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(54) **LUBRICATING OIL COMPOSITION, SHOCK ABSORBER, AND METHOD FOR USING LUBRICATING OIL COMPOSITION**

(57) Provided is a lubricating oil composition used for lubrication of a shock absorber, including a base oil (A), a polyalkyl (meth)acrylate (B) having a weight aver-

age molecular weight of 150,000 to 900,000, and an olefin copolymer (C) having a weight average molecular weight of 100,000 or less.

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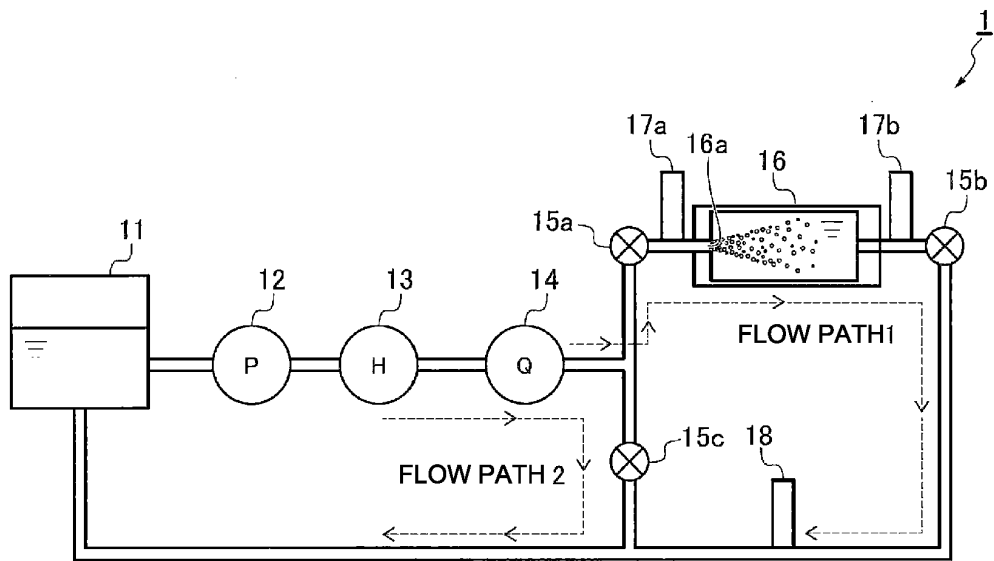


Fig. 1

Description

Technical Field

5 **[0001]** The present invention relates to a lubricating oil composition, a shock absorber using the lubricating oil composition, and a method for using the lubricating oil composition.

Background Art

10 **[0002]** A shock absorber is used by being filled with a lubricating oil composition for a shock absorber, and is a mechanism mounted on a car body in order to generate a damping force that damps the vibration of the car body, to optimize the friction characteristics of the sliding portion to control the riding quality of the car body, to suppress the friction wear of the sliding portion to secure durability, and the like.

15 **[0003]** Various lubricating oil compositions for a shock absorber that may be suitably used in such a shock absorber have been developed.

[0004] For example, Patent Literature 1 discloses an invention relating to a lubricating oil composition for a shock absorber that contains a lubricating base oil having a predetermined kinematic viscosity, a nondispersed poly(meth)acrylate-based viscosity modifier having a weight average molecular weight of 30,000 to 200,000, and a primary zinc dialkyldithiophosphate and a secondary zinc dialkyldithiophosphate in a predetermined content ratio.

Citation List

Patent Literature

25 **[0005]** Patent Literature 1: Japanese Patent Laid-Open No. 2018-203953

Summary of Invention

Technical Problem

30 **[0006]** According to the studies by the present inventors, the lubricating oil composition described in Patent Literature 1 has been found to be insufficient in an effect of suppressing cavitation. In addition, a lubricating oil composition used for lubrication of a shock absorber in which not only the effect of suppressing cavitation, but also characteristics such as cold startability and shear stability are improved is required.

Solution to Problem

35 **[0007]** The present invention provides a lubricating oil composition used for lubrication of a shock absorber containing a base oil, a polyalkyl (meth)acrylate having a predetermined weight average molecular weight, and an olefin copolymer having a predetermined weight average molecular weight. Specifically, the present invention provides the following embodiments [1] to [10].

40 **[1]** A lubricating oil composition used for lubrication of a shock absorber, comprising: a base oil (A), a polyalkyl (meth)acrylate (B) having a weight average molecular weight of 150,000 to 900,000, and an olefin copolymer (C) having a weight average molecular weight of 100,000 or less.

[2] The lubricating oil composition according to the above [1], wherein the total content of the component (B) and the component (C) is 20.0 mass% or less based on the total amount of the lubricating oil composition.

[3] The lubricating oil composition according to the above [1] or [2], wherein a content ratio [(B)/(C)] by mass of the component (B) to the component (C) is 1/99 to 90/10.

50 **[4]** The lubricating oil composition according to any one of the above [1] to [3], wherein a content of the component (B) is 0.1 to 10.0 mass% based on the total amount of the lubricating oil composition.

[5] The lubricating oil composition according to any one of the above [1] to [4], wherein a content of the component (C) is 0.1 to 10.0 mass% based on the total amount of the lubricating oil composition.

55 **[6]** The lubricating oil composition according to any one of the above [1] to [5], wherein a weight average molecular weight of the component (C) is 8,000 or more and 100,000 or less.

[7] The lubricating oil composition according to any one of the above [1] to [6], wherein the component (C) comprises an ethylene propylene copolymer (C1).

[8] The lubricating oil composition according to any one of the above [1] to [7], wherein the total content of the

components (A) to (C) is 80 to 100 mass% based on the total amount of the lubricating oil composition.

[9] The lubricating oil composition according to any one of the above [1] to [8], wherein a BF viscosity of the lubricating oil composition at -40°C is 1,500 mPa·s or less.

[10] Use of a lubricating oil composition, comprising applying the lubricating oil composition according to any one of the above [1] to [9] to lubrication of a shock absorber.

Advantageous Effects of Invention

[0008] The lubricating oil composition of one preferred embodiment of the present invention is excellent in characteristics such as cold startability, shear stability, and an effect of suppressing cavitation, and the lubricating oil composition of the particularly preferred embodiment is excellent in all of the cold startability, the shear stability, and the effect of suppressing cavitation, and therefore, it can be suitably applied to lubrication of a shock absorber.

Brief Description of Drawing

[0009] [Figure 1] Figure 1 is a schematic diagram of a testing apparatus for evaluating the effect of suppressing cavitation.

Description of Embodiments

[0010] In the present specification, a kinematic viscosity and a viscosity index mean values measured and calculated in accordance with JIS K2283:2000.

[0011] In the present specification, the weight average molecular weight (Mw) and the number average molecular weight (Mn) are values in terms of standard polystyrene measured by gel permeation chromatography (GPC), and specifically mean values measured by the method described in Examples.

[0012] In the numerical range described in the present specification, upper limit and lower limit values can be arbitrarily combined. For example, when a description of "preferably 30 to 100, more preferably 40 to 80" is described as a numerical range, ranges such as "30 to 80" and "40 to 100" are included in the numerical range described in the present specification. For example, when a description of "preferably 30 or more, more preferably 40 or more, and preferably 100 or less, more preferably 80 or less" is described as a numerical range, ranges such as "30 to 80" and "40 to 100" are also included in the numerical range described in the present specification.

[0013] In addition, for example, a description of "60 to 100" as the numerical range described in the present specification means a range of "60 or more and 100 or less".

[Constitution of lubricating oil composition]

[0014] The lubricating oil composition of the present invention contains a base oil (A), a polyalkyl (meth)acrylate (B) having a weight average molecular weight of 150,000 to 900,000, and an olefin copolymer (C) having a weight average molecular weight of 100,000 or less.

[0015] The lubricating oil composition used for a shock absorber requires various characteristics. As one of such characteristics, the effect of suppressing cavitation is required. Cavitation refers to a physical phenomenon in which generation and extinction of bubbles occur in a short time due to the pressure difference in the flow of the lubricating oil composition, leading to a factor for causing deterioration of responsiveness of shock absorbers and noises. For example, the generation of cavitation in a shock absorber mounted on a vehicle affects the ride quality of the vehicle and the like.

[0016] In addition, the lubricating oil composition used for a shock absorber requires not only the effect of suppressing cavitation, but also characteristics such as cold startability and shear stability.

[0017] The present inventors have intensively studied to obtain a lubricating oil composition in which these characteristics are improved in good balance, and have found that a combination of a polyalkyl (meth)acrylate (B) and an olefin copolymer (C) each having a predetermined weight average molecular weight is useful.

[0018] That is, it has been found by the studies of the present inventors that the component (B) is a factor that may improve the effect of suppressing cavitation and cold startability, but causes a reduction of the shear stability, whereas the component (C) is a factor that may improve the effect of suppressing cavitation and shear stability, but causes a reduction of the cold startability.

[0019] Thus, the present inventors have found that a lubricating oil composition in which cold startability, shear stability, and the effect of suppressing cavitation are improved in good balance can be obtained by using the components (B) and (C) in combination. The present invention has been made based on the findings.

[0020] In the lubricating oil composition of one embodiment of the present invention, from the viewpoint of obtaining a lubricating oil composition in which cold startability, shear stability, and the effect of suppressing cavitation are improved

in good balance, the content ratio [(B)/(C)] by mass of the component (B) to the component (C) is preferably 1/99 to 90/10, more preferably 5/85 to 80/20, more preferably 10/90 to 70/30, still more preferably 15/85 to 60/40, still much more preferably 20/80 to 50/50, and particularly preferably 25/75 to 45/55.

[0021] In the lubricating oil composition of one embodiment of the present invention, from the viewpoint of obtaining a lubricating oil composition having a good balance between cold startability and shear stability, the total content of the component (B) and the component (C) is preferably 20.0 mass% or less, more preferably 16.0 mass% or less, still more preferably 10.0 mass% or less, still much more preferably 8.0 mass% or less, and particularly preferably 6.0 mass% or less, and from the viewpoint of further improving the effect of suppressing cavitation, the total content of the component (B) and the component (C) is preferably 0.2 mass% or more, more preferably 0.6 mass% or more, still more preferably 1.0 mass% or more, still much more preferably 1.6 mass% or more, and particularly preferably 2.0 mass% or more, based on the total amount (100 mass%) of the lubricating oil composition.

[0022] Considering the handleability and the solubility with the component (A), the components (B) and (C) are often commercially available in a form of a solution dissolved in a diluent oil.

[0023] However, in the present specification, the content of the components (B) and (C) is, in a solution diluted with a diluent oil, a content in terms of resin content constituting the component (B) or (C), excluding the mass of the diluent oil.

[0024] The lubricating oil composition of one embodiment of the present invention may further contain lubricating oil additives other than the components (B) to (C).

[0025] However, in the lubricating oil composition of one embodiment of the present invention, from the viewpoint of obtaining a lubricating oil composition in which the effect of suppressing cavitation and cold startability are further improved, the total content of the components (A) to (C) is preferably 80 to 100 mass%, more preferably 85 to 100 mass%, still more preferably 90 to 100 mass%, still much more preferably 95 to 100 mass%, and particularly preferably 98 to 100 mass%, and further may be more than 98.5 mass% and 100 mass% or less, more than 99.0 mass% and 100 mass% or less, more than 99.5 mass% and 100 mass% or less, or more than 99.7 mass% and 100 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0026] Hereinafter, details of each component contained in the lubricating oil composition of one embodiment of the present invention will be described.

<Component (A): base oil>

[0027] As the base oil which is the component (A) used in one embodiment of the present invention, one or more selected from mineral oils and synthetic oils can be mentioned.

[0028] Examples of the mineral oils include atmospheric residues obtained by subjecting crude oils, such as paraffinic crude oil, intermediate base crude oil and naphthenic crude oil, to atmospheric distillation; distillates obtained by subjecting these atmospheric residues to vacuum distillation; and refined oils obtained by subjecting the distillates to one or more of refining treatments, such as solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, and hydrotreating.

[0029] Examples of the synthetic oils include poly- α -olefins, such as an α -olefin homopolymer; isoparaffin; polyalkylene glycol; ester oils, such as polyol ester, dibasic acid ester, and phosphoric acid ester; ether oils, such as polyphenyl ether; alkylbenzene; alkyl naphthalene; and synthetic oil (GTL) obtained by isomerizing wax (GTL WAX (Gas To Liquids WAX)) produced from natural gas through Fischer-Tropsch process or the like.

[0030] Among these, it is preferable to contain one or more selected from mineral oils classified in Group II and Group III of API (American Petroleum Institute) base oil categories, and synthetic oils, as the component (A) used in one embodiment of the present invention.

[0031] The kinematic viscosity of the component (A) used in one embodiment of the present invention at 40°C is preferably 3.0 to 100 mm²/s, more preferably 4.0 to 70 mm²/s, still more preferably 5.0 to 40 mm²/s, still much more preferably 5.5 to 30 mm²/s, and particularly preferably 6.0 to 20 mm²/s.

[0032] The viscosity index of the component (A) used in one embodiment of the present invention is appropriately set depending on the applications of the lubricating oil composition, and is preferably 70 or more, more preferably 80 or more, still more preferably 90 or more, still much more preferably 100 or more, and particularly preferably 105 or more.

[0033] When a mixed oil that is a combination of two or more base oils is used as the component (A) in one embodiment of the present invention, the kinematic viscosity and the viscosity index of the mixed oil are preferably in the above ranges.

[0034] In the lubricating oil composition of one embodiment of the present invention, the content of the component (A) is preferably 60 mass% or more, more preferably 70 mass% or more, more preferably 75 mass% or more, still more preferably 80 mass% or more, still much more preferably 85 mass% or more, and particularly preferably 90 mass% or more, and is preferably 99.8 mass% or less, more preferably 99.5 mass% or less, still more preferably 99.0 mass% or less, still much more preferably 98.5 mass% or less, and particularly preferably 98.0 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

<Component (B): polyalkyl (meth)acrylate>

[0035] The lubricating oil composition of the present invention contains a polyalkyl (meth)acrylate having a weight average molecular weight (Mw) of 150,000 to 900,000 as the component (B). When Mw is less than 150,000, the effect of suppressing cavitation is unlikely to be exhibited. When Mw is more than 900,000, it tends to be difficult to achieve both the effect of suppressing cavitation and shear stability. Since the component (B) and the component (C) described below are used in combination, the lubricating oil composition can be adjusted to have good shear stability.

[0036] The weight average molecular weight (Mw) of the polyalkyl (meth)acrylate used in one embodiment of the present invention as the component (B) is 150,000 or more, and from the viewpoint of obtaining a lubricating oil composition in which the effect of suppressing cavitation and cold startability are further improved, it is preferably 200,000 or more, more preferably 250,000 or more, more preferably 260,000 or more, more preferably 270,000 or more, more preferably 300,000 or more, still more preferably 320,000 or more, still more preferably 350,000 or more, still more preferably 370,000 or more, still more preferably 400,000 or more, still much more preferably 420,000 or more, still much more preferably 450,000 or more, still much more preferably 470,000 or more, still much more preferably 500,000 or more, and particularly preferably 520,000 or more. The weight average molecular weight (Mw) thereof is 900,000 or less, and from the viewpoint of obtaining a lubricating oil composition having further improved shear stability, it is preferably 850,000 or less, more preferably 800,000 or less, more preferably 750,000 or less, still more preferably 700,000 or less, still much more preferably 650,000 or less, and particularly preferably 600,000 or less.

[0037] In the lubricating oil composition of one embodiment of the present invention, from the viewpoint of obtaining a lubricating oil composition in which the effect of suppressing cavitation and cold startability are further improved, the content of the component (B) is preferably 0.1 mass% or more, more preferably 0.2 mass% or more, still more preferably 0.3 mass% or more, still much more preferably 0.5 mass% or more, and particularly preferably 0.7 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having further improved shear stability, the content of the component (B) is preferably 10.0 mass% or less, more preferably 8.0 mass% or less, still more preferably 5.0 mass% or less, still much more preferably 3.0 mass% or less, and particularly preferably 2.0 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0038] The component (B) used in one embodiment of the present invention may be a polymer having a structural unit derived from an alkyl acrylate or an alkyl methacrylate (hereinafter, collectively referred to as "alkyl (meth)acrylate"), or may be a copolymer having a structural unit derived from a monomer other than the alkyl (meth)acrylate.

[0039] The number of carbon atoms of the alkyl group in the alkyl (meth)acrylate may be 1 or more, 3 or more, 5 or more, or 10 or more, and may be 60 or less, 40 or less, 30 or less, or 20 or less.

[0040] In the component (B) used in one embodiment of the present invention, the content of the structural unit derived from the alkyl (meth)acrylate may be 10 mol% or more, 30 mol% or more, 50 mol% or more, 60 mol% or more, 70 mol% or more, 80 mol% or more, 90 mol% or more, 95 mol% or more, or 99 mol% or more, based on the total amount (100 mol%) of the structural unit of the component (B).

<<Comb-shaped polymer>>

[0041] The component (B) used in one embodiment of the present invention may be a comb-shaped polymer.

[0042] The comb-shaped polymer used in one embodiment of the present invention as the component (B) is only required to be a polymer having a structure including a large number of three-way branch points from which a side chain having a high-molecular weight comes out, in the main chain.

[0043] SSI (shear stability index) of the comb-shaped polymer used in one embodiment of the present invention as the component (B) is preferably 100 or less, more preferably 80 or less, still more preferably 70 or less, still much more preferably 60 or less, and particularly preferably 50 or less.

[0044] The lower limit value of SSI of the comb-shaped polymer is not particularly limited, and is usually 0.1 or more.

[0045] In the present specification, SSI (shear stability index) represents a decrease in viscosity caused by shear derived from the polymer component by percentage, and is a value measured in accordance with JPI-5S-29-06, more specifically, a value calculated by the following expression (1).

$$\text{Expression (1): SSI (\%)} = (Kv_0 - Kv_1) / (Kv_0 - Kv_{oil}) \times 100$$

[0046] In the above expression (1), Kv_0 is a value of the kinematic viscosity of a sample oil at 100°C in which the polymer component is diluted in a mineral oil, and Kv_1 is a value of the kinematic viscosity of the sample oil at 100°C in which the polymer component is diluted in a mineral oil, after being subjected to irradiation with ultrasonic wave for 30 minutes by an output method in accordance with the procedures of JPI-5S-29-06. Moreover, Kv_{oil} is a value of the kinematic viscosity of the mineral oil at 100°C used when the polymer component is diluted.

[0047] The value of SSI of the comb-shaped polymer varies with the structure thereof. Specifically, there are the following tendencies, and by considering these matters, the value of SSI of the comb-shaped polymer can be easily adjusted. The following matters are merely examples, and the value of SSI of the comb-shaped polymer can also be adjusted by considering matters other than these matters.

- A comb-shaped polymer whose side chain is constituted of the macromonomer (x1) and in which the content of the structural unit (x1) derived from the macromonomer (x1) is 0.5 mol% or more, based on the total amount (100 mol%) of the structural unit tends to have a low value of SSI.
- As the molecular weight of the macromonomer (x1) constituting the side chain of the comb-shaped polymer becomes higher, the value of SSI tends to become lower.

[0048] The comb-shaped polymer used in one embodiment of the present invention as the component (B) is preferably a polymer at least having a structural unit (x1) derived from a macromonomer (x1). This structural unit (x1) corresponds to the aforementioned "side chain having a high-molecular weight".

[0049] In the present specification, the above "macromonomer (x1)" means a high-molecular weight monomer having a polymerizable functional group, and is preferably a high-molecular weight monomer having a polymerizable functional group at a terminal thereof.

[0050] In the comb-shaped polymer used in one embodiment of the present invention as the component (B), the content of the structural unit (X1) is preferably 0.5 to 20 mol%, more preferably 0.7 to 10 mol%, and still more preferably 0.9 to 5 mol%, based on the total amount (100 mol%) of the structural unit of the comb-shaped polymer.

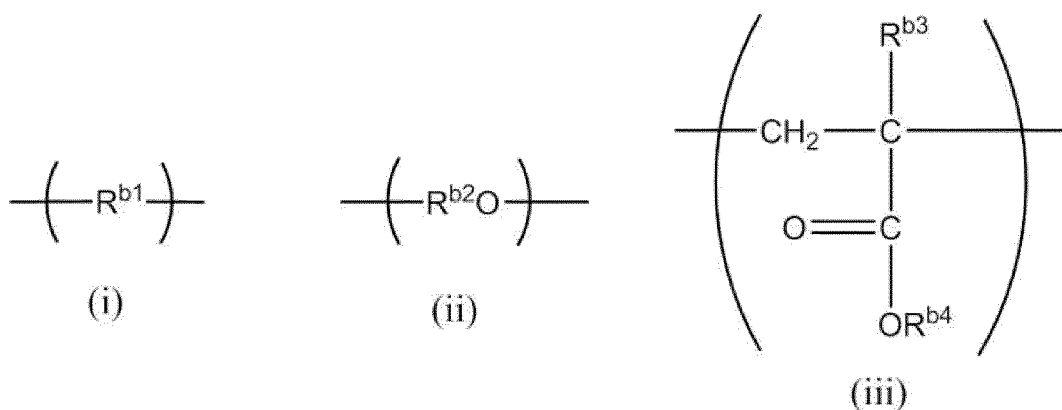
[0051] In the present specification, the content of the structural unit in the comb-shaped polymer means a value calculated by analyzing the ^{13}C -NMR quantitative spectrum.

[0052] The number average molecular weight (M_n) of the macromonomer (x1) is preferably 300 or more, more preferably 400 or more, still more preferably 500 or more, and preferably 100,000 or less, more preferably 50,000 or less, still more preferably 20,000 or less.

[0053] That is to say, the number average molecular weight (M_n) of the macromonomer (x1) is preferably 300 to 100,000, more preferably 400 to 50,000, and still more preferably 500 to 20,000.

[0054] Examples of the polymerizable functional group included in the macromonomer (x1) include an acryloyl group ($\text{CH}_2=\text{CH}-\text{COO}-$), a methacryloyl group ($\text{CH}_2=\text{C}(\text{CH}_3)-\text{COO}-$), an ethenyl group ($\text{CH}_2=\text{CH}-$), a vinyl ether group ($\text{CH}_2=\text{CHO}-$), an allyl group ($\text{CH}_2=\text{CH}-\text{CH}_2-$), an allyl ether group ($\text{CH}_2=\text{CH}-\text{CH}_2-\text{O}-$), a group represented by $\text{CH}_2=\text{CH}-\text{CONH}-$, and a group represented by $\text{CH}_2=\text{C}(\text{CH}_3)-\text{CONH}-$.

[0055] In addition to the above polymerizable functional group, the macromonomer (x1) may have, for example, one or more repeating units represented by the following general formulae (i) to (iii).



[0056] In the above general formula (i), R^{b1} is a linear or branched alkylene group having 1 to 10 carbon atoms.

[0057] In the general formula (ii), R^{b2} is a linear or branched alkylene group having 2 to 4 carbon atoms.

[0058] In the general formula (iii), R^{b3} is a hydrogen atom or a methyl group. R^{b4} is a linear or branched alkyl group having 1 to 10 carbon atoms.

[0059] When the macromonomer (x1) has a plurality of repeating units represented by each of the above general formulae (i) to (iii), R^{b1} , R^{b2} , R^{b3} and R^{b4} may be each the same as one another or may be different from one another.

[0060] In one embodiment of the present invention, the macromonomer (x1) is preferably a polymer having a repeating unit represented by the general formula (i), and more preferably a polymer having a repeating unit (X1-1) in which R^{b1}

in the general formula (i) is at least one selected from a 1,2-butylene group and a 1,4-butylene group.

[0061] The content of the repeating unit (X1-1) is preferably 1 to 100 mol%, more preferably 20 to 95 mol%, still more preferably 40 to 90 mol%, and still much more preferably 50 to 80 mol%, based on the total amount (100 mol%) of the structural unit of the macromonomer (x1).

[0062] When the macromonomer (x1) is a copolymer having two or more repeating units selected from the general formulae (i) to (iii), the form of copolymer may be a block copolymer or may be a random copolymer.

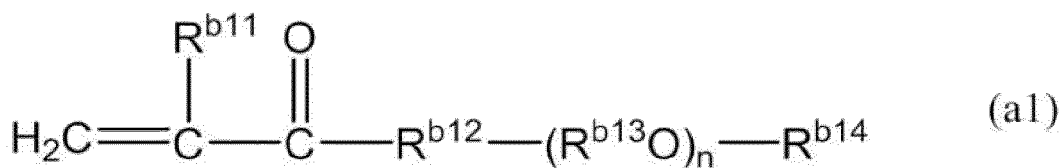
[0063] The comb-shaped polymer used in one embodiment of the present invention as a component (B) may be a homopolymer consisting only of a structural unit (x1) derived from one macromonomer (x1), or may be a copolymer having a structural unit (x1) derived from two or more macromonomers (x1).

[0064] The comb-shaped polymer used in one embodiment of the present invention as a component (B) may be a copolymer having a structural unit (X2) derived from a monomer other than the macromonomer (x1) together with a structural unit (x1) derived from a macromonomer (x1).

[0065] As a specific structure of such a comb-shaped polymer, a copolymer having a side chain including the structural unit (x1) derived from the macromonomer (x1) relative to the main chain including the structural unit (X2) derived from the monomer (x2) is preferable.

[0066] Examples of the monomer (x2) include alkyl (meth)acrylate, a nitrogen atom-containing vinyl monomer, a hydroxyl group-containing vinyl monomer, a phosphorus atom-containing monomer, an aliphatic hydrocarbon-based vinyl monomer, a cycloaliphatic hydrocarbon-based vinyl monomer, vinyl ester, vinyl ether, vinyl ketone, an epoxy group-containing vinyl monomer, a halogen element-containing vinyl monomer, an ester of unsaturated polycarboxylic acid, (di)alkyl fumarate, (di)alkyl maleate, and an aromatic hydrocarbon-based vinyl monomer.

[0067] The monomer (x2) is preferably a monomer other than the phosphorus atom-containing monomer and the aromatic hydrocarbon-based vinyl monomer, more preferably includes one or more selected from a monomer represented by the following general formula (a1), alkyl(meth)acrylate, and a hydroxyl group-containing vinyl monomer, and still more preferably includes at least a hydroxyl group-containing vinyl monomer (x2-d).



[0068] In the general formula (a1), $\text{R}^{\text{b}11}$ is a hydrogen atom or a methyl group.

[0069] $\text{R}^{\text{b}12}$ is a single bond, a linear or branched alkylene group having 1 to 10 carbon atoms, -O-, or -NH-.

[0070] $\text{R}^{\text{b}13}$ is a linear or branched alkylene group having 2 to 4 carbon atoms. Moreover, n represents an integer of 1 or more (preferably an integer of 1 to 20, and more preferably an integer of 1 to 5). When n is an integer of 2 or more, each $\text{R}^{\text{b}13}$ may be the same as one another or may be different from one another, and further, the $(\text{R}^{\text{b}13}\text{O})_n$ moiety may be a random bond or a block bond.

[0071] $\text{R}^{\text{b}14}$ is a linear or branched alkyl group having 1 to 60 (preferably 10 to 50, and more preferably 20 to 40) carbon atoms.

<Olefin copolymer (C)>

[0072] The lubricating oil composition of the present invention contains an olefin copolymer having a weight average molecular weight (M_w) of 100,000 or less as the component (C). By using the olefin copolymer having M_w within the above range and the component (B) in combination, a lubricating oil composition in which the effect of suppressing cavitation and shear stability are improved can be obtained. Since the component (C) and the component (B) described above are used in combination, the lubricating oil composition can be adjusted to have good cold startability.

[0073] The weight average molecular weight (M_w) of the olefin copolymer used in one embodiment of the present invention as the component (C) is 100,000 or less, and from the viewpoint of obtaining a lubricating oil composition having further improved cold startability and shear stability while having a further improved effect of suppressing cavitation, it is preferably 80,000 or less, more preferably 70,000 or less, more preferably 60,000 or less, still more preferably 40,000 or less, still much more preferably 30,000 or less, and particularly preferably 25,000 or less.

[0074] The weight average molecular weight (M_w) of the olefin copolymer as the component (C) may be 500 or more, 1,000 or more, 3,000 or more, 5,000 or more, 7,000 or more, 8,000 or more, more than 8,000, 8,500 or more, 9,000 or more, 9,500 or more, 10,000 or more, 11,000 or more, 12,000 or more, or 13,000 or more.

[0075] In the lubricating oil composition of one embodiment of the present invention, from the viewpoint of obtaining a lubricating oil composition in which the effect of suppressing cavitation and shear stability are further improved, the

content of the component (C) is preferably 0.1 mass% or more, more preferably 0.3 mass% or more, still more preferably 0.5 mass% or more, still much more preferably 0.8 mass% or more, and particularly preferably 1.0 mass% or more, and from the viewpoint of obtaining a lubricating oil composition having further improved cold startability, the content of the component (C) is preferably 10.0 mass% or less, more preferably 8.0 mass% or less, still more preferably 5.0 mass% or less, still much more preferably 4.0 mass% or less, and particularly preferably 3.0 mass% or less, and further may be 2.5 mass% or less, or 2.0 mass% or less, based on the total amount (100 mass%) of the lubricating oil composition.

[0076] The component (C) used in one embodiment of the present invention is preferably a copolymer having a structural unit derived from a monomer having an alkenyl group, and examples thereof include a copolymer of an α -olefin having 2 to 20 (preferably 2 to 16, more preferably 2 to 14) carbon atoms, and more specific examples thereof include an ethylene- α -olefin copolymer.

[0077] The number of carbon atoms of the α -olefin constituting the ethylene- α -olefin copolymer is preferably 3 to 20, more preferably 3 to 16, still more preferably 3 to 14, still much more preferably 3 to 6, and particularly preferably 3.

[0078] The component (C) used in one embodiment of the present invention may be a dispersion type olefin-based copolymer.

[0079] Examples of the dispersion type olefin-based copolymer include a copolymer obtained by graftpolymerizing the aforementioned ethylene- α -olefin copolymer with maleic acid, N-vinyl pyrrolidone, N-vinyl imidazole, or glycidyl acrylate.

[0080] The component (C) used in one embodiment of the present invention may be a copolymer further having a structural unit derived from an aromatic monomer together with a structural unit derived from a monomer having an alkenyl group. Examples of such an olefin-based copolymer include styrene-based copolymers such as a styrene-diene copolymer and a styrene-isoprene copolymer.

[0081] Among these, from the viewpoint of obtaining a lubricating oil composition in which the effect of suppressing cavitation and shear stability are improved, the component (C) used in one embodiment of the present invention preferably contains an ethylene propylene copolymer (C1).

[0082] In the lubricating oil composition of one embodiment of the present invention, the content ratio of the component (C1) is preferably 30 to 100 mass%, more preferably 50 to 100 mass%, still more preferably 70 to 100 mass%, still much more preferably 80 to 100 mass%, and particularly preferably 90 to 100 mass%, based on the total amount (100 mass%) of the component (C) contained in the lubricating oil composition.

<Lubricating oil additives>

[0083] The lubricating oil composition of one embodiment of the present invention may further contain lubricating oil additives other than the component (B) and the component (C) when needed as long as the effects of the present invention are not impaired.

[0084] Examples of such lubricating oil additives include an antioxidant such as a phenol-based antioxidant and an amino-based antioxidant; a metal-based detergent such as metal sulfonate, metal salicylate, and metal phenate; ashless dispersants such as alkenyl succinimide; a friction modifier such as a molybdenum-based friction modifier, a fatty acid ester, fatty acid, and an aliphatic alcohol; an anti-wear agent such as zinc dithiophosphate; an extreme-pressure agent such as a phosphorus-based extreme-pressure agent, a sulfur-based extreme-pressure agent, and a sulfur-phosphorus-based extreme-pressure agent; an anti-foaming agent such as a silicone-based anti-foaming agent; a metal deactivator such as a benzotriazole-based compound; an anticorrosive; and an antistatic agent.

[0085] These lubricating oil additives may be each used singly, or may be each used in combination of two or more.

[0086] The contents of these lubricating oil additives can be each appropriately prepared as long as the effects of the present invention are not impaired, but the contents of the additives are each independently usually 0.001 to 15 mass%, preferably 0.005 to 10 mass%, and more preferably 0.01 to 5 mass%, based on the total amount (100 mass%) of the lubricating oil composition.

<Production method for lubricating oil composition>

[0087] The production method for the lubricating oil composition of one embodiment of the present invention is not particularly limited, but from the viewpoint of productivity, preferable is a method having a step of compounding the component (B) and the component (C), and if necessary, other lubricating oil additives with the component (A).

[0088] From the viewpoint of compatibility with the component (A), the resin component such as the component (B) and the component (C) is preferably in a form of a solution dissolved in a diluent oil and the solution is preferably compounded with the component (A).

[Properties of lubricating oil composition]

[0089] The kinematic viscosity of the lubricating oil composition of one embodiment of the present invention at 40°C is preferably 5.0 to 130 mm²/s, more preferably 6.5 to 100 mm²/s, still more preferably 8.0 to 100 mm²/s, still much more preferably 10.0 to 60 mm²/s, and particularly preferably 11.0 to 40 mm²/s.

[0090] The kinematic viscosity of the lubricating oil composition of one embodiment of the present invention at 100°C is preferably 2.0 to 30 mm²/s, more preferably 2.3 to 20 mm²/s, still more preferably 2.6 to 15 mm²/s, still much more preferably 3.0 to 10 mm²/s, and particularly preferably 3.2 to 7.0 mm²/s.

[0091] The kinematic viscosity of the lubricating oil composition of one embodiment of the present invention at 150°C is preferably 1.0 to 20 mm²/s, more preferably 1.2 to 10 mm²/s, still more preferably 1.4 to 7.0 mm²/s, still much more preferably 1.6 to 5.0 mm²/s, and particularly preferably 1.8 to 3.0 mm²/s.

[0092] The viscosity index of the lubricating oil composition of one embodiment of the present invention is preferably 100 or more, more preferably 120 or more, still more preferably 140 or more, still much more preferably 160 or more, and particularly preferably 180 or more.

[0093] From the viewpoint of obtaining a lubricating oil composition having good cold startability, the BF viscosity (Brookfield viscosity) of the lubricating oil composition of one embodiment of the present invention at -40°C is preferably 1,500 mPa·s or less, more preferably 1,400 mPa·s or less, still more preferably 1,300 mPa·s or less, and still much more preferably 1,200 mPa·s or less, and is preferably 100 mPa·s or more, more preferably 300 mPa·s or more, still more preferably 500 mPa·s or more, and still much more preferably 700 mPa·s or more.

[0094] In the present specification, the BF viscosity means a value measured in accordance with ASTM D2983-09.

[0095] From the viewpoint of obtaining a lubricating oil composition having good shear stability, the kinematic viscosity reduction rate calculated in accordance with the method described in Examples of the lubricating oil composition of one embodiment of the present invention below is preferably less than 11.0%, more preferably less than 10.5%, still more preferably less than 10.0%, and still much more preferably less than 9.5%.

[0096] From the viewpoint of obtaining a lubricating oil composition excellent in the effect of suppressing cavitation, the value of the cavitation factor calculated in accordance with the method described in Examples of the lubricating oil composition of one embodiment of the present invention below is preferably 0.45 or less, more preferably 0.44 or less, and still more preferably 0.43 or less, and typically 0.40 or more.

[Characteristics and use application of lubricating oil composition]

[0097] The lubricating oil composition of one embodiment of the present invention has excellent characteristics such as cold startability, shear stability, and the effect of suppressing cavitation.

[0098] Thus, the lubricating oil composition of one embodiment of the present invention can be suitably used for lubrication of a shock absorber, and more specifically, can be used for both a double cylinder type shock absorber and a single cylinder type shock absorber, and can be suitably used for both a shock absorber for two wheels and a shock absorber for four wheels.

[0099] When these characteristics of the lubricating oil composition of one embodiment of the present invention are taken into consideration, the present invention can also provide the following [1] and [2].

[1] A shock absorber filled with the aforementioned lubricating oil composition of one embodiment of the present invention.

[2] Use of a lubricating oil composition, wherein the aforementioned lubricating oil composition of one embodiment of the present invention is applied to lubrication of a shock absorber.

Examples

[0100] Next, the present invention will be described in much more detail with reference to Examples, but the present invention is in no way limited to these Examples. Measuring methods for various properties are as follows.

(1) Kinematic viscosity, viscosity index

[0101] The kinematic viscosity and viscosity index were measured and calculated in accordance with JIS K2283:2000.

(2) Weight average molecular weight (Mw)

[0102] Using a gel permeation chromatograph apparatus (manufactured by Agilent Technologies, Inc., "1260 model HPLC"), the weight-average molecular weight was measured under the following conditions, and a value measured in

terms of standard polystyrene was used.

(Measurement conditions)

5 [0103]

Column: sequentially connected two of "Shodex LF404".

Column temperature: 35°C

Developing solvent: chloroform

10 Flow rate: 0.3 mL/min

Example 1 and Comparative Examples 1 to 8

15 [0104] Each additive was compounded with the base oil in the types and compounding amounts shown in Table 1, thereby preparing each lubricating oil composition. The compounding amount of each additive described in Table 1 describes the compounding amount in terms of active ingredients (in terms of solid content) from which the mass of the diluent oil was excluded, even when each additive was compounded in a state being dissolved in the diluent oil.

[0105] Details of the base oil and each additive used in the preparation of each lubricating oil composition are as follows.

20 <Base oil>

[0106] "Paraffinic mineral oil": paraffinic mineral oil, 40°C kinematic viscosity = 7.1 mm²/s, 100°C kinematic viscosity = 2.17 mm²/s, viscosity index = 109, 15°C density = 0.82 g/cm³.

25 <PMA>

[0107] "PMA (550,000)": polyalkyl (meth)acrylate, weight average molecular weight (Mw) = 550,000.

[0108] "PMA (29,000)": polyalkyl (meth)acrylate, weight average molecular weight (Mw) = 29,000.

30 [0109] "PMA (140,000)": polyalkyl (meth)acrylate, weight average molecular weight (Mw) = 140,000.

<OCP>

[0110] "OCP (17,000)": ethylene propylene copolymer, weight average molecular weight (Mw) = 17,000.

[0111] "OCP (780,000)": olefin copolymer, weight average molecular weight (Mw) = 780,000.

35 [0112] Regarding the lubricating oil composition prepared, the 40°C kinematic viscosity, 100°C kinematic viscosity, 150°C kinematic viscosity, and viscosity index were measured or calculated in accordance with the aforementioned method, and the following measurement or evaluation was carried out. The results of them are set forth in Table 1.

(1) Evaluation of cold startability

40 [0113] The BF viscosity at -40°C was measured in accordance with ASTM D2983-09.

[0114] It is deemed that as the BF viscosity becomes lower, the lubricating oil composition has more excellent cold startability. When the BF viscosity at -40°C was 1,500 mPa·s or less, the lubricating oil composition was determined to have excellent cold startability.

45 (2) Evaluation of shear stability

50 [0115] The shear test was carried out in accordance with the ultrasonic A method (JPI-5S-29) by using the lubricating oil composition prepared as the sample oil and irradiating 30 mL of the sample oil with ultrasonic waves at 25°C for 60 minutes. As the output voltage of ultrasonic waves, the value of an output voltage at which the reduction rate of the 40°C kinematic viscosity after 30 mL of a standard oil whose 40°C kinematic viscosity was measured in advance was irradiated with ultrasonic waves at 25°C for 60 minutes was 25% was employed.

[0116] Then, the 40°C kinematic viscosity of the sample oil was measured before and after the shear test, and the kinematic viscosity reduction rate was calculated by the following expression, thereby evaluating the shear stability.

$$\text{Kinematic viscosity reduction rate (\%)} = ([40^{\circ}\text{C} \text{ kinematic viscosity of sample oil before shear test}] - [40^{\circ}\text{C} \text{ kinematic viscosity of sample oil after shear test}]) / [40^{\circ}\text{C} \text{ kinematic viscosity of sample oil before shear test}] \times 100$$

[0117] It is deemed that as the value of the kinematic viscosity reduction rate becomes smaller, the lubricating oil composition has more excellent shear stability. When the value of the kinematic viscosity reduction rate was less than 11.0%, the lubricating oil composition was determined to have excellent shear stability.

(3) Evaluation of effect of suppressing cavitation

[0118] Figure 1 is a schematic diagram of a testing apparatus for evaluating the effect of suppressing cavitation. A testing apparatus 1 shown in Figure 1 has an oil tank 11 that stores the sample oil of the subject to be evaluated, a pump 12 that circulates the sample oil, a heater 13 that adjusts the temperature of the sample oil, a flowmeter 14 that controls the flow velocity of the sample oil, valves 15a, 15b, and 15c that control the flow of the sample oil, an observation tank 16 provided with an observation window made of sapphire on a side surface and an orifice 16a with a diameter of 1 mm in an inlet on the upstream side, pressure gauges 17a and 17b on the upstream side and the downstream side of the observation tank, and a thermocouple 18.

[0119] First, the oil tank 11 was filled with the lubricating oil composition prepared as the sample oil, the valves 15a, 15b, and 15c were fully opened, the pump 12 and the heater 13 were operated, and the observation tank 16 was also filled with the sample oil while allowing the sample oil to be circulated along with a flow path 1 and a flow path 2. Then, the state where the temperature of the sample oil reached 150°C and stabilized was taken as the initial state.

[0120] From the initial state, while limiting the flow of the sample oil along with the flow path 2 by gradually closing the valve 15c from the fully-opened state, the state where the pressure gauge 17a on the upstream side exhibited "0.5 MPa" was taken as the starting point, and the valve 15a on the upstream side and the valve 15b on the downstream side were controlled to pressurize the sample oil in a stepwise manner until the pressure gauge 17a on the upstream side exhibited "5.0 MPa". In the pressurizing process, the degree of generation of cavitation was visually observed through a transparent window of the observation tank 16, based on the cavitation score whose criteria were defined in advance depending on the degree of generation of cavitation. At a point where the cavitation score becomes "5", the pressure on the upstream side P_u shown by the pressure gauge 17a on the upstream side and the pressure on the downstream side P_d shown by the pressure gauge 17b on the downstream side were confirmed, thereby calculating the cavitation factor.

[0121] The above cavitation score was evaluated by 11-grade in increments of one, by taking no generation of cavitation as "0" and the state where cavitation was most generated was "10". The criteria at each grade were based on the criteria defined in advance depending on the degree of generation of cavitation.

[0122] The cavitation factor was calculated from the following expression, and the value was set forth in Table 1.

$$\text{Cavitation factor} = (P_d + \text{atmospheric pressure}) / (P_u - P_d)$$

[0123] In the above expression, P_u is the pressure on the upstream side (unit: Pa) and P_d is the pressure on the downstream side (unit: Pa).

[0124] It is deemed that as the cavitation factor calculated from the above expression becomes smaller, the lubricating oil composition has a higher effect of suppressing cavitation. When the value of the cavitation factor was 0.45 or less, the lubricating oil composition was determined to have an excellent effect of suppressing cavitation.

[0125] When cavitation with a cavitation score of "5" or more was already generated at the starting point at which the pressure on the upstream side exhibits 0.5 MPa, cavitation was considered to be generated at all times, which is set forth in Table 1 as "F".

[Table 1]

[0126]

Table 1

			Example 1	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7	Comparative Example 8
	Base oil	Paraffinic mineral oil	mass%	100.00	96.00	98.46	91.74	95.10	97.60	96.25	95.00
Composition	PMA	PMA (550,000)	mass%	-	-	1.54	-	0.77	-	-	-
		PMA (29,000)	mass%	-	-	-	8.26	4.13	-	-	-
		PMA (140,000)	mass%	-	-	-	-	-	2.40	-	-
		OCP (17,000)	mass%	-	4.00	-	-	-	-	-	-
	OCP	OCP (780,000)	mass%	-	-	-	-	-	-	3.75	5.00
		Total	mass%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Properties	40°C kinematic viscosity		mm ² /s	12.28	13.23	10.47	12.50	11.76	10.74	13.25	14.19
	100°C kinematic viscosity		mm ² /s	3.658	3.554	3.551	3.836	3.796	3.437	3.771	3.817
	150°C kinematic viscosity		mm ² /s	1.988	1.867	2.026	2.103	2.121	1.922	2.014	1.998
	Viscosity index		-	206	159	264	228	250	227	192	173

(continued)

Evaluation	(1) Low temperature fluidity	BF viscosity (-40°C)	mPa·s	Example 1	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7	Comparative Example 8
	(2) Shear stability	Kinematic viscosity reduction rate	%	9.4	0.0	0.3	19.6	0.1	11.7	11.0	22.1	22.0
	(3) Effect of suppressing cavitation	Cavitation factor	-	0.43	F	0.30	0.33	0.48	0.49	F	0.34	F
	(**1) Solidified and unmeasurable											

[0127] As shown in Table 1, the lubricating oil composition prepared in Example 1 has excellent cold startability and shear stability, resulting in a high effect of suppressing cavitation. On the other hand, the lubricating oil compositions prepared in Comparative Examples 1 to 8 resulted in having poor cold startability, poor shear stability, or a poor effect of suppressing cavitation.

Reference Signs List

[0128]

1	Testing apparatus
11	Oil tank
12	Pump
13	Heater
14	Flowmeter
15a, 15b, 15c	Valve
16	Observation tank
16a	Orifice
17a, 17b	Pressure gauge
18	Thermocouple

Claims

1. A lubricating oil composition used for lubrication of a shock absorber, comprising: a base oil (A), a polyalkyl (meth)acrylate (B) having a weight average molecular weight of 150,000 to 900,000, and an olefin copolymer (C) having a weight average molecular weight of 100,000 or less.
2. The lubricating oil composition according to claim 1, wherein the total content of the component (B) and the component (C) is 20.0 mass% or less based on the total amount of the lubricating oil composition.
3. The lubricating oil composition according to claim 1 or 2, wherein a content ratio [(B)/(C)] by mass of the component (B) to the component (C) is 1/99 to 90/10.
4. The lubricating oil composition according to any one of claims 1 to 3, wherein a content of the component (B) is 0.1 to 10.0 mass% based on the total amount of the lubricating oil composition.
5. The lubricating oil composition according to any one of claims 1 to 4, wherein a content of the component (C) is 0.1 to 10.0 mass% based on the total amount of the lubricating oil composition.
6. The lubricating oil composition according to any one of claims 1 to 5, wherein a weight average molecular weight of the component (C) is 8,000 or more and 100,000 or less.
7. The lubricating oil composition according to any one of claims 1 to 6, wherein the component (C) comprises an ethylene propylene copolymer (C1).
8. The lubricating oil composition according to any one of claims 1 to 7, wherein the total content of the components (A) to (C) is 80 to 100 mass% based on the total amount of the lubricating oil composition.
9. The lubricating oil composition according to any one of claims 1 to 8, wherein a BF viscosity of the lubricating oil composition at -40°C is 1,500 mPa·s or less.
10. Use of a lubricating oil composition, comprising applying the lubricating oil composition according to any one of claims 1 to 9 to lubrication of a shock absorber.

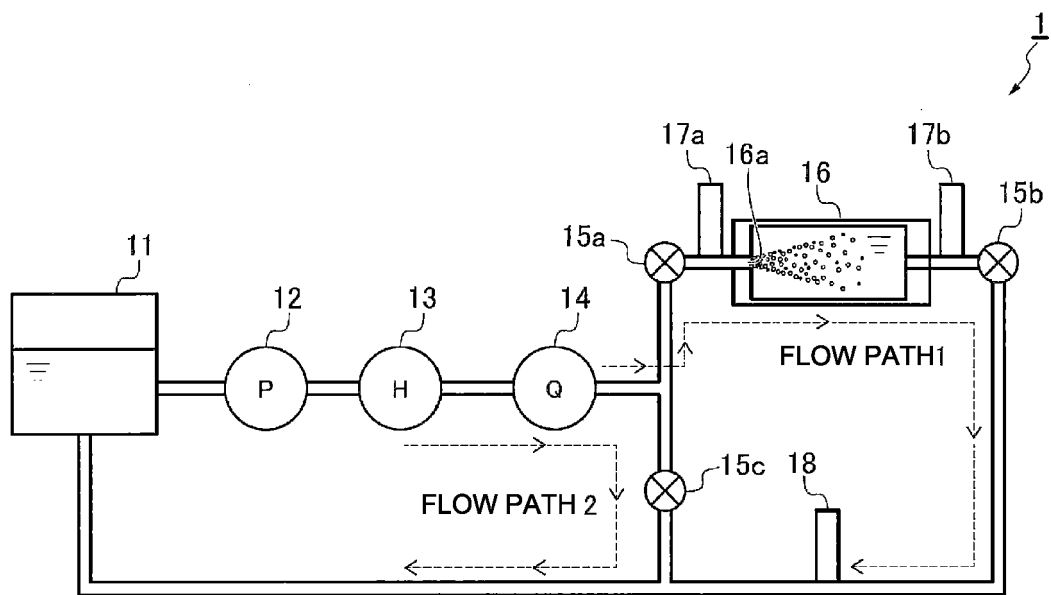


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/029794

A. CLASSIFICATION OF SUBJECT MATTER

C10M 157/04(2006.01)i; **C10N 20/02**(2006.01)n; **C10N 20/04**(2006.01)n; **C10N 30/00**(2006.01)n; **C10N 30/02**(2006.01)n;
C10N 30/08(2006.01)n; **C10N 40/06**(2006.01)n; **C10M 143/00**(2006.01)i; **C10M 143/04**(2006.01)i; **C10M 145/14**(2006.01)i
 FI: C10M157/04; C10M145/14; C10M143/00; C10M143/04; C10N20/04; C10N40/06; C10N20/02; C10N30/00 Z;
 C10N30/02; C10N30/08

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)

C10M157/04; C10N20/02; C10N20/04; C10N30/00; C10N30/02; C10N30/08; C10N40/06; C10M143/00; C10M143/04;
 C10M145/14

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

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2021
 Registered utility model specifications of Japan 1996-2021
 Published registered utility model applications of Japan 1994-2021

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 50-151903 A (NIPPON OIL CO., LTD.) 06 December 1975 (1975-12-06)	1-10
A	JP 2014-55214 A (COSMO OIL LUBRICANTS CO., LTD.) 27 March 2014 (2014-03-27)	1-10
A	WO 2020/085478 A1 (IDEMITSU KOSAN CO., LTD.) 30 April 2020 (2020-04-30)	1-10
A	JP 6-228530 A (SANYO CHEMICAL INDUSTRIES, LTD.) 16 August 1994 (1994-08-16)	1-10
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A	JP 6-57276 A (NIPPON STEEL CHEMICAL CO., LTD.) 01 March 1994 (1994-03-01)	1-10
A	JP 2005-307099 A (MITSUI CHEMICALS, INC.) 04 November 2005 (2005-11-04)	1-10
A	Lucant, MITSUI CHEMICALS, INC., March 2016 entire text	1-10

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

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2021/029794

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JP 2005-307099 A	04 November 2005	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

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