), claims 1 to 6; paragraphs [0011], [0063], [0069]; examples 1, 2; comparative examples 1 to 3 & US 2011/0275867 A1 & EP 2383328 A1 & CN 102292421 A	1-15
Y	JP 2009-500489 A (Exxonmobil Chemical Patents Inc.), 08 January 2009 (08.01.2009), claims 1 to 19; examples 1 to 22 & US 2007/0000807 A1 & EP 1907516 A1 & WO 2007/005094 A1 & CA 2608181 A & AU 2006266482 A & MX 2007016285 A	1-15
Y	JP 2006-176760 A (Mitsui Chemicals, Inc.), 06 July 2006 (06.07.2006), claims 1 to 6; paragraph [0011]; examples 1 to 10; comparative examples 1 to 4; table 1 & US 2006/0116303 A1 & EP 1661921 A1 & CN 1782044 A	1-15
A	JP 2000-1681 A (New Japan Chemical Co., Ltd.), 07 January 2000 (07.01.2000), claims 1 to 6; examples 1 to 14 (Family: none)	1-15

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INTERNATIONAL SEARCH REPORT

International application No.

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Continuation of A. CLASSIFICATION OF SUBJECT MATTER
(International Patent Classification (IPC))

*C10M111/04(2006.01)i, C10M169/04(2006.01)i, C10M105/32(2006.01)n,
C10M105/36(2006.01)n, C10M107/02(2006.01)n, C10M133/12(2006.01)n,
C10M133/42(2006.01)n, C10M137/10(2006.01)n, C10M143/06(2006.01)n,
C10N20/02(2006.01)n, C10N20/04(2006.01)n, C10N30/08(2006.01)n,
C10N40/02(2006.01)n, C10N40/04(2006.01)n, C10N40/32(2006.01)n*

(According to International Patent Classification (IPC) or to both national
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005314650 A [0007]