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(54) LUBRICANT OIL COMPOSITION

(57) A lubricating oil composition of the invention contains: a lubricating base oil; a component (A) that is a polymethacrylate having a mass average molecular weight in a range from 30,000 to 600,000; and a component (B) that is an olefin copolymer having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of SSI (Shear Stability Index).

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Description

TECHNICAL FIELD

[0001] The present invention relates to a lubricating oil composition.

BACKGROUND ART

[0002] In response to the demand for reducing environmental burden, reduction of CO_2 has strongly been desired worldwide as a countermeasure against global warming. An improvement in a fuel efficiency of an automobile is crucial for reduction of CO_2. A small and light-weight engine having a high power has been increasingly used. Accordingly, it is concerned that piston detergency of an engine oil may be deteriorated by an increase in heat load.

[0003] Moreover, a fuel-saving performance of the engine oil also needs to be further improved. In order to improve the fuel-saving performance of the engine oil, an improvement in temperature-viscosity characteristics is effective for reducing friction in a fluid lubrication region. In order to improve the temperature-viscosity characteristics, a viscosity index improver is used. As the viscosity index improver, a polymethacrylate (PMA), a polyolefin copolymer (OCP) and the like are used (Patent Literatures 1 to 4). Particularly, PMA-based viscosity index improver that is excellent in temperature-viscosity characteristics is often used. However, the PMA-based viscosity index improver is not satisfactory in terms of the piston detergency under severer conditions of high temperatures and also may not be so favorable in terms of the shear stability. Accordingly, a lubricating oil composition exhibiting an excellent fuel-saving performance and maintaining favorable piston detergency and shear stability has been demanded.

CITATION LIST

PATENT LITERATURE(S)

[0004]

Patent Literature 1: JP-A-2008-184569
Patent Literature 2: JP-A-2010-280817
Patent Literature 3: JP-A-2008-248139
Patent Literature 4: JP-A-2010-043250

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] However, the lubricating oil compositions disclosed in Patent Literatures 1 to 4 cannot maintain favorable piston detergency and shear stability although exhibiting an excellent fuel-saving performance.

[0006] An object of the invention is to provide a lubricating oil composition exhibiting an excellent fuel-saving performance and capable of maintaining favorable piston detergency and shear stability.

MEANS FOR SOLVING THE PROBLEMS

[0007] In order to solve the above problem, the invention provides a lubricating oil composition as follows.

(1) According to an aspect of the invention, a lubricating oil composition includes: a lubricating base oil; a component (A) that is a polymethacrylate having a mass average molecular weight in a range from 30,000 to 600,000; and a component (B) that is an olefin copolymer having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of a shear stability index.

(2) With the above arrangement, the component (A) is a polymethacrylate having a mass average molecular weight in a range from 200,000 to 600,000, and the shear stability index of the component (B) is 30 or less.

(3) With the above arrangement, when the lubricating oil composition has a kinematic viscosity at 100 degrees C in a range from 9.3 mm^2/s to less than 12.5 mm^2/s, the kinematic viscosity at 100 degrees C of the lubricating oil composition after a shear stability test is 9.3 mm^2/s or more.

(4) With the above arrangement, the kinematic viscosity at 100 degrees C of the lubricating oil composition after the shear stability test is 10 mm^2/s or less.

(5) With the above arrangement, when the lubricating oil composition has a kinematic viscosity at 100 degrees C

in a range from 5.6 mm^2/s to less than 9.3 mm^2/s, the kinematic viscosity at 100 degrees C of the lubricating oil composition after a shear stability test is 5.6 mm^2/s or more.

(6) With the above arrangement, the lubricating oil composition has a viscosity index of 120 or more.

(7) With the above arrangement, a phosphorus content is 0.12 mass% or less of a total amount of the composition.

(8) With the above arrangement, the lubricating oil composition further includes a metal detergent, a content of the metal detergent being in a range from 0.05 mass% to 0.3 mass% of the total amount of the composition in terms of metals.

(9) With the above arrangement, the lubricating oil composition further includes at least one ashless dispersant selected from the group consisting of polybutenyl succinimide and polybutenyl succinimide borate.

(10) With the above arrangement, the lubricating oil composition is used for an internal combustion engine.

[0008] A lubricating oil composition according to the above aspect of the invention contains: a lubricating base oil; a component (A) that is a polymethacrylate having a mass average molecular weight in a range from 30,000 to 600,000; and a component (B) that is an olefin copolymer having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of SSI (Shear Stability Index).

[0009] A manufacturing method of a lubricating oil composition according to the above another aspect of the invention includes blending: a lubricating base oil; a component (A) that is a polymethacrylate having a mass average molecular weight in a range from 30,000 to 600,000; and a component (B) that is an olefin copolymer having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of SSI (Shear Stability Index).

[0010] According to the above aspect of the invention, a lubricating oil composition exhibiting an excellent fuel-saving performance and maintaining favorable piston detergency and shear stability can be provided.

DESCRIPTION OF EMBODIMENT(S)

[0011] A lubricating oil composition in an exemplary embodiment of the invention (hereinafter, occasionally simply referred to as "the present composition") is provided by blending: a lubricating base oil; a component (A) that is a polymethacrylate having a mass average molecular weight in a range from 30,000 to 600,000; and a component (B) that is an olefin copolymer having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of SSI (Shear Stability Index). The present composition will be described in detail below.

Lubricating Base Oil

[0012] The lubricating base oil used in the present composition may be a mineral lubricating base oil or a synthetic lubricating base oil. The kind of the lubricating base oil is not particularly limited but may be suitably selected from any mineral oil and synthetic oil that have been conventionally used as a lubricating base oil for an internal combustion engine. A viscosity index of the lubricating oil composition is preferably 120 or more in terms temperature-viscosity characteristics and shear stability.

[0013] Examples of the mineral lubricating base oil include a paraffinic mineral oil, an intermediate mineral oil and a naphthenic mineral oil. Examples of the synthetic lubricating base oil include polybutene, polyolefin, polyol ester, diacid ester, phosphate, polyphenyl ether, polyglycol, alkylbenzene and alkylnaphthalene. Examples of polyolefin include an α-olefin homopolymer and an α-olefin copolymer. One of the above base oils may be used alone or a combination of two or more thereof may be used.

Component (A)

[0014] The component (A) of the present composition is a polymethacrylate (PMA) having a mass average molecular weight in a range from 30,000 to 600,000. When the mass average molecular weight is less than the above lower limit, the fuel-saving performance is deteriorated. On the other hand, when the mass average molecular weight exceeds the above upper limit, the shear stability of the lubricating oil composition is lowered. The mass average molecular weight of the component (A) is more preferably in a range from 200,000 to 600,000, further preferably in a range from 350,0000 to 450,000, particularly preferably in a range from 380,0000 to 420,000.

[0015] The polymethacrylate may be a non-dispersed polymethacrylate or a dispersed polymethacrylate.

[0016] A content of the component (A) is preferably in a range from 1 mass% to 20 mass% of a total amount of the composition, more preferably in a range from 2 mass% to 15 mass%. When the content is less than the above lower limit, a viscosity index-improving effect tends to be insufficient. On the other hand, when the content exceeds the above upper limit, the shear stability and piston detergency of the lubricating oil composition tend to be lowered.

Component (B)

[0017] The component (B) of the present composition is an olefin copolymer (OCP) having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of SSI. When the 95% weight-loss temperature exceeds 500 degrees C, the piston detergency of the lubricating oil composition is lowered. When SSI exceeds 40, the shear stability of the lubricating oil composition is lowered. The SSI of the component (B) is more preferably 30 or less, further preferably in a range from 2 to 30, particularly preferably in a range from 2 to 20, most preferably in a range from 6 to 19. The 95% weight-loss temperature of the component (B) is more preferably 480 degrees C or less, particularly preferably in a range from 461 degrees C to 476 degrees C.

[0018] The 95% weight-loss temperature can be measured using a known differential thermal analyzer. Test conditions are, for instance, in nitrogen, a flow rate of 200 mL/min, a temperature-increasing rate of 10 degrees C/min, use of a platinum pan, and a sample amount of 6 mg. SSI can be calculated by: measuring a kinematic viscosity at 100 degrees C of an unused oil, a kinematic viscosity at 100 degrees C of the oil after a shear stability test (ASTM D6278) and a kinematic viscosity at 100 degrees C of the base oil; and applying the obtained measurement values to a formula: (kinematic viscosity of an unused oil - kinematic viscosity of the oil after the shear stability test) / (kinematic viscosity of the unused oil - kinematic viscosity of the base oil) X 100.

[0019] Examples of the olefin copolymer include an ethylene-propylene copolymer, an ethylene-butylene copolymer, a styrene-isoprene copolymer and a styrene-butadiene copolymer.

[0020] A content of the component (B) is preferably in a range from 1 mass% to 15 mass% of the total amount of the composition, more preferably in a range from 2 mass% to 10 mass%.

Other Additives

[0021] The present composition may be added with various additives described below as long as the advantages of the invention are not hampered. Specifically, a detergent dispersant, antioxidant, antiwear agent or extreme pressure agent, pour point depressant, friction reducing agent, metal deactivator, rust inhibitor, surfactant or demulsifier, antifoaming agent, anticorrosive agent, friction modifier, oiliness agent and acid scavenger can be suitably blended in use.

[0022] As the detergent dispersant, an ashless dispersant and a metal detergent are usable. Examples of the ashless dispersant include a succinimide compound, a boron imide compound, a Mannich dispersant and an acid amide compound. Among the above, polybutenyl succinimide and polybutenyl succinimide borate are preferable. One of the above ashless dispersants may be used alone or a combination of two or more thereof may be used.

[0023] A content of the ashless dispersant is not particularly limited, but is preferably in a range from 0.1 mass% to 10 mass% of the total amount of the composition.

[0024] Examples of the metal detergent include alkali metal sulfonate, alkali metal phenate, alkali metal salicylate, alkali metal naphthenate, alkaline earth metal sulfonate, alkaline earth metal phenate, alkaline earth metal salicylate, and alkaline earth metal naphthenate. Among the above metal detergents, alkaline earth metal salicylate is preferable. Among the above alkaline earth metals, calcium and magnesium are preferable. One of the above metal detergents may be used alone or a combination of two or more thereof may be used.

[0025] A content of the metal detergent is not particularly limited, but is preferably in a range from 0.05 mass% to 0.3 mass% of the total amount of the composition in terms of metals.

[0026] Examples of the antioxidant include an amine antioxidant, a phenolic antioxidant and a sulfur antioxidant. One of the above antioxidants may be used alone or a combination of two or more thereof may be used.

[0027] A content of the antioxidant is not particularly limited, but is preferably in a range from 0.05 mass% to 7 mass% of the total amount of the composition.

[0028] Examples of the antiwear agent or extreme pressure agent include phosphorus extreme pressure agent and sulfur extreme pressure agent. Examples of the phosphorus extreme pressure agent include phosphites, phosphates, thiophosphates and an amine salt or a metal salt thereof. Examples of the sulfur extreme pressure agent include an olefin sulfide, a sulfurized fat and oil, an ester sulfide, thiocarbonates, dithiocarbamates and polysulfides. One of the above antiwear agent or extreme pressure agent may be used alone or a combination of two or more thereof may be used.

[0029] A content of the antiwear agent or extreme pressure agent is not particularly limited, but is preferably in a range from 0.1 mass% to 10 mass% of the total amount of the composition.

[0030] The present composition usually contains the blended components per se. However, the present composition includes a composition of the blended components, at least a part of which may be reacted to become a compound different from the blended components.

[0031] A manufacturing method of a lubricating oil composition in the exemplary embodiment includes blending the lubricating base oil, the component (A) and the component (B). In the above manufacturing method, various additives described above may be further added to the lubricating base oil as needed.

Lubricating Oil Composition

[0032] The present composition prepared based on the above blend composition is not particularly limited, but preferably satisfies the following conditions.

[0033] The present composition preferably has a kinematic viscosity at 100 degrees C in a range from 2 mm^2/s to 20 mm^2/s, more preferably in a range from 5.6 mm^2/s to less than 12.5 mm^2/s. The kinematic viscosity can be measured by a method of JIS K 2283.

[0034] When the kinematic viscosity at 100 degrees C is in a range from 9.3 mm^2/s to less than 12.5 mm^2/s, the kinematic viscosity at 100 degrees C after the shear stability test is preferably 9.3 mm^2/s or more, more preferably in a range from 9.3 mm^2/s to 10 mm^2/s.

[0035] When the kinematic viscosity at 100 degrees C is in a range from 5.6 mm^2/s to less than 9.3 mm^2/s, the kinematic viscosity at 100 degrees C after the shear stability test is preferably 5.6 mm^2/s or more.

[0036] When the kinematic viscosity at 100 degrees C after the shear stability test is less than the lower limit, the shear stability tends to be insufficient. For instance, particularly, when a viscosity grade of the present composition is 5W-30, the kinematic visocity of the present composition cannot achieve a stay-in-grade. On the other hand, when the kinematic viscosity at 100 degrees C after the shear stability test exceeds the upper limit, the fuel-saving performance tends to be deteriorated. The shear stability test can be conducted by a test method defined in ASTM D6278.

[0037] The viscosity index is preferably 150 or more, more preferably 170 or more. When the viscosity index is less than the lower limit, temperature dependency of the viscosity is adversely increased. The viscosity index can be measured by a method of JIS K 2283.

[0038] A phosphorus content of the present composition is preferably 0.12 mass% or less of the total amount of the composition in order to decrease a phosphorus content in the present composition.

Examples

[0039] Next, the invention will be further described in detail based on Examples, which by no means limit the invention.

Examples 1 to 3 and Comparatives 1 to 6

[0040] In Examples and Comparatives, lubricating oil compositions (hereinafter, also referred to as sample oils) shown in Table 1 were prepared using the following base oils and additives. Note that the viscosity grade of each of the sample oils was adjusted to 5W-30 in performing experiments.

[0041]

(1) Lubricating Base Oil: hydrorefined base oil with a kinematic viscosity at 40 degrees C of 19.6 mm^2/s, a kinematic viscosity at 100 degrees C of 4.2 mm^2/s, a viscosity index of 122; %CA of 0.0, and a sulfur content of less than 10 ppm by mass.
(2) Viscosity Index Improver PMA1: a polymethacrylate with a mass average molecular weight of 380,000
(3) Viscosity Index Improver PMA2: a polymethacrylate with a mass average molecular weight of 420,000
(4) Viscosity Index Improver PMA3: a polymethacrylate with a mass average molecular weight of 25,000
(5) Viscosity Index Improver OCP1: an olefin copolymer with a shear stability index of 6 and a 95% weight-loss temperature of 464 degrees C as calculated by differential thermal analysis
(6) Viscosity Index Improver OCP2: an olefin copolymer with a shear stability index of 15 and a 95% weight-loss temperature of 476 degrees C as calculated by differential thermal analysis
(7) Viscosity Index Improver OCP3: an olefin copolymer with a shear stability index of 19 and a 95% weight-loss temperature of 461 degrees C as calculated by differential thermal analysis
(8) Viscosity Index Improver OCP4: an olefin copolymer with a shear stability index of 50 and a 95% weight-loss temperature of 480 degrees C as calculated by differential thermal analysis
(9) Viscosity Index Improver OCP5: an olefin copolymer with a shear stability index of 20 and a 95% weight-loss temperature of 520 degrees C as calculated by differential thermal analysis
(10) Zinc Dialkyldithiophosphate A: primary alkyl zinc dialkyldithiophosphate with a zinc content of 8.9 mass% and a phosphorus content of 7.4 mass%
(11) Zinc Dialkyldithiophosphate B: secondary alkyl zinc dialkyldithiophosphate with a zinc content of 9.0 mass% and a phosphorus content of 8.2 mass%
(12) Antioxidant A: amine antioxidant
(13) Antioxidant B: phenolic antioxidant
(14) Metal Detergent A: overbased calcium salicylate with a base number of 350 mg KOH/g (perchloric acid method) and a calcium content of 12.1 mass%

(15) Metal Detergent B: overbased calcium salicylate with a base number of 225 mg KOH/g (perchloric acid method) and a calcium content of 7.8 mass%

(16) Polybutenyl Succinic Bisimide: a number average molecular weight of the polybutenyl group being 2000; a base number of 11.9 mg KOH/g (perchloric acid method); and a nitrogen content of 0.99 mass%

(17) Polybutenyl Succinic Monoimide Borate: a number average molecular weight of the polybutenyl group being 1000; a base number of 25 mg KOH/g (perchloric acid method); a nitrogen content of 1.23 mass%; and a boron content of 1.3 mass% (18) Other Additives: a pour point depressant; a rust inhibitor; and the like

[0042] Next, properties and characteristics of each of the sample oils were measured or calculated. Measurement methods or calculation methods are described below. Results are shown in Table 1.

(1) Kinematic Viscosities at 40 degrees C and 100 degrees C and Viscosity Index

[0043] Measurement was conducted in accordance with "Test Method of Kinematic Viscosity of Petroleum Products" defined in JIS K 2283.

(2) High Temperature High Shear Viscosity (HTHS viscosity at 150 degrees C)

[0044] Measurement was conducted by a method defined in ASTM D4683 using a TBS (Tapered Bearing Simulator) high temperature viscometer.

(3) Kinematic Viscosity (at 100 Degrees C) after Shear Stability Test

[0045] A shear stability test (30 cycles) was conducted by a test method defined in ASTM D6278. After the test, a kinematic viscosity at 100 degrees C was measured in accordance with "Test Method of Kinematic Viscosity of Petroleum Products" defined in JIS K 2283.

(4) Motoring Torque

[0046] A test device below was filled with each of the sample oils. A motoring torque test was conducted to measure a motoring torque. Test conditions are shown below. Note that lower motoring torque indicates more favorable fuel-saving performance.

[0047] Test Device: an engine motoring-driving torque measurement machine

[0048] Sample Engine: an in-line four-cylinder gasoline engine (2 liter displacement, a roller type valve train system)

[0049] Test Conditions: an oil temperature of 60 degrees C and 100 degrees C; and revolution rate of 1500 rpm

[0050] Evaluation Item: torque (unit: N·m) when the engine was driven.

(5) Panel Coking Test

[0051] An amount of deposit was measured using a test device below. Test conditions are shown below. Note that less mount of the deposit in the panel coking test indicates more favorable piston detergency.

[0052] Test device: panel coking (panecon) test machine

[0053] Test Conditions: panel temperature of 300 degrees C; an oil temperature of 100 degrees C; and a duration time of three hours (operation of splashing for 15 seconds and halting for 45 seconds)

[0054] Evaluation Item: an amount of the deposit on the panel after the test

Table 1

				Examples			Comparatives					
				1	2	3	1	2	3	4	5	6
blend composition (mass%)	lubricating base oil			rest	rest	rest	rest	rest	rest	rest	rest	rest
	(component A) viscosity index improver	PMA1	–	11.50	–	–	19.00	–	–	–	–	–
		PMA2	–	–	10.50	10.50	–	15.00	–	7.50	10.00	–
	viscosity index improver	PMA3	–	–	–	–	–	–	–	–	–	6.00
	(component B) viscosity index improver	OCP1	SSI 6	–	6.45	–	–	–	–	–	–	–
		OCP2	SSI 15	3.80	–	–	–	–	–	–	–	–
		OCP3	SSI 19	–	–	3.30	–	–	10.90	–	–	3.30
	viscosity index improver	OCP4	SSI 50	–	–	–	–	–	–	5.40	–	–
		OCP5	SSI 20	–	–	–	–	–	–	–	4.00	–
	zinc dialkyldithiophosphate A			0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	zinc dialkyldithiophosphate B			1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	antioxidant A			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	antioxidant B			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	metal detergent A			1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	metal detergent B			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	polybutenyl succinic bisimide			4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	polybutenyl succinic monoimide borate			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	other additives			0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
evaluation results	kinematic viscosity	@40°C	mm^2/s	47.4	43.3	44.4	42.4	39.8	56.8	47.8	45.5	53.2
		@100°C	mm^2/s	10.4	10.4	10.5	10.4	10.4	11.1	10.4	10.5	9.6
	viscosity index	–	–	215	239	236	247	264	192	214	230	170
	high temperature high shear viscosity	@150°C	mPa·s	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	kinematic viscosity after shear stability test	@100°C	mm^2/s	9.3	9.3	9.3	8.9	8.9	10.6	8.8	9.3	9.4
	motoring torque	@60°C	N·m	10.7	10.5	10.6	10.5	10.4	11	10.7	10.6	10.8
		@100°C	N·m	8.5	8.5	8.5	8.5	8.5	8.6	8.6	8.5	8.6
	amount of deposit in panel coking test	@300°C	mg	95	86	88	142	135	60	90	110	100

[0055] As obvious from the results shown in Table 1, it was observed that the lubricating oil composition of the invention (in Examples 1 to 3) maintained the kinematic viscosity after the shear stability test at a stay-in-grade kinematic viscosity of 9.3 mm^2/s or more (i.e., favorable shear stability), provided less amount of the deposit in the panel coking test (i.e., favorable piston detergency), and exhibited a low motoring torque (i.e., favorable fuel-saving performance). On the other hand, in the sample oils of Comparatives I and 2, it was found that the motoring torque was low but the shear stability and the piston detergency were deteriorated since only the polymethacrylate was contained. Moreover, in the sample oil of Comparative 3 containing only the olefin copolymer, it was found that the motoring torque was increased. In the sample oil of Comparative 4, it was found that the kinematic viscosity after the shear stability test did not satisfy the stay-in-grade kinematic viscosity (9.3 mm^2/s or more) since the olefin copolymer having a poor shear stability (i.e., a high SSI) was contained. In the sample oil of Comparative 5, it was found that the piston detergency was deteriorated since the olefin copolymer having 500 degrees C or more of the 95% weight-loss temperature calculated by the differential thermal analysis was contained. In the sample oil of Comparative 6, it was found that the temperature-viscosity characteristics were deteriorated and the motoring torque was increased (i.e., poor fuel-saving performance) since the amount of the contained polymethacrylate was below the lower limit of the range of the molecular weight of the invention.

Claims

1. A lubricating oil composition comprising:

a lubricating base oil;
a component (A) that is a polymethacrylate having a mass average molecular weight in a range from 30,000 to 600,000; and
a component (B) that is an olefin copolymer having a 95% weight-loss temperature of 500 degrees C or less as calculated by differential thermal analysis and having 40 or less of a shear stability index.

2. The lubricating oil composition according to claim 1, wherein
the component (A) is a polymethacrylate having a mass average molecular weight in a range from 200,000 to 600,000, and
the shear stability index of the component (B) is 30 or less.

3. The lubricating oil composition according to claim 1 or 2, wherein
when the lubricating oil composition has a kinematic viscosity at 100 degrees C in a range from 9.3 mm^2/s to less than 12.5 mm^2/s, the kinematic viscosity at 100 degrees C of the lubricating oil composition after a shear stability test is 9.3 mm^2/s or more.

4. The lubricating oil composition according to claim 3, wherein
the kinematic viscosity at 100 degrees C of the lubricating oil composition after the shear stability test is 10 mm^2/s or less.

5. The lubricating oil composition according to claim 1 or 2, wherein
when the lubricating oil composition has a kinematic viscosity at 100 degrees C in a range from 5.6 mm^2/s to less than 9.3 mm^2/s, the kinematic viscosity at 100 degrees C of the lubricating oil composition after a shear stability test is 5.6 mm^2/s or more.

6. The lubricating oil composition according to any one of claims 1 to 5, wherein
the lubricating oil composition has a viscosity index of 120 or more.

7. The lubricating oil composition according to any one of claims 1 to 6, wherein
a phosphorus content is 0.12 mass% or less of a total amount of the composition.

8. The lubricating oil composition according to any one of claims 1 to 7, further comprising:

a metal detergent, a content of the metal detergent being in a range from 0.05 mass% to 0.3 mass% of the total amount of the composition in terms of metals.

9. The lubricating oil composition according to any one of claims 1 to 8, further comprising:

at least one ashless dispersant selected from the group consisting of polybutenyl succinimide and polybutenyl succinimide borate.

10. The lubricating oil composition according to any one of claims 1 to 9, wherein the lubricating oil composition is used for an internal combustion engine.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/054815

A. CLASSIFICATION OF SUBJECT MATTER
C10M157/00(2006.01)i, *C10M161/00*(2006.01)i, *C10M133/16*(2006.01)n, *C10M133/56*(2006.01)n, *C10M143/00*(2006.01)n, *C10M145/14*(2006.01)n, *C10N20/00*(2006.01)n, *C10N20/02*(2006.01)n, *C10N20/04*(2006.01)n,
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)
C10M157/00, C10M161/00, C10M133/16, C10M133/56, C10M143/00, C10M145/14, C10N20/00, C10N20/02, C10N20/04, C10N30/00, C10N30/04, 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	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 55-112298 A (Roehm GmbH), 29 August 1980 (29.08.1980), & US 4290925 A & EP 14746 A1 & DE 2905954 A1	1-10
A	JP 2000-087070 A (Nippon Mitsubishi Oil Corp.), 28 March 2000 (28.03.2000), & CN 1247219 A	1-10
A	JP 2011-195734 A (Idemitsu Kosan Co., Ltd.), 06 October 2011 (06.10.2011), & US 2013/0029892 A1 & WO 2011/115265 A1 & CN 102782107 A	1-10
A	JP 2008-248139 A (Nippon Oil Corp.), 16 October 2008 (16.10.2008), (Family: none)	1-10

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

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 07 May, 2014 (07.05.14)	Date of mailing of the international search report 03 June, 2014 (03.06.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/054815

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 63-210198 A (Idemitsu Kosan Co., Ltd.), 31 August 1988 (31.08.1988), & US 4776967 A & EP 280260 A2 & EP 452998 A2	1-10
A	JP 2002-003874 A (Sanyo Chemical Industries, Ltd.), 09 January 2002 (09.01.2002), (Family: none)	1-10

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/054815

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

C10N30/00(2006.01)n, *C10N30/04*(2006.01)n, *C10N40/25*(2006.01)n

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

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- JP 2008184569 A **[0004]**
- JP 2010280817 A **[0004]**
- JP 2008248139 A **[0004]**
- JP 2010043250 A **[0004]**