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(71) Applicant: **Idemitsu Kosan Co., Ltd**
Tokyo 100-8321 (JP)

(72) Inventor: **TSUBOUCHI, Toshiyuki**
Sodegaura-shi
Chiba 299-0293 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **LUBRICATING OIL COMPOSITION AND DEVICE USING SAME**

(57) A lubricating oil composition contains a base oil containing a compound (A) and a compound (B) below and a compound (C). The lubricating oil composition exhibits a kinematic viscosity at 40 degrees C in a range of 20 mm²/s to 40 mm²/s, a density at 15 degrees C of 1.1 g/cm³ or more, a flash point of 200 degrees C or more, and a viscosity index of 100 or more. The compound (A)

is an ester or an ether having two or more aromatic rings. The compound (B) is an ester or an ether having a kinematic viscosity at 40 degrees C of 12 mm²/s or less, a density at 15 degrees C of 0.9 g/cm³ or more and a flash point of 100 degrees C or more. The compound (C) is a poly(meth)acrylate having a mass average molecular weight of 50000 or less.

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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a lubricating oil composition, more specifically, a lubricating oil composition applicable to a hydraulic device, a rotary device, a bearing, a gear and the like, and a device using the lubricating oil composition.

BACKGROUND ART

10 **[0002]** A variety of hydraulic devices using hydraulic fluids such as a construction machine, an injection molding machine, a press machine, a crane and a machining center have been widely used. A variety of oils have been used in these hydraulic devices (see, for instance, Patent Literature 1 or 2).

15 **[0003]** Patent Literature 1 discloses a hydraulic fluid for a vibration suppression damper, the hydraulic fluid having a viscosity index of 110 or more and a pour point of minus 25 degrees C or less, and specifically containing poly α -olefin, polyol ester and polyether. Patent Literature 2 discloses a lubricating oil such as a compressor oil, a turbine oil and a hydraulic fluid, which is used for a lubricating system requiring a large working load, and contains alkyl diphenyl and alkyl diphenyl ether.

20 **[0004]** However, since a bulk modulus of elasticity of each of the above lubricating oils of Patent Literatures 1 and 2 is not so high, the above lubricating oils do not sufficiently function as a pressure transmission medium.

25 **[0005]** In view of this point, a hydraulic fluid and a pressure transmission medium with a high bulk modulus of elasticity and containing an ester or an ether having two aromatic rings as a base oil have been proposed (see Patent Literatures 3 and 4). These base oils are characterized by having a density at 15 degrees C as high as 1.0g/cm³ or more. Since the density and the bulk modulus of elasticity are correlative, when the density at 15 degrees C is 1.1 g/cm³ or more, a tangent bulk modulus of elasticity at 40 degrees C and 50 MPa becomes about 1.8 GPa or more, which means that the hydraulic fluid and the pressure transmission medium respectively in Patent Literatures 3 and 4 are an excellent lubricating oil having a tangent bulk modulus of elasticity that is higher by 20% than a tangent bulk modulus of elasticity (about 1.5 GPa) of a mineral oil.

CITATION LIST

PATENT LITERATURE(S)

[0006]

35 Patent Literature 1: JP-A-2000-119672
 Patent Literature 2: JP-A-6-200277
 Patent Literature 3: WO2008/133233
 Patent Literature 4: WO2010/005022

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SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

45 **[0007]** However, even the lubricating oils described in Patent Literatures 1 and 2 are low in viscosity index and there are not a well-balanced lubricating oil.

[0008] An object of the invention is to provide a lubricating oil composition having a high density, a low viscosity and a high viscosity index, and a device using the lubricating oil composition.

MEANS FOR SOLVING THE PROBLEMS

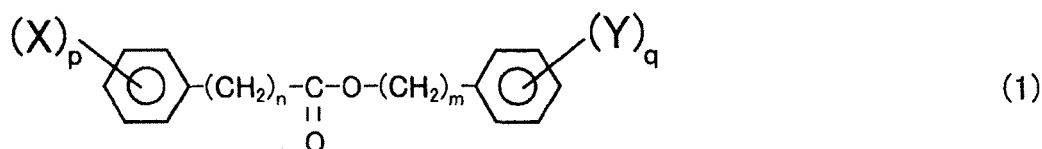
50 **[0009]** In order to solve the above problems, the invention provides a lubricating oil composition described below and a device using the lubricating oil composition.

55 (1) A lubricating oil composition according to an aspect of the invention contains: a base oil containing a compound (A) and a compound (B); and a compound (C), in which the compound (A) is an ester or an ether having two or more aromatic rings, the compound (B) is ester or ether having a kinematic viscosity at 40 degrees C of 12 mm²/s or less, a density at 15 degrees C of 0.9 g/cm³ or more and a flash point of 100 degrees C or more, and the compound

(C) is a poly(meth)acrylate having a mass average molecular weight of 50000 or less, and the lubricating oil composition has a kinematic viscosity at 40 degrees C in a range of 20 mm²/s to 40 mm²/s, a density at 15 degrees C of 1.1 g/cm³ or more, a flash point of 200 degrees C or more, and a viscosity index of 100 or more.

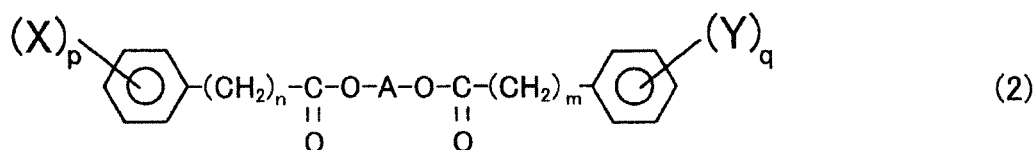
(2) In the lubricating oil composition according to the above aspect of the invention, the compound (A) is represented by any one of formulae (1), (2) and (3) below.

[Formula 1]



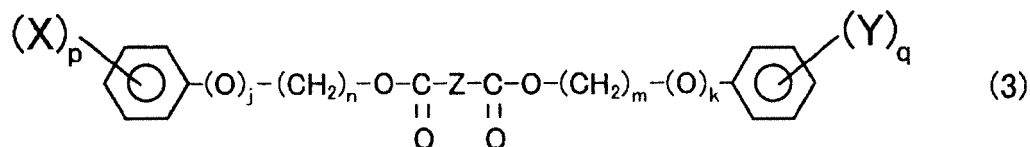
n and m are each 0 or 1; p and q are each an integer of 0 to 3; and X and Y are each an alkyl group having 1 to 30 carbon atoms that optionally includes a cycloalkyl group or an aromatic group, a cycloalkyl group or an aromatic group having 5 to 12 carbon atoms, an alkyloxycarbonyl group having 2 to 30 carbon atoms that optionally includes a cycloalkyl group or an aromatic group, or an alkylcarbonyloxy group having 2 to 30 carbon atoms that optionally includes a cycloalkyl group or an aromatic group.

[Formula 2]



n and m are each 0 or 1; p and q are each an integer of 0 to 3; X and Y are each an alkyl group having 1 to 10 carbon atoms; and A represents an alkylene group having 2 to 18 carbon atoms that optionally includes oxygen in a main chain and/or optionally includes a side chain.

[Formula 3]



j, k, n and m are each 0 or 1; p and q are each an integer of 0 to 3; X and Y are each an alkyl group having 1 to 10 carbon atoms; and Z is an alkylene group having 1 to 18 carbon atoms that optionally includes a side chain.

(3) In the lubricating oil composition according to the above aspect of the invention, the compound (B) is one selected from adipic acid diester of ethyleneglycolmonobutylether, adipic acid diester of diethyleneglycolmonobutylether, 2-ethyl hexanoic acid diester of triethyleneglycol, dibutyl sebacate, dioctyl adipate, dioctyl azelate, dioctyl sebacate, dimethyl phthalate, diethyl phthalate, tetraethyleneglycoldimethylether, and diethyl succinate.

(4) In the lubricating oil composition according to the above aspect of the invention, a ratio of the compound (A) to

the compound (B) in the base oil is in a range of 2 to 10 by a mass ratio ((A)/(B)).

(5) In the lubricating oil composition according to the above aspect of the invention, a total amount of the compound (A) and the compound (B) is 85 mass% or more of the base oil.

(6) In the lubricating oil composition according to the above aspect of the invention, a ratio of the compound (A) is in a range of 40 mass% to 95 mass% of a total amount of the composition.

(7) In the lubricating oil composition according to the above aspect of the invention, a ratio of the compound (B) is in a range of 5 mass% to 60 mass% of the total amount of the composition.

(8) In the lubricating oil composition according to the above aspect of the invention, the lubricating oil composition is a lubricating oil composition or grease used in a hydraulic device, a rotary device, a bearing or a gear.

(9) A device applied with the lubricating oil composition according to the above aspect of the invention.

[0010] According to the invention, a lubricating oil composition having a high density and a high viscosity index can be provided. Accordingly, the lubricating oil composition of the invention is suitably applicable to devices such as a hydraulic device, a rotary device, a bearing and a gear.

DESCRIPTION OF EMBODIMENT(S)

[0011] A lubricating oil composition according to an exemplary embodiment is provided by blending a compound (C) in a base oil containing a compound (A) and a compound (B) described below. The lubricating oil composition will be described below in detail.

[0012] The compound (A) is an ester or an ether having two or more aromatic rings.

[0013] The compound (B) is an ester or an ether having a kinematic viscosity at 40 degrees C of 12 mm²/s or less, a density at 15 degrees C of 0.9 g/cm³ or more and a flash point of 100 degrees C or more.

[0014] The compound (C) is a poly(meth)acrylate having a mass average molecular weight of 50000 or less.

Compound (A)

[0015] The compound (A) in the exemplary embodiment is an ester or an ether having two or more aromatic rings. A manufacturing method of the compound is not particularly limited. A variety of typical manufacturing methods for esterification or etherification are applicable.

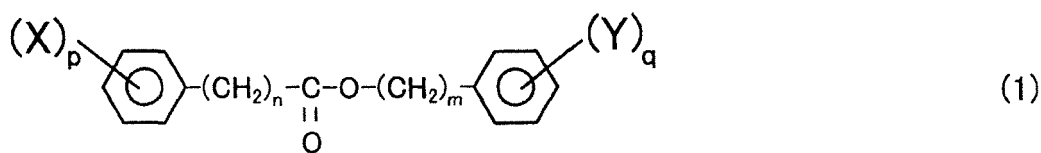
[0016] For instance, carboxylic acid, carboxylic acid ester, carboxylic acid chloride or a derivative thereof, alcohol or a derivative thereof are used as the material. Specific examples of usable dicarboxylic acid include oxalic acid, malonic acid, succinic acid, adipic acid, azelaic acid, sebacic acid and dodecanedioic acid. Specific examples of a usable carboxylic acid are benzoic acid, toluic acid, phenylacetic acid, phenoxyacetic acid, anisic acid, and salicylic acid. Examples of usable alcohol include phenol, cresol, xlenol, benzyl alcohol, phenethyl alcohol, phenoxyethanol, benzyl oxyethanol, diethylene glycol monobenzyl ether, and ethylene glycol monobenzyl ether.

[0017] Examples of a substituent include an aromatic ring group optionally substituted by an alkyl group, a nitro group, a hydroxyl group or an alkoxy group. A material containing these substituents is typically used. However, when being substituted by an alkyl group, the material may be alkylated after esterification. Alternatively, an initially alkylated material may be used. An esterification catalyst is not particularly limited. Alternatively, no catalyst may be used for esterification.

[0018] A manufacturing method of an ether compound is not limited to a typical Williamson synthesis method. A carboxylic acid having an ether bond such as phenoxyacetic acid, phenoxyethanol, benzyl oxyethanol and diethylene glycol monobenzyl ether, or alcohol having an ether bond may be used as a material for esterification.

[0019] Among the above esters, the compound (A) is preferably an ester represented by one of formulae (1), (2) and (3) below.

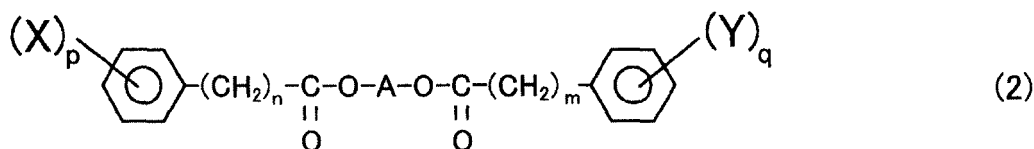
[Formula 4]



[0020] n and m are each 0 or 1. p and q are each an integer of 0 to 3. X and Y are each an alkyl group having 1 to 30 carbon atoms that may include a cycloalkyl group or an aromatic group, a cycloalkyl group or an aromatic group having

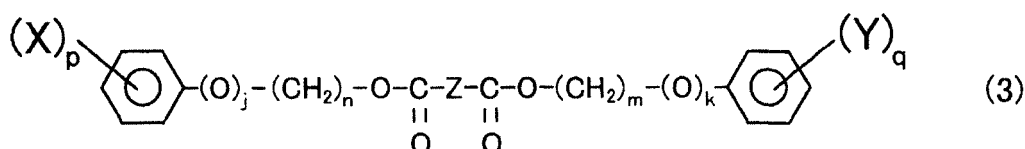
5 to 12 carbon atoms, an alkyloxycarbonyl group having 2 to 30 carbon atoms that may include a cycloalkyl group or an aromatic group, or an alkylcarbonyloxy group having 2 to 30 carbon atoms that may include a cycloalkyl group or an aromatic group.

[Formula 5]



[0021] n and m are each 0 or 1. p and q are each an integer of 0 to 3. X and Y are each an alkyl group having 1 to 10 carbon atoms. A is an alkylene group having 2 to 18 carbon atoms that may contain oxygen in a main chain and/or include a side chain.

[Formula 6]



[0022] j, k, n and m are each 0 or 1. p and q are each an integer of 0 to 3. X and Y are each an alkyl group having 1 to 10 carbon atoms. Z is an alkylene group having 1 to 18 carbon atoms that may include a side chain.

[0023] In the carboxylic acid ester including the aromatic ester skeleton structure represented by the formula (1), when n or m is a natural number of 2 or more, a bulk modulus of elasticity may be unfavorably decreased. For this reason, a carboxylic acid ester in which n and m are 0 or 1 is preferably used.

[0024] When p or q is a natural number of 4 or more in the formula (1), a kinematic viscosity may become excessively high. For this reason, a carboxylic acid ester in which p and q are each an integer of 0 to 3 is preferably used.

[0025] In the formula (1), X and Y are each an alkyl group having 1 to 30 carbon atoms that may include a cycloalkyl group or an aromatic group, a cycloalkyl group or an aromatic group having 5 to 12 carbon atoms, an alkyloxycarbonyl group having 2 to 30 carbon atoms that may include a cycloalkyl group or an aromatic group, or an alkylcarbonyloxy group having 2 to 30 carbon atoms that may include a cycloalkyl group or an aromatic group. When each of X and Y has 31 carbon atoms or more, the kinematic viscosity may become excessively high. When each of X and Y has 13 carbon atoms or more, the kinematic viscosity may become excessively high and a low-temperature fluidity may be deteriorated.

[0026] In the carboxylic acid ester including the aromatic carboxylic acid diester a skeleton structure of diol represented by the formula (2), when n or m is an integer of 2 or more, the bulk modulus of elasticity may be unfavorably decreased. For this reason, a carboxylic acid ester in which n and m are 0 or 1 is preferably used.

[0027] When p or q is a natural number of 4 or more in the formula (2), the kinematic viscosity may become excessively high. For this reason, a carboxylic acid ester in which p and q are each an integer of 0 to 3 is preferably used.

[0028] Moreover, in the formula (2), X and Y are each an alkyl group having 1 to 10 carbon atoms. When X and Y are each an alkyl group having 11 carbon atoms or more, the kinematic viscosity may become excessively high. When A is an alkylene group having 19 carbon atoms or more, the kinematic viscosity may become excessively high.

[0029] In the carboxylic acid ester including the aromatic alcohol diester skeleton structure of the dibasic acid represented by the formula (3), when j or k is a natural number of 2 or more and n or m is a natural number of 3 or more, the bulk modulus of elasticity may be unfavorably decreased. For this reason, a carboxylic acid ester in which j and k are 0 or 1 and n and m are an integer of 0 to 2 is preferably used.

[0030] When p or q is a natural number of 4 or more in the formula (3), the kinematic viscosity may become excessively high. For this reason, a carboxylic acid ester in which p and q are each an integer of 0 to 3 is preferably used.

[0031] Moreover, in the formula (3), X and Y are each an alkyl group having 1 to 10 carbon atoms. When X and Y are each an alkyl group having 11 carbon atoms or more, the kinematic viscosity may become excessively high. When Z

has 19 carbon atoms or more, the kinematic viscosity may become excessively high.

[0032] A content of the compound (A) is preferably in a range of 40 mass% to 95 mass% of a total amount of the lubricating oil composition, more preferably in a range of 50 mass% to 95 mass%, further preferably in a range of 60 mass% to 95 mass%. When the content of the compound (A) is less than 40 mass%, the density (bulk modulus of elasticity) may be hardly increased. On the other hand, when the content of the compound (A) is more than 95 mass%, the kinematic viscosity is also hardly decreased even by mixing the compound (A) with the compound (B). Rather, the kinematic viscosity of the composition may be increased.

Compound (B)

[0033] The compound (B) is an ester or ether having a kinematic viscosity at 40 degrees C of 12 mm²/s or less, a density at 15 degrees C of 0.9 g/cm³ or more and a flash point of 100 degrees C or more. The base oil in the exemplary embodiment can be provided by blending the compound (B) with the compound (A).

[0034] When the kinematic viscosity at 40 degrees C of the compound (B) is more than 12 mm²/s, it is difficult to obtain a predetermined performance of the lubricating oil composition described below even by mixing the compound (B) with the compound (A). When the density at 15 degrees C of the compound (B) is less than 0.9 g/cm³, the base oil provided by mixing the compound (B) with the compound (A) may not have a high density (high bulk modulus of elasticity). When the flash point of the compound (B) is less than 100 degrees C, the flash point of the resulting lubricating oil composition may be excessively low.

[0035] Examples of the compound (B) include adipic acid diester of ethyleneglycolmonobutylether, adipic acid diester of diethyleneglycolmonobutylether, 2-ethyl hexanoic acid diester of triethyleneglycol, dibutyl sebacate, dioctyl adipate, dioctyl azelate, dioctyl sebacate, dimethyl phthalate, diethyl phthalate, tetraethyleneglycoldimethylether, and diethyl succinate.

[0036] A content of the compound (B) is preferably in a range of 5 mass% to 60 mass% of the total amount of the lubricating oil composition, more preferably in a range of 5 mass% to 50 mass%, further preferably in a range of 5 mass% to 40 mass%. When the content of the compound (B) is less than 5 mass%, the kinematic viscosity may not be unfavorably decreased. On the other hand, when the content of the compound (B) is more than 60 mass%, the base oil provided by mixing the compound (B) with the compound (A) may have a low density (low bulk modulus of elasticity).

[0037] A total amount of the components (A) and (B) is preferably 85 mass% or more of the base oil in terms of advantages of the invention, more preferably 87 mass% or more, further preferably 90 mass% or more.

[0038] A ratio of the compound (A) to the compound (B) in the base oil is preferably in a range of 2 to 10 by a mass ratio ((A)/(B)), more preferably in a range of 2.1 to 9.5. When the ratio is less than 2, the base oil may have a low density (low bulk modulus of elasticity). On the other hand, when the ratio is more than 10, the base oil may have a high kinematic viscosity.

Compound (C)

[0039] The compound (C) in the exemplary embodiment is a poly(meth)acrylate having a mass average molecular weight of 50000 or less.

[0040] The compound (C) advantageously increases the viscosity index in the lubricating oil composition according to the exemplary embodiment. However, when the mass average molecular weight is more than 50000, the molecular weight is significantly reduced by shear, so that the viscosity index of the composition is reduced by use of the composition for a long time. On the other hand, when the mass average molecular weight is less than 10000, the viscosity index of the composition is not sufficiently improved.

[0041] Examples of the poly(meth)acrylate include non-dispersed polymethacrylate and dispersed polymethacrylate. One of the poly(meth)acrylates may be used alone or a combination of two or more thereof may be used. A content of the compound (C) is preferably in a range of 1 mass% to 15 mass% of the total amount of the lubricating oil composition, more preferably in a range of 1 mass% to 10 mass%. When the content of the compound (C) is 1 mass% or more, the viscosity index of the composition is sufficiently improved. When the content of the compound (C) is 15 mass% or less, the kinematic viscosity of the composition can be reduced.

[0042] The lubricating oil composition according to the exemplary embodiment is provided by blending the base oil containing the compound (A) and the compound (B) with the compound (C), and exhibits the kinematic viscosity at 40 degrees C in a range of 20 mm²/s to 40 mm²/s, the density at 15 degrees C of 1.1 g/cm³ or more, the flash point of 200 degrees C or more, and the viscosity index of 100 or more.

[0043] When the kinematic viscosity at 40 degrees C is less than 20 mm²/s, the fluidity of the lubricating oil composition is unfavorably excessively high. For instance, the liquid is easily leaked from a sealed part. On the other hand, when the kinematic viscosity is more than 40 mm²/s, flow resistance is excessively high, which unfavorably increases consumption energy. When the density at 15 degrees C is less than 1.1 g/cm³, the bulk modulus of elasticity is unfavorably

excessively low. When the flash point is less than 200 degrees C, danger of fire in a working site is unfavorably increased. The viscosity index of less than 100 shows an unfavorably high temperature-dependency of the viscosity.

[0044] The lubricating oil composition according to the exemplary embodiment can contain various additives as needed. For instance, an antioxidant, a detergent dispersant, a friction reducer, a metal deactivator, a pour point depressant, an antiwear agent, an antifoaming agent, and an extreme pressure agent are usable as needed.

[0045] Examples of the antioxidant include a phenol antioxidant such as 2,6-di-t-butyl-4-methylphenol and 4,4'-methylenebis-(2,6-di-t-butylphenol), an amine antioxidant such as alkylated diphenylamine, phenyl- α -naphthylamine and alkylated- α -naphthylamine, dialkylthiodipropionate, dialkyldithiocarbamate derivative (except for a metal salt), bis(3,5-di-t-butyl-4-hydroxybenzyl)sulfide, mercaptobenzothiazole, a reaction product of phosphorus pentasulfide and olefin and a sulfur antioxidant such as dicetyl sulfide. One of the antioxidants is used alone or a two or more thereof are used in combination. Particularly, the phenol antioxidant, the amine antioxidant or zinc alkyldithio phosphate, and a mixture thereof are preferably used. A content of the antioxidant is preferably in a range of 0.1 mass% to 10 mass% of the total amount of the composition.

[0046] The detergent dispersant is exemplified by alkenyl succinimide. A content of the detergent dispersant is preferably in a range of 0.1 mass% to 10 mass% of the total amount of the composition.

[0047] Examples of the metal deactivator include benzotriazole and thiadiazole, which are used either alone or in combination of two or more thereof. A content of the metal deactivator is preferably in a range of 0.1 mass% to 5 mass%.

[0048] The pour point depressant is exemplified by a polymethacrylate. A content of the pour point depressant is preferably in a range of 0.5 mass% to 10 mass%.

[0049] The antiwear agent is exemplified by zinc alkyldithiophosphate. A content of the antiwear agent is preferably in a range of 0.1 mass% to 10 mass%.

[0050] Examples of the antifoaming agent include a silicone compound and an ester compound, which may be used alone or in a combination of two or more. A content of the antifoaming agent is preferably in a range of 0.01 mass% to 1 mass%.

[0051] The extreme pressure agent is exemplified by tricresyl phosphate. A content of the extreme pressure agent is preferably in a range of 0.1 mass% to 10 mass%.

[0052] With this arrangement, a lubricating oil composition having a high density (a high bulk modulus of elasticity) and a high viscosity index can be provided. Accordingly, the lubricating oil composition of the exemplary embodiment is preferably applicable to various devices: hydraulic devices such as a construction machine, injection molding machine, press machine, crane, machining center, hydraulic continuously variable transmission, robot, machine tool, hydraulic circuit of a hydraulic device, servo hydraulic control circuit, damper, shock absorber, brake system, power steering and rolling machine; rotary devices such as a pump and a compressor; bearings such as a hydrostatic bearing, slide bearing and ball bearing; and gears such as a spur gear, bevel gear and worm gear.

[0053] Because of a high density and a high bulk modulus of elasticity, the lubricating oil composition of the exemplary embodiment particularly exhibits a high-pressure hydraulic performance described below.

- 1) An energy loss due to compression of the lubricating oil composition is small to achieve energy saving.
- 2) Response of the lubricating oil composition to hydraulic pressure is excellent to achieve a high-speed operation in hydraulic circuit.
- 3) Stability of lubricating oil composition to the hydraulic pressure is excellent to achieve a high precision of control in the hydraulic pressure.

[0054] Further, due to a high density, the lubricating oil composition of the exemplary embodiment also exhibits a low-pressure hydraulic performance described below.

- 1) Since a difference between a concentration of dissolved gas under increased pressure and a concentration of dissolved gas under ordinary pressure is small, less air bubbles are formed in a reservoir tank, so that a decline of the hydraulic performance caused by the air bubbles is significantly small.
- 2) Since a difference in relative density between the air bubbles and the lubricating oil is large, air bubbles are separated at a high speed in a reservoir tank, so that a decline of the hydraulic performance caused by the air bubbles is significantly small.
- 3) Since the solubility of air in the lubrication oil composition is about one digit smaller than that in mineral oil, an amount of dissolved gas is small, so that cavitation and erosion are unlikely to occur (i.e., a lifetime of a hydraulic valve and pump is prolonged). Example(s)

[0055] Next, the above invention will be described in more detail below with reference to Examples and Comparatives. The invention should not be construed as limited to what is described in the examples and the like.

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Synthesis of Base Oil A-1 (Compound (A))

[0056] To a 1-L four necked flask equipped with Dean Stark, 490 g of methyl benzoate (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent), 233 g of polyethylene glycol 200 (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent), and 0.2 g of titanium tetraisopropoxide (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent) were added and reacted with stirring at 150 degrees C for four hours under nitrogen stream while distilling methanol. Subsequently, the reactant was washed three times each by saturated saline and by 0.1 N aqueous sodium hydroxide and then dried by anhydrous magnesium sulfate (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent). After magnesium sulfate was filtered, excessive methyl benzoate (material) was distilled to obtain 440 g of dibenzoate of polyethylene glycol 200.

Synthesis of Base Oil A-2 (Compound (A))

[0057] A base oil A-2 was synthesized in the same manner as in synthesis of the above base oil A-1, except for using 82 g of diethylene glycol (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent), 34 g of dipropylene glycol (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent) and 28 g of triethylene glycol (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent) in place of 233 g of polyethylene glycol 200 (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent). Consequently, 320 g of an ester mixture containing 65 mass% of dibenzoate of diethylene glycol, 20 mass% of dibenzoate of dipropylene glycol and 15 mass% of dibenzoate of triethylene glycol was obtained.

Preparation for Base Oils B-1 to B-7 (Compounds (B))

[0058] 500 g of each of the following commercially available reagents was prepared. Properties are shown in Table 1.

Base Oil B-1

[0059] Adipic acid diester of diethylene glycol monobutyl ether (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent)

Base Oil B-2

[0060] Adipic acid diester of ethylene glycol monobutyl ether (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent)

Base Oil B-3

[0061] Dioctyl sebacate (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent) Base Oil B-4

[0062] Dibutyl sebacate (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent) Base Oil B-5

[0063] Dioctyl adipate (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent) Base Oil B-6

[0064] Tetraethylene glycol dimethyl ether (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent)

Base Oil B-7

[0065] Diethyl phthalate (manufactured by Tokyo Chemical Industry Co., Ltd.: reagent)

Table 1

	B-1	B-2	B3	B-4	B-5	B-6	B-7
Kinematic viscosity at 40°C, mm ² /s	11.43	6.997	11.65	5.779	7.76	2.426	5.872
Kinematic viscosity at 100°C, mm ² /s	3.212	2.247	3.271	2.069	2.35	1.046	1.721
Viscosity index	157	141	160	188	123	-	-
Density at 15°C, g/cm ³	1.0256	1.0003	0.9172	0.9401	0.929	1.0153	1.1226
Flash point, °C	207	199	222	190	205	141	162

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Examples 1 to 11

[0066] The base oil A-1 or A-2 was blended with the base oils B-1 to B-7 and PMA (manufactured by KURARAY CO., LTD.: polymethylmethacrylate LW1000P in a form of beads and having 33,500 of mass average molecular weight: compound (C)) at a predetermined ratio to be dissolved, thereby preparing sample oils. Properties of the samples oils are shown in Tables 2 and 3.

Comparatives 1 and 2

[0067] 2 mass% of PMA (same the above) was dissolved in the base oils A-1 and A-2, thereby preparing sample oils. Properties of the samples oils are shown in Tables 2 and 3.

Table 2

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Comparative 1
Composition (mass%)	A-1 (Compound A)	69	74	79	79	79	86	77	98
	A-2 (Compound A)	—	—	—	—	—	—	—	—
	B-1 (Compound B)	29	—	—	—	—	—	—	—
	B-2 (Compound B)	—	24	—	—	—	—	—	—
	B-3 (Compound B)	—	—	19	—	—	—	—	—
	B-4 (Compound B)	—	—	—	19	—	—	—	—
	B-5 (Compound B)	—	—	—	—	19	—	—	—
	B-6 (Compound B)	—	—	—	—	—	12	—	—
	B-7 (Compound B)	—	—	—	—	—	—	21	—
	PMA (Compound C)	2	2	2	2	2	2	2	2
Properties	Kinematic viscosity at 40°C, mm ² /s	34.42	31.3	37.01	31.02	34.07	32.3	34.71	56.66
	Kinematic viscosity at 100°C, mm ² /s	6.265	5.822	6.384	5.861	6.009	5.809	5.779	7.866
	Viscosity index	133	131	124	135	123	123	107	104
	Density at 15°C, g/cm ³	1.1239	1.1236	1.1092	1.116	1.1121	1.1482	1.1578	1.168
	Flash point, °C	230	238	244	235	240	220	218	256

Table 3

		Example 8	Example 9	Example 10	Example 11	Comparative 2
Composition (mass%)	A-1 (Compound A)	—	—	—	—	—
	A-2 (Compound A)	69	74	79	78	98
	B-1 (Compound B)	29	—	—	—	—
	B-2 (Compound B)	—	24	—	—	—
	B-3 (Compound B)	—	—	19	—	—
	B-4 (Compound B)	—	—	—	9.5	—
	B-5 (Compound B)	—	—	—	9.5	—
	B-6 (Compound B)	—	—	—	—	—
	B-7 (Compound B)	—	—	—	—	—
	PMA (Compound C)	2.5	3	2	3	2
Properties	Kinematic viscosity at 40°C, mm ² /s	32.44	31.61	29.7	31.52	43.37
	Kinematic viscosity at 100°C, mm ² /s	5.743	5.646	5.119	5.56	5.896
	Viscosity index	119	119	100	115	67
	Density at 15°C, g/cm ³	1.1239	1.1242	1.1081	1.1141	1.1667
	Flash point, °C	224	218	230	212	236

Evaluation Results

[0068] The sample oils of Examples 1 to 7 shown in Table 2 were provided by blending (mixing) the base oils B-1 to B-7 with the base oil A-1 (a base material). Each of the sample oils exhibits a high viscosity index with a high density while the viscosity of the base oil A-1 is reduced. On the other hand, the sample oil of Comparative 1, which was provided by adding PMA only to the base oil A-1, exhibits a high kinematic viscosity and a low viscosity index.

[0069] The sample oils of Examples 8 to 11 shown in Table 3 were provided by blending the base oils B-1 to B-5 with the base oil A-2 (the base material). Each of the sample oils keeps a high density and exhibits a high viscosity index while the viscosity of the base oil A-2 is reduced. On the other hand, the sample oil of Comparative 2, which was provided by adding PMA only to the base oil A-2, exhibits a high kinematic viscosity and a low viscosity index.

[0070] From the above results, each of the sample oils of Examples 1 to 11 is a composition having a high density (a high bulk modulus of elasticity) and a high viscosity index within a low density zone, from which advantages of the invention can be understood.

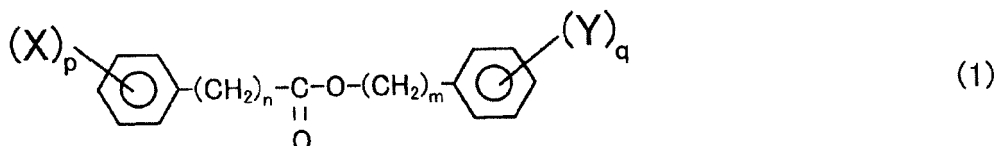
Claims

1. A lubricating oil composition comprising:

a base oil comprising a compound (A) and a compound (B); and a compound (C), wherein the compound (A) is an ester or an ether having two or more aromatic rings, the compound (B) is an ester or an ether having a kinematic viscosity at 40 degrees C of 12 mm²/s or less, a density at 15 degrees C of 0.9 g/cm³ or more and a flash point of 100 degrees C or more, the compound (C) is a poly(meth)acrylate having a mass average molecular weight of 50000 or less, and the lubricating oil composition has a kinematic viscosity at 40 degrees C in a range of 20 mm²/s to 40 mm²/s, a density at 15 degrees C of 1.1 g/cm³ or more, a flash point of 200 degrees C or more, and a viscosity index of 100 or more.

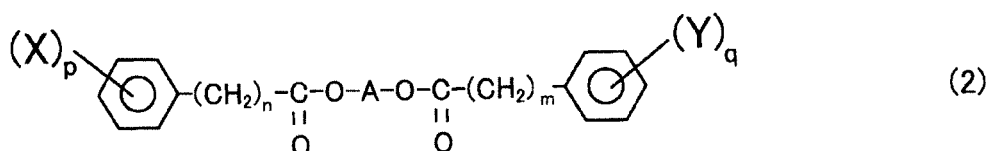
2. The lubricating oil composition according to claim 1, wherein the compound (A) is represented by any one of formulae (1), (2) and (3) below,

[Formula 1]



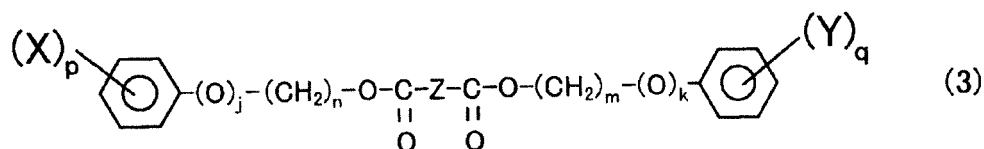
where: n and m are each 0 or 1; p and q are each an integer of 0 to 3; and X and Y are each an alkyl group having 1 to 30 carbon atoms that optionally includes a cycloalkyl group or an aromatic group, a cycloalkyl group or an aromatic group having 5 to 12 carbon atoms, an alkyloxycarbonyl group having 2 to 30 carbon atoms that optionally includes a cycloalkyl group or an aromatic group, or an alkylcarbonyloxy group having 2 to 30 carbon atoms that optionally includes a cycloalkyl group or an aromatic group,

[Formula 2]



where: n and m are each 0 or 1; p and q are each an integer of 0 to 3; X and Y are each an alkyl group having 1 to 10 carbon atoms; and A represents an alkylene group having 2 to 18 carbon atoms that optionally includes oxygen in a main chain and/or optionally includes a side chain,

[Formula 3]



where: j, k, n and m are each 0 or 1; p and q are each an integer of 0 to 3; X and Y are each an alkyl group having 1 to 10 carbon atoms; and Z is an alkylene group having 1 to 18 carbon atoms that optionally includes a side chain.

3. The lubricating oil composition according to claim 1 or 2, wherein the compound (B) is one selected from adipic acid diester of ethyleneglycolmonobutylether, adipic acid diester of diethyleneglycolmonobutylether, 2-ethyl hexanoic acid diester of triethyleneglycol, dibutyl sebacate, dioctyl adipate, dioctyl azelate, dioctyl sebacate, dimethyl phthalate, diethyl phthalate, tetraethyleneglycoldimethylether, and diethyl succinate.
4. The lubricating oil composition according to any one of claims 1 to 3, wherein a ratio of the compound (A) to the compound (B) in the base oil is in a range of 2 to 10 by a mass ratio ((A)/(B)).
5. The lubricating oil composition according to any one of claims 1 to 4, wherein a total amount of the compound (A) and the compound (B) is 85 mass% or more of the base oil.

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6. The lubricating oil composition according to any one of claims 1 to 5, wherein a ratio of the compound (A) is in a range of 40 mass% to 95 mass% of a total amount of the composition.
7. The lubricating oil composition according to any one of claims 1 to 6, wherein a ratio of the compound (B) is in a range of 5 mass% to 60 mass% of the total amount of the composition.
8. The lubricating oil composition according to any one of claims 1 to 7, wherein the lubricating oil composition is a lubricating oil composition or grease used in a hydraulic device, a rotary device, a bearing or a gear.
9. A device applied with the lubricating oil composition according to any one of claims 1 to 7.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/056809

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A. CLASSIFICATION OF SUBJECT MATTER
C10M169/04(2006.01)i, C10M105/18(2006.01)i, C10M105/34(2006.01)i,
C10M105/36(2006.01)i, C10M105/38(2006.01)i, C10M145/14(2006.01)i,
C10N30/02(2006.01)n, C10N40/02(2006.01)n, C10N40/04(2006.01)n,
According to International Patent Classification (IPC) or to both national classification and IPC

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B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
C10M169/04, C10M105/18, C10M105/34, C10M105/36, C10M105/38, C10M145/14,
C10N30/02, C10N40/02, C10N40/04, C10N40/08

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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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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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.
A	JP 2012-17391 A (Idemitsu Kosan Co., Ltd.), 26 January 2012 (26.01.2012), claims 1 to 8; paragraph [0021]; examples 1 to 4 (Family: none)	1-9
A	JP 2012-31359 A (Idemitsu Kosan Co., Ltd.), 06 February 2012 (06.02.2012), claims 1 to 8; paragraph [0022]; examples 1 to 7 & US 2012/0283162 A1 & EP 2520637 A1	1-9
A	JP 2011-213920 A (Idemitsu Kosan Co., Ltd.), 27 October 2011 (27.10.2011), claims 1 to 7; paragraphs [0017] to [0019]; examples 1 to 7 & US 2013/0017984 A1 & EP 2554646 A1	1-9

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 05 June, 2013 (05.06.13)	Date of mailing of the international search report 18 June, 2013 (18.06.13)
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Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008/133233 A1 (Idemitsu Kosan Co., Ltd.), 06 November 2008 (06.11.2008), claims 1 to 14; paragraph [0055]; examples & EP 2157159 A1 & WO 2008/133233 A1	1-9
A	WO 2010/005022 A1 (Idemitsu Kosan Co., Ltd.), 14 January 2010 (14.01.2010), claims 1 to 6; examples 1 to 7 & EP 2302022 A1 & WO 2010/005022 A1	1-9

INTERNATIONAL SEARCH REPORT

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

C10N40/08(2006.01)n

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/056809

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(1) The "compound (A)" recited in claims 1 and 3-9 includes, within its scope, all of compounds each of which is an ester or an ether and has at least two aromatic rings. However, those compounds which are disclosed in the meaning within PCT Article 5 are only specific compounds (A) which are described in the description. Therefore, these claims are not supported in the meaning within PCT Article 6.

(2) The "compound (B)" recited in claims 1, 2 and 4-9 includes, within its scope, all of compounds each of which is an ester or an ether and has a kinematic viscosity of 12 mm²/s or less at 40°C, a density of 0.9 g/cm³ or less at 15°C and an ignition point of 100°C or higher. However, those compounds which are disclosed in the meaning within PCT Article 5 are only specific compounds (B) which are described in the description. Therefore, these claims are not supported in the meaning within PCT Article 6.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000119672 A [0006]
- JP 6200277 A [0006]
- WO 2008133233 A [0006]
- WO 2010005022 A [0006]