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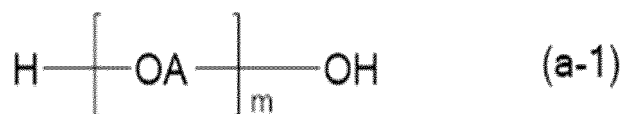
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81675 München (DE)(30) Priority: **29.03.2021 JP 2021055460**(54) **AQUEOUS PROCESSING LIQUID**

(57) Provided is an aqueous working fluid containing compound (A) represented by the following general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group, wherein the aqueous working fluid has a viscosity at 25°C of 4.0 to 20.0 mPa·s:



wherein A is an alkylene group having 2 to 4 carbon atoms, and when there is a plurality of A, the plurality of A may be the same or different; and m is an integer of 1 or more.

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Description

[Technical Field]

5 **[0001]** The present invention relates to an aqueous working fluid, a concentrate for the aqueous working fluid, the use of the aqueous working fluid, and a method for processing a brittle material using the aqueous working fluid.

[Background Art]

10 **[0002]** In the manufacture of semiconductor products, silicon ingot, which is a brittle material, needs to be cut, and wire sawing is generally used from the viewpoint of cutting accuracy and productivity. Here, in the cutting of silicon ingot, there are a loose abrasive process involving cutting silicon ingot, with abrasive grains being dispersed in a working fluid, and a fixed abrasive process involving cutting silicon ingot, with abrasive grains being fixed to the wire surface in advance. A variety of working fluids are proposed that can be suitably used in the respective abrasive processes.

15 **[0003]** For example, Patent Literature 1 discloses an invention relating to a water-soluble working fluid composition for fixed abrasive wire sawing used in the cutting of a workpiece other than rare-earth magnets, in which (A) the aqueous working fluid composition for fixed-abrasive wire sawing comprises glycol.

[Citation List]

20

[Patent Literature]

[0004] [Patent Literature 1] JP-A-2003-82334

25 [Summary of Invention]

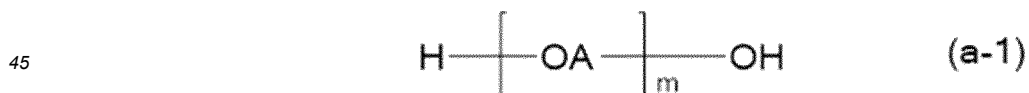
[Technical Problem]

30 **[0005]** Under such circumstances, the demand exists for a novel aqueous working fluid that is more readily applicable to the step of cutting brittle materials than conventional working fluids.

[Solution to Problem]

35 **[0006]** The present invention provides an aqueous working fluid that has a specific structure, contains an ether compound having a specific molecular weight and water-insoluble polyoxyalkylene ether, and is regulated to a predetermined viscosity. Specifically, the present invention provides, for example, the following embodiments [1] to [15]:

40 [1] An aqueous working fluid comprising compound (A) represented by the following general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group, wherein the aqueous working fluid has a viscosity at 25°C of 4.0 to 26.0 mPa·s:



wherein

50 A is an alkylene group having 2 to 4 carbon atoms, and when there is a plurality of A, the plurality of A may be the same or different; and m is an integer of 1 or more.

[2] The aqueous working fluid according to [1], having a surface tension of 45.0 mN/m or less.

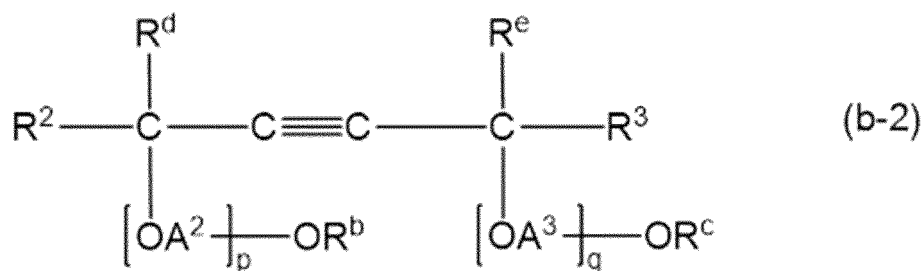
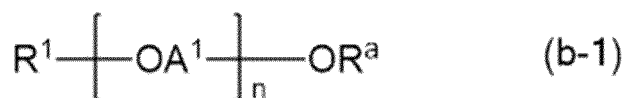
55 [3] The aqueous working fluid according to [1] or [2], having a content of component (A) of 15.0 to 95.0% by mass based on the total amount of the aqueous working fluid.

[4] The aqueous working fluid according to any one of [1] to [3], having a content of component (B) of 0.0001 to 1.0% by mass based on the total amount of the aqueous working fluid.

[5] The aqueous working fluid according to any one of [1] to [4], wherein a ratio of the content of component (B) to 100 parts by mass of component (A) is 0.0001 to 1.80 parts by mass.

[6] The aqueous working fluid according to any one of [1] to [5], wherein component (A) comprises one or more selected from diethylene glycol, dipropylene glycol, polyethylene glycol, and polypropylene glycol.

[7] The aqueous working fluid according to any one of [1] to [6], wherein component (B) comprises one or more selected from water-insoluble polyoxyalkylene ether (B1) represented by the following general formula (b-1) and an alkylene oxide adduct of water-insoluble acetylene glycol (B2) represented by the following general formula (b-2):



wherein

A¹ to A³ are each independently an alkylene group having 2 to 4 carbon atoms;

R^a to R^e are each independently a hydrogen atom, an alkyl group, a cycloalkyl group optionally having an alkyl group, or an aryl group optionally having an alkyl group;

R¹ to R³ are each independently an alkyl group, a cycloalkyl group optionally having an alkyl group, or an aryl group optionally having an alkyl group; and

n, p, and q are each independently an integer of 1 or more.

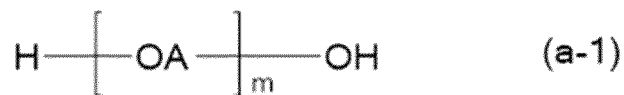
[8] The aqueous working fluid according to any one of [1] to [7], further comprising (C) water.

[9] The aqueous working fluid according to [8], wherein a content of the component (C) is 5.0 to 70.0% by mass based on the total amount of the aqueous working fluid.

[10] The aqueous working fluid according to any one of [1] to [9], having a pH of 4.0 to 10.0.

[11] The aqueous working fluid according to any one of [1] to [10], which is used when cutting a brittle material by means of a wire saw.

[12] A concentrate for an aqueous working fluid, comprising compound (A) represented by the following general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group:



wherein

A is an alkylene group having 2 to 4 carbon atoms, and when there is a plurality of A, the plurality of A may be the same or different; and

m is an integer of 1 or more.

[13] The concentrate for an aqueous working fluid according to [12], which is capable of preparing an aqueous working fluid having a viscosity at 25°C of 4.0 to 20.0 mPa·s by being diluted with water.

[14] Use of an aqueous working fluid, wherein the aqueous working fluid according to any one of [1] to [11] is applied to the step of cutting a brittle material by means of a wire saw.

[15] A method for processing a brittle material, comprising the step of cutting a brittle material by means of a wire

saw with applying the aqueous working fluid according to any one of [1] to [11].

[Advantageous Effect of Invention]

[0007] The aqueous working fluid of one suitable embodiment of the present invention has various characteristics (such as appropriate viscosity characteristics, small surface tension, good antifoaming properties) that can increase workability and, therefore, can be an aqueous working fluid suitable for processing brittle materials.

[Description of Embodiment]

[0008] Concerning the numerical ranges described herein, the upper limits and the lower limits can be suitably combined. For example, when a numerical range is described as being "preferably 30 to 100, and more preferably 40 to 80", the range of "30 to 80" and the range of "40 to 100" are also included in the numerical range described herein. Also, for example, when a numerical range is described as being "preferably 30 or more and more preferably 40 or more, and preferably 100 or less and more preferably 80 or less", the range of "30 to 80" and the range of "40 to 100" are also included in the numerical range described herein.

[0009] In addition, for example, "60 to 100" as a numerical range described herein means the range of "60 or more and 100 or less".

[0010] Moreover, concerning the specification of the upper limits and the lower limits described herein, a numerical range from a lower limit to an upper limit can be specified by suitably selecting from, and appropriately combining, the respective options.

[0011] Also, concerning the various requirements described as preferable embodiments herein, multiple requirements can be combined.

[Configuration of aqueous working fluid]

[0012] The aqueous working fluid of the present invention contains compound (A) represented by the above general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group, and has a viscosity at 25°C of 4.0 to 26.0 mPa·s.

[0013] The aqueous working fluid of the present invention is a solution that is directly used in the processing of a workpiece without being diluted.

[0014] On the other hand, the concentrate for an aqueous working fluid of the present invention as will be described below is a solution that can be diluted with water to be formed into an aqueous working fluid having the above-described viscosity, and is distinguished from the aqueous working fluid of the present invention in that the concentrate for an aqueous working fluid is not a solution directly used in the processing of a workpiece.

[0015] Containing component (A) and component (B), the aqueous working fluid of one embodiment of the present invention is prepared as an aqueous working fluid having various characteristics that can increase workability, or, in particular, small surface tension.

[0016] Also, having a viscosity at 25°C of 4.0 to 26.0 mPa·s, i.e., appropriate viscosity characteristics, the aqueous working fluid of the present invention can be an aqueous working fluid having excellent brittle material workability.

[0017] From the viewpoint of providing an aqueous working fluid having excellent brittle material workability, the viscosity at 25°C of the aqueous working fluid of one embodiment of the present invention is 4.0 mPa·s or more, preferably 4.5 mPa·s or more, more preferably 5.0 mPa·s or more, more preferably 5.5 mPa·s or more, more preferably 6.0 mPa·s or more, even more preferably 6.5 mPa·s or more, even more preferably 7.0 mPa·s or more, even more preferably 7.5 mPa·s or more, yet more preferably 8.0 mPa·s or more, yet more preferably 8.5 mPa·s or more, and particularly preferably 9.0 mPa·s or more, and, moreover, may be 9.5 mPa·s or more, 10.0 mPa·s or more, 10.5 mPa·s or more, 11.0 mPa·s or more, 11.5 mPa·s or more, 12.0 mPa·s or more, 12.5 mPa·s or more, 13.0 mPa·s or more, 13.5 mPa·s or more, or 14.0 mPa·s or more, and is 26.0 mPa·s or less, preferably 25.0 mPa·s or less, more preferably 24.0 mPa·s or less, more preferably 23.0 mPa·s or less, even more preferably 22.0 mPa·s or less, even more preferably 21.0 mPa·s or less, yet more preferably 20.5 mPa·s or less, and particularly preferably 20.0 mPa·s or less, and, moreover, may be 19.0 mPa·s or less, 18.0 mPa·s or less, 17.0 mPa·s or less, 16.0 mPa·s or less, or 15.0 mPa·s or less.

[0018] Herein, the viscosity at 25°C of the aqueous working fluid can be measured by the method described in the Examples.

[0019] The aqueous working fluid of one embodiment of the present invention may further contain (C) water from the viewpoint of providing an aqueous working fluid regulated to the above-described viscosity range.

[0020] From the viewpoint of providing an aqueous working fluid capable of preventing corrosion of apparatuses and wires, the aqueous working fluid of one embodiment of the present invention may contain one or more selected from (D) carboxylic acid and (E) an amine compound.

[0021] The aqueous working fluid of one embodiment of the present invention may contain, as necessary, other additives other than the components (A) to (E) as long as the effects of the present invention are not impaired.

[0022] In the aqueous working fluid of one embodiment of the present invention, the total content of the components (A) and (B) is preferably more than 15% by mass, more preferably more than 20% by mass, more preferably more than 25% by mass, even more preferably more than 30% by mass, even more preferably more than 35% by mass, yet more preferably more than 40% by mass, particularly preferably more than 45% by mass, and, moreover, may be more than 50% by mass, more than 55% by mass, more than 60% by mass, more than 65% by mass, or more than 70% by mass, and may be 100% by mass or less, 98% by mass or less, 96% by mass or less, 95% by mass or less, 93% by mass or less, or 90% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

[0023] In the aqueous working fluid of one embodiment of the present invention, the total content of the components (A) and (B) is preferably 70% by mass or more, more preferably 80% by mass or more, even more preferably 90% by mass or more, yet more preferably 95% by mass or more, and particularly preferably 98% by mass or more, and may be 100% by mass or less, 99.99% by mass or less, 99.90% by mass or less, or 99.80% by mass or less based on the total amount (100% by mass) of the components contained in the aqueous working fluid excluding water (C).

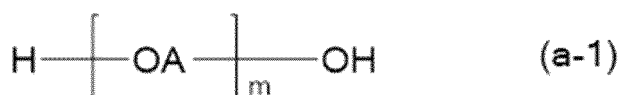
[0024] In the aqueous working fluid of one embodiment of the present invention, the total content of the components (A), (B), and (C) is preferably 20% by mass or more, more preferably 30% by mass or more, more preferably 40% by mass or more, even more preferably 50% by mass or more, even more preferably 60% by mass or more, yet more preferably 70% by mass or more, and particularly preferably 75% by mass or more, and, moreover, may be 80% by mass or more, 85% by mass or more, 90% by mass or more, or 95% by mass or more, and may be 100% by mass or less, 99.999% by mass or less, 99.99% by mass or less, or 99.98% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

[0025] Below, the respective components contained in the aqueous working fluid of one embodiment of the present invention will now be described.

<Component (A)>

[0026] The aqueous working fluid of the present invention contains a compound represented by the following general formula (a-1) and having a weight average molecular weight of 12,000 or less as component (A).

[0027] Containing component (A), the aqueous working fluid can have excellent brittle material workability. One component (A) may be used singly, or two or more may be used in combination.



[0028] In the above general formula (a-1), A is an alkylene group having 2 to 4 carbon atoms, and when there is a plurality of A, the plurality of A may be the same or different; and m is an integer of 1 or more, and preferably an integer of 2 or more.

[0029] Examples of the alkylene group that can be selected as A include alkylene groups having 2 carbon atoms such as an ethylene group (-CH₂CH₂-) and an ethylidene group (-CH(CH₃)-); alkylene groups having 3 carbon atoms such as a trimethylene group (-CH₂CH₂CH₂-), a propylene group (-CH(CH₃)CH₂-), a propylidene group (-CHCH₂CH₃-), and an isopropylidene group (-C(CH₃)₂-); and alkylene groups having 4 carbon atoms such as a tetramethylene group (-CH₂CH₂CH₂CH₂-), a 1-methyltrimethylene group (-CH(CH₃)CH₂CH₂-), a 2-methyltrimethylene group (-CH₂CH(CH₃)CH₂-), and a butylene group (-C(CH₃)₂CH₂-). The alkylene group may be a linear alkylene group or may be a branched alkylene group.

[0030] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid having excellent brittle material workability, component (A) preferably contains one or more selected from diethylene glycol, dipropylene glycol, polyethylene glycol, and polypropylene glycol, and more preferably contains one or more selected from diethylene glycol and polyethylene glycol.

[0031] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid having excellent brittle material workability, the total content of diethylene glycol and polyethylene glycol is preferably 30 to 100% by mass, more preferably 40 to 100% by mass, more preferably 50 to 100% by mass, more preferably 60 to 100% by mass, even more preferably 70 to 100% by mass, even more preferably 80 to 100% by mass, and yet more preferably 90 to 100% by mass, and particularly preferably 95 to 100% by mass based on the total amount (100% by mass) of component (A) contained in the aqueous working fluid.

[0032] From the viewpoint of providing an aqueous working fluid having small surface tension and suitable brittle material workability, the weight average molecular weight of component (A) is 12,000 or less, preferably 10,000 or less,

more preferably 8,000 or less, more preferably 6,500 or less, even more preferably 5,000 or less, even more preferably 4,000 or less, yet more preferably 3,000 or less, yet more preferably 2,000 or less, and particularly preferably 1,000 or less, and, moreover, may be 900 or less, 800 or less, 700 or less, 600 or less, 500 or less, 450 or less, 400 or less, or 350 or less.

[0033] The lower limit of the weight average molecular weight of component (A) is not particularly limited, and the minimum molecular weight of component (A) should be equal to or greater than the molecular weight of ethylene glycol, i.e., 62, and, moreover, may be 65 or more, 70 or more, 80 or more, 90 or more, or 100 or more.

[0034] Herein, the weight average molecular weight means a value measured by the method described in the Examples.

[0035] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid regulated to the above-described viscosity range and having excellent brittle material workability, the content of component (A) is preferably 15.0% by mass or more, more preferably 20% by mass or more, more preferably 25% by mass or more, even more preferably 30% by mass or more, even more preferably 35% by mass or more, yet more preferably 40% by mass or more, and particularly preferably 45% by mass or more, and, moreover, may be 50% by mass or more, 55% by mass or more, 60% by mass or more, 65% by mass or more, or 70% by mass or more, and is preferably 95.0% by mass or less, more preferably 92.0% by mass or less, more preferably 90.0% by mass or less, even more preferably 87.0% by mass or less, even more preferably 85.0% by mass or less, yet more preferably 83.0% by mass or less, and particularly preferably 80.0% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

<Component (B)>

[0036] The aqueous working fluid of the present invention contains water-insoluble compound (B) having a polyoxyalkylene group as component (B).

[0037] Containing component (B) enables the surface tension of the aqueous working fluid to be small, and an aqueous working fluid having excellent brittle material workability to be provided.

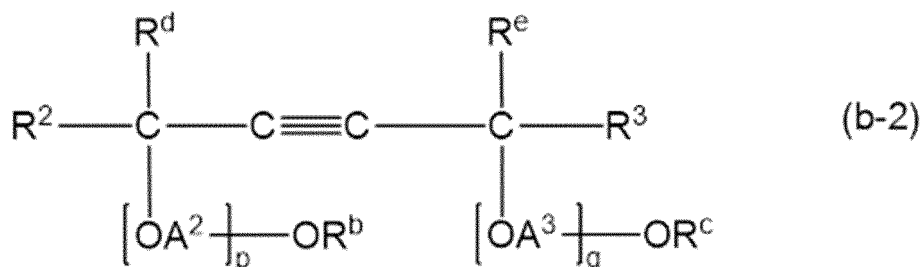
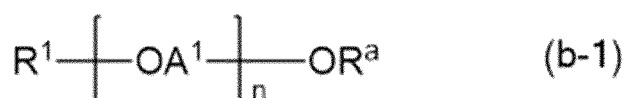
[0038] One component (B) may be used singly, or two or more may be used in combination.

[0039] Herein, concerning the "water-insoluble compound", the compound of interest can be determined as being a water-insoluble compound when 0.1 g of the compound of interest is added to 99.9 g of ion exchanged water at 25°C, the mixture is stirred and left to stand still at 25°C for 24 hours, and residues of the compound of interest are visually confirmed.

[0040] From the viewpoint of providing an aqueous working fluid regulated to a smaller surface tension and having excellent brittle material workability, the HLB value of component (B) used in one embodiment of the present invention is preferably 10.0 or less, more preferably 9.0 or less, and even more preferably 8.0 or less, and, moreover, may be 7.0 or less, 6.0 or less, 5.0 or less, or 4.0 or less, and may be more than 0, 1.0 or more, or 2.0 or more.

[0041] Herein, the HLB value means a value calculated by Griffin's method.

[0042] From the viewpoint of providing an aqueous working fluid regulated to a smaller surface tension and having excellent brittle material workability, component (B) preferably contains one or more selected from water-insoluble polyoxyalkylene ether (B1) represented by the following general formula (b-1) and an alkylene oxide adduct of water-insoluble acetylene glycol (B2) represented by the following general formula (b-2):



[0043] In the general formulae (b-1) and (b-2), A¹ to A³ are each independently an alkylene group having 2 to 4 carbon atoms;

[0044] R^a to R^e are each independently a hydrogen atom, an alkyl group, a cycloalkyl group optionally having an alkyl

group, or an aryl group optionally having an alkyl group, and is preferably a hydrogen atom or an alkyl group;

[0045] R^1 to R^3 are each independently an alkyl group, a cycloalkyl group optionally having an alkyl group, or an aryl group optionally having an alkyl group, and is preferably an alkyl group; and

[0046] n , p , and q are each independently an integer of 1 or more.

[0047] Examples of the alkylene group having 2 to 4 carbon atoms that can be selected as A^1 to A^3 include those identical to the above-described alkylene groups having 2 to 4 carbon atoms that can be selected as A in the above general formula (a-1), an alkylene group having 2 to 3 carbon atoms is preferable, an ethylene group, a trimethylene group, or a propylene group is more preferable, and an ethylene group is even more preferable. The alkylene group may be a linear alkylene group or may be a branched alkylene group.

[0048] Examples of the alkyl group that can be selected as R^a to R^e and R^1 to R^3 include a methyl group, an ethyl group, a propyl group (a *n*-propyl group, an isopropyl group), a butyl group (a *n*-butyl group, a *s*-butyl group, a *t*-butyl group, an isobutyl group), a pentyl group, a hexyl group, a heptyl group, an octyl group, a 2-ethylhexyl group, a nonyl group, a 1,1-dimethylheptyl group, a decyl group, an undecyl group, a dodecyl group, a tridecyl group, a tetradecyl group, a pentadecyl group, a hexadecyl group, a heptadecyl group, and an octadecyl group, and these alkyl groups may be linear alkyl groups or branched alkyl groups. The number of carbon atoms in the alkyl group is preferably 1 to 20, more preferably 1 to 16, even more preferably 1 to 12, and yet more preferably 1 to 10.

[0049] Examples of the cycloalkyl group optionally having an alkyl group, which can be selected as R^a to R^e and R^1 to R^3 , include a cyclopentyl group, a cyclohexyl group, a dimethylcyclohexyl group, an ethylcyclohexyl group, a propylcyclohexyl group, a butylcyclohexyl group, and a heptylcyclohexyl group. The number of ring-forming carbon atoms in the cycloalkyl group is preferably 5 to 18, more preferably 5 to 12, and even more preferably 6 to 10.

[0050] Examples of the aryl group optionally having an alkyl group, which can be selected as R^a to R^e and R^1 to R^3 , include a phenyl group, a naphthyl group, an anthracenyl group, a biphenyl group, a terphenyl group, a tolyl group, a dimethylphenyl group, a butylphenyl group, a nonylphenyl group, a methylbenzyl group, and a dimethylnaphthyl group. The number of ring-forming carbon atoms in the aryl group is preferably 6 to 24, more preferably 6 to 18, and even more preferably 6 to 12.

[0051] Component (B1) used in one embodiment of the present invention is preferably water-insoluble polyoxyalkylene ether of the above general formula (b-1) wherein A^1 is an ethylene group, R^a is a hydrogen atom, and R^1 is an alkyl group having 1 to 20 (preferably 1 to 10) carbon atoms.

[0052] Component (B2) used in one embodiment of the present invention is preferably an ethylene oxide adduct of water-insoluble acetylene glycol of the above general formula (b-2) wherein A^2 and A^3 are ethylene groups, R^b and R^c are hydrogen atoms, R^d and R^e are each independently a hydrogen atom or an alkyl group having 1 to 10 carbon atoms (preferably 1 to 6, more preferably 1 to 4, and even more preferably 1 to 3), and R^2 and R^3 are each independently an alkyl group (preferably a branched alkyl group) having 1 to 20 carbon atoms (preferably 2 to 16, more preferably 3 to 10, even more preferably 4 to 8, and yet more preferably 4 to 6).

[0053] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid regulated to a smaller surface tension and having excellent brittle material workability, the content of component (B) is preferably 0.0001% by mass or more, more preferably 0.0003% by mass or more, more preferably 0.0005% by mass or more, even more preferably 0.0010% by mass or more, even more preferably 0.0020% by mass or more, yet more preferably 0.0030% by mass or more, and particularly preferably 0.0040% by mass or more, is preferably 1.0% by mass or less, more preferably 0.80% by mass or less, more preferably 0.50% by mass or less, even more preferably 0.30% by mass or less, even more preferably 0.10% by mass or less, yet more preferably 0.080% by mass or less, and particularly preferably 0.050% by mass or less, and, moreover, may be 0.030% by mass or less, 0.020% by mass or less, 0.010% by mass or less, 0.0090% by mass or less, 0.0080% by mass or less, or 0.0070% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

[0054] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid regulated to the above-described viscosity range, also regulated to a smaller surface tension, and having excellent brittle material workability, the ratio of the content of component (B) to 100 parts by mass of component (A) is preferably 0.0001 parts by mass or more, more preferably 0.0003 parts by mass or more, more preferably 0.0005 parts by mass or more, even more preferably 0.0010 parts by mass or more, even more preferably 0.0020 parts by mass or more, yet more preferably 0.0030 parts by mass or more, yet more preferably 0.0040 parts by mass or more, and particularly preferably 0.0050 parts by mass or more, is preferably 1.80 parts by mass or less, more preferably 1.70 parts by mass or less, more preferably 1.50 parts by mass or less, even more preferably 1.40 parts by mass or less, yet more preferably 1.30 parts by mass or less, and particularly preferably 1.25 parts by mass or less, and, moreover, may be 1.00 parts by mass or less, 0.500 parts by mass or less, 0.100 parts by mass or less, 0.050 parts by mass or less, 0.020 parts by mass or less, or 0.010 parts by mass or less.

<Component (C)>

[0055] From the viewpoint of providing an aqueous working fluid regulated to the above-described viscosity range, the aqueous working fluid of one embodiment of the present invention may further contain water as the component (C).

[0056] In the aqueous working fluid of one embodiment of the present invention, examples of water used as the component (C) include ultrapure water, pure water, distilled water, ion exchanged water, tap water, and water for industrial use.

[0057] In the aqueous working fluid of one embodiment of the present invention, the content of the component (C) is preferably 5.0% by mass or more, more preferably 7.0% by mass or more, more preferably 10.0% by mass or more, even more preferably 12.0% by mass or more, even more preferably 15.0% by mass or more, yet more preferably 17.0% by mass or more, and particularly preferably 20.0% by mass or more, is preferably 70.0% by mass or less, more preferably 67.0% by mass or less, more preferably 65.0% by mass or less, even more preferably 63.0% by mass or less, even more preferably 60.0% by mass or less, yet more preferably 57.0% by mass or less, and particularly preferably 55.0% by mass or less, and, moreover, may be 50.0% by mass or less, 45.0% by mass or less, 40.0% by mass or less, 35.0% by mass or less, 30.0% by mass or less, or 27.0% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

<Component (D)>

[0058] From the viewpoint of providing an aqueous working fluid capable of preventing corrosion of apparatuses and wires, the aqueous working fluid of one embodiment of the present invention may further contain carboxylic acid as the component (D).

[0059] One component (D) may be used singly, and two or more may be used in combination.

[0060] Examples of carboxylic acid used as the component (D) in one embodiment of the present invention include saturated monocarboxylic acid, unsaturated monocarboxylic acid, dicarboxylic acid, and tricarboxylic acid.

[0061] Among these, carboxylic acid used as the component (D) in one embodiment of the present invention is preferably saturated monocarboxylic acid or unsaturated monocarboxylic acid, more preferably saturated monocarboxylic acid, and even more preferably branched saturated monocarboxylic acid.

[0062] Examples of saturated monocarboxylic acid include linear saturated monocarboxylic acid such as valeric acid, caproic acid, enanthic acid, caprylic acid, pelargonic acid, capric acid, undecanoic acid, lauric acid, tridecanoic acid, myristic acid, pentadecanoic acid, palmitic acid, heptadecanoic acid, stearic acid, nonadecanoic acid, arachic acid, and behenic acid; and branched saturated monocarboxylic acid such as isomyristic acid, isopalmitic acid, isostearic acid, 2,2-dimethylpropanoic acid, 2,2-dimethylbutanoic acid, 2,2-dimethylpentanoic acid, 2,2-dimethyloctanoic acid, 2-ethyl-2,3,3-trimethylbutanoic acid, 2,2,3,4-tetramethylpentanoic acid, 2,5,5-trimethyl-2-t-butylhexanoic acid, 2,3,3-trimethyl-2-ethylbutanoic acid, 2,3-dimethyl-2-isopropylbutanoic acid, 2-ethylhexanoic acid, and 3,5,5-trimethylhexanoic acid (isononanoic acid). Among these, branched saturated monocarboxylic acid is preferable, and 3,5,5-trimethylhexanoic acid (isononanoic acid) is more preferable.

[0063] Examples of unsaturated monocarboxylic acid include undecylenic acid, oleic acid, elaidic acid, erucic acid, nervonic acid, linoleic acid, γ -linolenic acid, arachidonic acid, α -linolenic acid, stearidonic acid, eicosapentaenoic acid, and docosahexaenoic acid.

[0064] Examples of dicarboxylic acid include adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioic acid, dodecanedioic acid, brassylic acid, and tetradecanedioic acid.

[0065] Examples of tricarboxylic acid include propanetricarboxylic acid, propan-1-ene-1,2,3-tricarboxylic acid, butanetricarboxylic acid, pentanetricarboxylic acid, hexanetricarboxylic acid, octanetricarboxylic acid, nonanetricarboxylic acid, decanetricarboxylic acid, undecanetricarboxylic acid, and monomethyldecanetricarboxylic acid.

[0066] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid capable of preventing corrosion of apparatuses and wires, the content of the component (D) is preferably 0.001% by mass or more, more preferably 0.003% by mass or more, even more preferably 0.005% by mass or more, yet more preferably 0.007% by mass or more, and particularly preferably 0.009% by mass or more, and is preferably 3.0% by mass or less, more preferably 2.0% by mass or less, more preferably 1.0% by mass or less, even more preferably 0.50% by mass or less, yet more preferably 0.20% by mass or less, and particularly preferably 0.10% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

<Component (E)>

[0067] From the viewpoint of providing an aqueous working fluid capable of preventing corrosion of apparatuses and wires, the aqueous working fluid of one embodiment of the present invention may further contain an amine compound as the component (E). One component (E) may be used singly, or two or more may be used in combination.

[0068] Examples of the amine compound used as the component (E) in one embodiment of the present invention include alkylamine, alkanolamine, and polyalkylenepolyamine.

[0069] Among these, alkanolamine is preferable as the amine compound used as the component (E) in one embodiment of the present invention, and alkanolamine having 2 to 6 carbon atoms is more preferable.

[0070] Examples of alkylamine include primary aliphatic alkylamine such as monomethylamine, monoethylamine, monopropylamine, monobutylamine, and monopentylamine; and secondary aliphatic alkylamine such as dimethylamine, methylethylamine, diethylamine, methylpropylamine, and ethylpropylamine.

[0071] Examples of alkanolamine include monomethanolamine, monoethanolamine, monopropanolamine, monoisopropanolamine, monobutanolamine, dimethanolamine, methanolethanolamine, diethanolamine, methanolpropanolamine, ethanolpropanolamine, dipropanolamine, diisopropanolamine, trimethanolamine, triethanolamine, tripropanolamine, triisopropanolamine, tributanolamine, and monobutyldiethanolamine.

[0072] Among these alkanolamines, alkanolamine having 2 to 6 carbon atoms is preferable, one or more selected from monoethanolamine, diethanolamine, triethanolamine, monoisopropanolamine, diisopropanolamine, and triisopropanolamine are more preferable, and one or more selected from triethanolamine and triisopropanolamine are even more preferable, and triisopropanolamine is yet more preferable.

[0073] Examples of polyalkylenepolyamine include diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenehexamine, hexaethyleneheptamine, tetrapropylenehexamine, and hexabutyleneheptamine.

[0074] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid capable of preventing corrosion of apparatuses and wires, the content of the component (E) is preferably 0.001% by mass or more, more preferably 0.005% by mass or more, even more preferably 0.007% by mass or more, yet more preferably 0.010% by mass or more, and particularly preferably 0.015% by mass or more, is preferably 5.0% by mass or less, more preferably 3.0% by mass or less, even more preferably 2.0% by mass or less, yet more preferably 1.0% by mass or less, and particularly preferably 0.70% by mass or less, and, moreover, may be 0.50% by mass or less, 0.30% by mass or less, 0.20% by mass or less, 0.10% by mass or less, 0.070% by mass or less, or 0.050% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

[0075] In the aqueous working fluid of one embodiment of the present invention, from the viewpoint of providing an aqueous working fluid capable of preventing corrosion of apparatuses and wires, the mass ratio of the content of the component (D) to the content of the component (E) [(D)/(E)] is preferably 0.01 or more, more preferably 0.05 or more, more preferably 0.10 or more, even more preferably 0.20 or more, yet more preferably 0.30 or more, and particularly preferably 0.40 or more, and is preferably 1.2 or less, more preferably 1.0 or less, more preferably 0.90 or less, even more preferably 0.80 or less, yet more preferably 0.75 or less, and particularly preferably 0.70 or less.

<Other additives>

[0076] The aqueous working fluid of one embodiment of the present invention may further contain, as necessary, other additives other than the components (A) to (E) as long as the effects of the present invention are not impaired.

[0077] Examples of such other additives include rust inhibitors (such as alkylbenzene sulfonate, dinonylnaphthalene sulfonate, alkenyl succinate, and polyhydric alcohol ester), friction modifiers (such as various nonionic surfactants), antifoaming agents (such as silicone oil, fluorosilicone oil, and fluoroalkyl ether), metal deactivators (such as imidazoline, pyrimidine derivatives, thiadiazole, and benzotriazole), bactericides/preservatives (such as paraoxybenzoic acid esters; benzoic acid, salicylic acid, sorbic acid, dehydroacetic acid, p-toluenesulfonic acid, and salts thereof; and phenoxyethanol), and pH adjusters (such as organic acids such as acetic acid, malic acid, and citric acid, and salts thereof; and phosphoric acid and salts thereof).

[0078] Each of these additives may be used singly, or two or more may be used in combination.

[0079] In the aqueous working fluid of one embodiment of the present invention, the content of each of these various additives is suitably set according to the type and the function of each component, and may be 0.0001% by mass or more, 0.005% by mass or more, 0.01% by mass or more, 0.05% by mass or more, or 0.1% by mass or more, and may be 20% by mass or less, 10% by mass or less, 5% by mass or less, 2% by mass or less, or 1% by mass or less based on the total amount (100% by mass) of the aqueous working fluid.

<Method for producing aqueous working fluid>

[0080] The method for producing an aqueous working fluid of one embodiment of the present invention is not particularly limited, and is preferably a method comprising the step of blending the components (A) and (B) and, optionally, the components (C) to (E) and other additives.

[0081] For example, when producing an aqueous working fluid containing water as the component (C), the aqueous working fluid can be produced by blending water with the components (A) and (B) and, optionally, the components (C) to (E) and other additives, and optionally stirring the mixture. The order of blending the respective components can be

suitably set.

[Properties of aqueous working fluid]

[0082] From the viewpoint of providing an aqueous working fluid having excellent brittle material workability, the lower the surface tension of the aqueous working fluid of one embodiment of the present invention is, the more preferable it is.

[0083] From the above viewpoint, the surface tension of the aqueous working fluid of one embodiment of the present invention is preferably 45.0 mN/m or less, more preferably 43.0 mN/m or less, more preferably 40.0 mN/m or less, even more preferably 38.0 mN/m or less, yet more preferably 36.0 mN/m or less, and particularly preferably 35.0 mN/m or less, and may be 1.0 mN/m or more, 3.0 mN/m or more, 5.0 mN/m or more, 7.0 mN/m or more, 10.0 mN/m or more, or 15.0 mN/m or more.

[0084] Herein, the surface tension of the aqueous working fluid means a value measured in accordance with the platinum plate method of JIS K 2241.

[0085] From the viewpoint of suppressing rusting of processing equipment and from the viewpoint of preventing corrosion of a workpiece, the pH of the aqueous processing liquid of one embodiment of the present invention is preferably 4.0 to 10.0, more preferably 5.0 to 9.0, even more preferably 6.0 to 8.5, and yet more preferably 7.0 to 8.0.

[0086] The pH of the aqueous working fluid means a value measured at 25°C in accordance with JIS Z 8802.

[0087] The amount of produced foam after adding 90 mL of the aqueous working fluid of one embodiment of the present invention to a 100 mL graduated cylinder, placing a lid on the graduated cylinder, vigorously shaking the graduated cylinder up and down 10 times, and leaving the graduated cylinder to stand still for 10 seconds is preferably 15 mL or less, more preferably 10 mL or less, even more preferably 9.0 mL or less, yet more preferably 8.0 mL or less, and particularly preferably 7.5 mL or less, and, moreover, is preferably less than 6.0 mL, less than 5.0 mL, less than 4.0 mL, less than 3.5 mL, less than 3.0 mL, less than 2.5 mL, less than 2.0 mL, less than 1.5 mL, or less than 1.0 mL.

[0088] The amount of foam means a value measured by the method of the Examples described below.

[Concentrate for aqueous working fluid]

[0089] The present invention also provides a concentrate for an aqueous working fluid that contains compound (A) represented by the above general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group.

[0090] By being diluted with water, the concentrate for an aqueous working fluid of the present invention can be prepared into an aqueous working fluid having a viscosity at 25°C of 4.0 to 20.0 mPa·s. That is to say, the aqueous working fluid concentrate of the present invention can be prepared into the above-described aqueous working fluid of one embodiment of the present invention by being diluted with water.

[0091] In the concentrate for an aqueous working fluid of one embodiment of the present invention, the ratio of the content of component (B) to 100 parts by mass of component (A) is preferably 0.0001 parts by mass or more, more preferably 0.0003 parts by mass or more, more preferably 0.0005 parts by mass or more, even more preferably 0.0010 parts by mass or more, even more preferably 0.0020 parts by mass or more, yet more preferably 0.0030 parts by mass or more, yet more preferably 0.0040 parts by mass or more, and particularly preferably 0.0050 parts by mass or more, is preferably 1.80 parts by mass or less, more preferably 1.70 parts by mass or less, more preferably 1.50 parts by mass or less, even more preferably 1.40 parts by mass or less, yet more preferably 1.30 parts by mass or less, and particularly preferably 1.25 parts by mass or less, and, moreover, may be 1.00 parts by mass or less, 0.500 parts by mass or less, 0.100 parts by mass or less, 0.050 parts by mass or less, 0.020 parts by mass or less, or 0.010 parts by mass or less.

[0092] The concentrate for an aqueous working fluid of one embodiment of the present invention may contain, other than the components (A) and (B), the components (D) and (E) and the above-described other additives.

[0093] In the concentrate for an aqueous working fluid of one embodiment of the present invention, specific embodiments (including preferable embodiments as well) of the components (A) and (B), the components (D) and (E), and the above-described other additives are the same as those described for the respective components of the above-described aqueous working fluid of one embodiment of the present invention.

[0094] In the concentrate for an aqueous working fluid of one embodiment of the present invention, the total content of the components (A) and (B) is preferably 70% by mass or more, more preferably 80% by mass or more, even more preferably 90% by mass or more, yet more preferably 95% by mass or more, and particularly preferably 98% by mass or more, and may be 100% by mass or less, 99.99% by mass or less, 99.90% by mass or less, or 99.80% by mass or less based on the total amount (100% by mass) of the concentrate for an aqueous working fluid.

[Application of aqueous working fluid, use of aqueous working fluid, method for processing brittle material]

[0095] The aqueous working fluid of one preferable embodiment of the present invention contains the components

(A) and (B) and has a viscosity at 25°C that is regulated to a specific range, thus has various characteristics (such as appropriate viscosity characteristics, small surface tension, and good antifoaming properties) that can increase workability, and thus can be suitably applied to the processing of brittle materials.

[0096] In particular, the aqueous working fluid of one preferable embodiment of the present invention has appropriate viscosity characteristics, small surface tension, and good antifoaming properties, is thus suitable as an aqueous working fluid used when cutting brittle materials by means of a wire saw, and is more suitable as an aqueous working fluid for a fixed abrasive process wherein brittle materials are cut using a wire, to the surface of which abrasive grains are fixed in advance. The aqueous working fluid of one embodiment of the present invention enables highly accurate cutting to be performed even when cutting brittle materials by a fixed abrasive process.

[0097] Examples of the brittle material as a workpiece include silicon ingot, crystal, carbon, and glass, and silicon ingot is preferable.

[0098] The diameter of the wire for a fixed-abrasive process may be 0.2 mm or less, 0.12 mm or less, 0.1 mm or less, or 0.08 mm or less, and may be 0.01 mm or more, 0.02 mm or more, 0.03 mm or more, 0.04 mm or more, 0.05 mm or more, or 0.06 mm or more.

[0099] Note that a wire having a smaller diameter can provide a higher yield when obtaining a product from a brittle material as a workpiece, but impairs properties of a brittle material as a workpiece and tends to result in poor cutting efficiency. On the other hand, by using the aqueous working fluid of one embodiment of the present invention, the biting of abrasive grains is increased, and cutting efficiency can be increased, thus enabling a wire having a smaller diameter to be used. Also, the aqueous working fluid of one embodiment of the present invention, because the surface tension of which is small, can suppress repulsion between wires, prevent wires from being intertwined, and increase workability.

[0100] Considering the above characteristics of the aqueous working fluid of one embodiment of the present invention, the present invention can also provide [1] and [2] below:

[1] Use of an aqueous working fluid, wherein the above-described aqueous working fluid of one embodiment of the present invention is applied to the step of cutting a brittle material by means of a wire saw.

[2] A method for processing a brittle material, comprising the step of cutting a brittle material by means of a wire saw with applying the above-described aqueous working fluid of one embodiment of the present invention.

[0101] The cutting step in [1] and [2] is preferably performed by a fixed abrasive process wherein a wire, to the surface of which abrasive grains are fixed in advance, is used to cut a brittle material. Specific embodiments of the wire and the brittle material used in wire sawing are as described above.

Examples

[0102] Next, the present invention will now be described in more detail by way of Examples, but the present invention is not limited to these Examples in any way.

[0103] In the following Examples, the methods for measuring and calculating the following physical property values are as follows.

(1) Weight average molecular weight

[0104] Using a gel permeation chromatograph (manufactured by Agilent Technologies, "1260 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)

[0105]

- Column: Two "Shodex LF-404" columns sequentially connected.
- Column temperature: 35°C
- Developing solvent: Chloroform
- Flow rate: 0.3 mL/min

(2) HLB

[0106] Calculated by Griffin's method.

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Examples 1 to 10, Comparative Examples 1 to 7

[0107] Various components of the types shown in Tables 1 and 2 were added and mixed in the amounts shown in Tables 1 and 2 to prepare respective aqueous working fluids. Details of each component used in the preparation of the aqueous working fluids are as follows.

<(Poly)alkylene glycol>

[0108]

- DEG: Diethylene glycol
- PEG 200: Polyethylene glycol having weight average molecular weight of 200.
- PEG 400: Polyethylene glycol having weight average molecular weight of 400.
- PEG 600: Polyethylene glycol having weight average molecular weight of 600.
- PEG 13000: Polyethylene glycol having weight average molecular weight of 13,000.

<Compound having polyoxyalkylene group>

[0109]

- Water-insoluble polyoxyethylene ether: Aliphatic polyoxyethylene ether having general formula (b-1) wherein A¹ is an ethylene group, R^a is a hydrogen atom, and R¹ is an alkyl group having 1 to 10 carbon atoms, a water-insoluble compound.
- Water-insoluble acetylene glycol EO adduct (1):
Ethylene oxide adduct of acetylene glycol having general formula (b-2) wherein A² and A³ are ethylene groups, R^b and R^c are hydrogen atoms, R^d and R^e are methyl groups, and R² and R³ are isobutyl groups, a water-insoluble compound, water insoluble, HLB = 8
- Water-insoluble acetylene glycol EO adduct (2):
Ethylene oxide adduct of acetylene glycol having general formula (b-2) wherein A² and A³ are ethylene groups, R^b and R^c are hydrogen atoms, R^d and R^e are methyl groups, and R² and R³ are isobutyl groups, a water-insoluble compound, HLB = 4
- Water-soluble acetylene glycol EO adduct: Ethylene oxide adduct of acetylene glycol, water soluble, HLB = 13

<Other components>

[0110]

- Isononanoic acid
- Triisopropanolamine
- Ion exchanged water

[0111] The physical property values of the viscosity at 25°C, surface tension, and pH of the prepared aqueous working fluids were measured by the following methods, and also the antifoaming properties were evaluated by the following method. Moreover, the brittle material workability of the aqueous working fluids of Example 1 and Comparative Examples 5 and 6 was evaluated by the following method. The results thereof are shown in Tables 1 and 2. In Comparative Example 1, water-insoluble polyoxyethylene ether blended did not dissolve in water, and thus it was not possible to measure the above physical property values and evaluate antifoaming properties. Also, the aqueous working fluid of Comparative Example 4 had high viscosity, and thus it was not possible to evaluate antifoaming properties.

(1) Viscosity at 25°C

[0112] Viscosity was measured at a rotor speed of 60 rpm using a Brookfield rotary viscometer TVB-10 (trade name, manufactured by Toki Sangyo Co., Ltd.).

(2) Surface tension

[0113] Surface tension was measured by a platinum plate method in accordance with JIS K 2241.

(3) pH

[0114] pH was measured at 25°C in accordance with JIS Z 8802.

(4) Evaluation of antifoaming properties

[0115] The amount of foam after adding 90 mL of the prepared aqueous working fluid to a 100 mL graduated cylinder, placing a lid on the graduated cylinder, vigorously shaking the graduated cylinder up and down 10 times, and leaving the graduated cylinder to stand still for 10 seconds was measured by reading the marked line on the graduated cylinder. It can be said that the smaller the amount of foam is, the better the antifoaming properties of the aqueous working fluid are.

(5) Evaluation of brittle material workability

[0116] Using a multi wire saw and a fixed abrasive wire (an electrodeposited diamond wire), single crystal silicon ingot was cut into a silicon wafer while pouring the prepared aqueous working fluid onto the fixed abrasive wire.

[0117] Then, total thickness variation (TTV) was measured to evaluate the flatness of the silicon wafer obtained by the above cutting, and the brittle material workability was evaluated based on the following criteria. TTV used in the flatness evaluation is a value expressed by the difference between the maximum thickness and the minimum thickness obtained by measuring the thickness of the resulting silicon wafer with a dial indicator, and it can be said that the smaller the value is, the higher the flatness of the silicon wafer is. In the present Examples, a dial indicator "DIGIMATIC INDICATOR ID-C112CX" (trade name, manufactured by Mitutoyo Corporation) was used.

(Evaluation criteria for brittle material workability)

[0118]

- A: TTV is less than 10 μm .
- B: TTV is 10 μm or more and less than 15 μm .
- C: TTV is 15 μm or more.

[Table 1]

Composition of aqueous working fluid	Component (A)	DEG	% by mass	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10
	Component (A)	PEG200	% by mass	-	65.900	-	-	85.000	75.900	-	-	75.900	75.900
	Component (A)	PEG400	% by mass	-	-	55.900	-	-	-	-	-	-	-
	Component (A)	PEG600	% by mass	-	-	-	40.000	-	-	40.000	40.000	-	-
	-	PEG13000	% by mass	-	-	-	-	-	-	-	-	-	-
	Component (B)	Water-insoluble polyoxyethylene ether	% by mass	0.005	0.005	0.005	0.005	0.005	-	-	-	0.010	0.0005
	Component (B)	EO adduct of water-insoluble acetylene glycol (1)	% by mass	-	-	-	-	-	0.500	0.500	-	-	-
	Component (B)	EO adduct of water-insoluble acetylene glycol (2)	% by mass	-	-	-	-	-	-	-	0.500	-	-
	-	EO adduct of water-soluble acetylene glycol	% by mass	-	-	-	-	-	-	-	-	-	-
	Component (D)	Isononanoic acid	% by mass	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
	Component (E)	Trisopropanolamine	% by mass	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	Component (C)	Ion exchanged water	% by mass	24.065	34.065	44.065	59.965	14.965	23.570	59.470	59.470	24.060	24.070
	Total amount		% by mass	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

(continued)

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10
Ratio of content of component (B) to 100 parts by mass of component (A)	0.0066	0.0076	0.0089	0.0125	0.0059	0.6588	1.2500	1.2500	0.0132	0.0007
Viscosity at 25°C	14.6	17.1	18.6	9.1	21.5	14.8	9.2	9.2	14.7	14.3
Surface tension	34.3	34.7	34.4	32.7	34.3	35.3	28.5	29.3	33.9	42.5
pH	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Evaluation of antifoaming properties Amount of foam	1.0	1.0	1.0	1.0	1.0	3.0	0.5	1.0	1.0	2.0
Evaluation of brittle material workability TTV	A	-	-	-	-	-	-	-	-	-

[Table 2]

Composition of aqueous working fluid	Component (A)	DEG	% by mass	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7
	Component (A)	PEG200	% by mass	-	-	-	-	-	-	-
	Component (A)	PEG400	% by mass	-	10.000	-	-	-	-	-
	Component (A)	PEG600	% by mass	-	-	-	-	-	-	-
	-	PEG13000	% by mass	-	-	-	40.000	-	-	-
	Component (B)	Water-insoluble polyoxyethylene ether	% by mass	0.005	0.005	0.005	0.005	0.005	-	-
	Component (B)	EO adduct of water-insoluble acetylene glycol (1)	% by mass	-	-	-	-	-	-	-
	Component (B)	EO adduct of water-insoluble acetylene glycol (2)	% by mass	-	-	-	-	-	-	-
	-	EO adduct of water-soluble acetylene glycol	% by mass	-	-	-	- - -	-	-	0.005
	Component (D)	Isononanoic acid	% by mass	0.010	0.010	0.010	0.010	0.010	0.010	0.010
	Component (E)	Triisopropanolamine	% by mass	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	Component (C)	Ion exchanged water	% by mass	99.965	89.965	4.965	59.965	64.965	24.070	24.065
	Total amount		% by mass	100.000	100.000	100.000	100.000	100.000	100.000	100.000

(continued)

Ratio of content of component (B) to 100 parts by mass of component (A)	Part by mass	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6	Comparative Example 7
		-	0.0500	0.0053	-	0.0143	-	-
Viscosity at 25°C	mPa·s	*1	1.5	30.2	298.0	3.0	15.1	14.6
Surface tension	mN/m	*1	32.3	34.8	37.8	33.2	47.9	47.8
pH	-	*1	7.3	7.3	7.3	7.3	7.3	7.3
Evaluation of antifoaming properties								
Amount of foam	mL	*1	4.0	1.0	*2	4.0	2.0	6.0
Evaluation of brittle material workability TTV	-	-	-	-	-	C	B	-

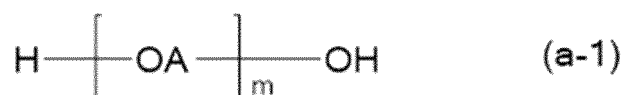
*1 The experiment was terminated without measurement and evaluation of physical properties because water-insoluble polyoxyethylene ether blended did not dissolve in water.
 *2 It was not possible to evaluate antifoaming properties because of high viscosity.

[0119] From Table 1, the aqueous working fluids of Examples 1 to 10 have good antifoaming properties and, excellent brittle material workability, in view of the viscosity characteristics and surface tension. In fact, the aqueous working fluid of Example 1 had a TTV value of less than 10 μm and was confirmed as having excellent brittle material workability.

[0120] On the other hand, from Table 2, the aqueous working fluids of Comparative Examples 2 to 5 have excessively low or high viscosity, and are thus considered as being problematic in brittle material workability. Also, the aqueous working fluids of Comparative Examples 6 and 7 have high surface tension and, likewise, are considered as being problematic in brittle material workability. In fact, the aqueous working fluids of Comparative Examples 5 and 6 had a TTV value of 10 μm or more, and were confirmed as having poorer brittle material workability than the aqueous working fluid of Example 1. Concerning the aqueous working fluid of Comparative Example 1, the experiment was terminated without measurement and evaluation of physical properties because water-insoluble polyoxyethylene ether blended did not dissolve in water.

Claims

1. An aqueous working fluid comprising compound (A) represented by the following general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group,
wherein the aqueous working fluid has a viscosity at 25°C of 4.0 to 26.0 mPa·s:

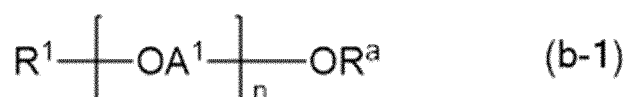


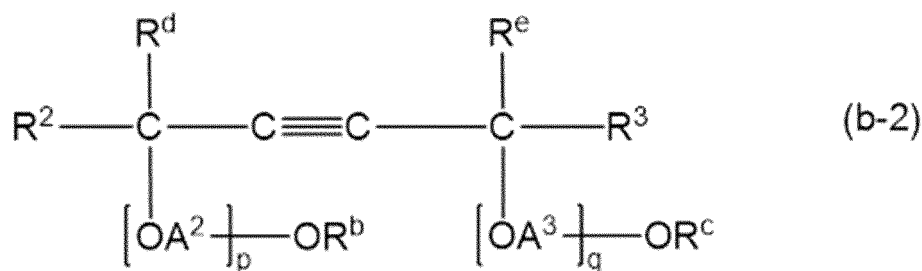
wherein

A is an alkylene group having 2 to 4 carbon atoms, and when there is a plurality of A, the plurality of A may be the same or different; and

m is an integer of 1 or more.

2. The aqueous working fluid according to claim 1, having a surface tension of 45.0 mN/m or less.
3. The aqueous working fluid according to claim 1 or 2, having a content of component (A) of 15.0 to 95.0% by mass based on the total amount of the aqueous working fluid.
4. The aqueous working fluid according to any one of claims 1 to 3, having a content of component (B) of 0.0001 to 1.0% by mass based on the total amount of the aqueous working fluid.
5. The aqueous working fluid according to any one of claims 1 to 4, wherein a ratio of the content of component (B) to 100 parts by mass of component (A) is 0.0001 to 1.80 parts by mass.
6. The aqueous working fluid according to any one of claims 1 to 5, wherein component (A) comprises one or more selected from diethylene glycol, dipropylene glycol, polyethylene glycol, and polypropylene glycol.
7. The aqueous working fluid according to any one of claims 1 to 6, wherein component (B) comprises one or more selected from water-insoluble polyoxyalkylene ether (B1) represented by the following general formula (b-1) and an alkylene oxide adduct of water-insoluble acetylene glycol (B2) represented by the following general formula (b-2):





wherein

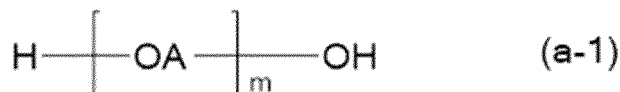
A¹ to A³ are each independently an alkylene group having 2 to 4 carbon atoms;

R^a to R^e are each independently a hydrogen atom, an alkyl group, a cycloalkyl group optionally having an alkyl group, or an aryl group optionally having an alkyl group;

R¹ to R³ are each independently an alkyl group, a cycloalkyl group optionally having an alkyl group, or an aryl group optionally having an alkyl group; and

n, p, and q are each independently an integer of 1 or more.

8. The aqueous working fluid according to any one of claims 1 to 7, further comprising (C) water.
9. The aqueous working fluid according to claim 8, wherein a content of the component (C) is 5.0 to 70.0% by mass based on the total amount of the aqueous working fluid.
10. The aqueous working fluid according to any one of claims 1 to 9, having a pH of 4.0 to 10.0.
11. The aqueous working fluid according to any one of claims 1 to 10, which is used when cutting a brittle material by means of a wire saw.
12. A concentrate for an aqueous working fluid, comprising compound (A) represented by the following general formula (a-1) and having a weight average molecular weight of 12,000 or less, and water-insoluble compound (B) having a polyoxyalkylene group:



wherein

A is an alkylene group having 2 to 4 carbon atoms, and when there is a plurality of A, the plurality of A may be the same or different; and

m is an integer of 1 or more.

13. The concentrate for an aqueous working fluid according to claim 12, which is capable of preparing an aqueous working fluid having a viscosity at 25°C of 4.0 to 20.0 mPa·s by being diluted with water.
14. Use of an aqueous working fluid, wherein the aqueous working fluid according to any one of claims 1 to 11 is applied to the step of cutting a brittle material by means of a wire saw.
15. A method for processing a brittle material, comprising the step of cutting a brittle material by means of a wire saw with applying the aqueous working fluid according to any one of claims 1 to 11.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/014260

A. CLASSIFICATION OF SUBJECT MATTER

C10M 173/02(2006.01); *C10N 30/00*(2006.01)n; *C10N 30/18*(2006.01)n; *C10N 40/22*(2006.01)n; *C10M 105/18*(2006.01)n; *C10M 107/34*(2006.01)n

FI: C10M173/02; C10M107/34; C10M105/18; C10N40/22; C10N30/18; C10N30/00 Z

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)

C10M173/02; C10N30/00; C10N30/18; C10N40/22; C10M105/18; C10M107/34

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 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2011-12249 A (NISSHIN CHEM IND CO LTD) 20 January 2011 (2011-01-20) claims 1-7, paragraphs [0001]-[0002], [0005], [0008]-[0021], examples 1-6, 8-11	1-15
X	WO 2014/136830 A1 (IDEMITSU KOSAN CO., LTD.) 12 September 2014 (2014-09-12) claims 1-10, paragraphs [0001]-[0006], [0008]-[0023], [0034], examples 1-6	1, 3-15
Y		1-15
X	WO 2018/169008 A1 (IDEMITSU KOSAN CO., LTD.) 20 September 2018 (2018-09-20) claims 1-9, paragraphs [0001]-[0008], [0010]-[0055], [0066], examples 1, 3-9	12
Y		1-2, 4-11, 13-15
A		3
Y	JP 2014-132090 A (YUSHIRO CHEMICAL INDUSTRY CO LTD) 17 July 2014 (2014-07-17) claim 2, paragraphs [0014], [0029]-[0031], [0064], examples 1, 3	2
A	JP 56-98294 A (HONDA MOTOR CO LTD) 07 August 1981 (1981-08-07) claims 1-2	1-15

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

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

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

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“&” document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2022	10 May 2022
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer
	Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/014260

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-23662 A (NOF CORP) 04 February 2013 (2013-02-04) claims 1-3	1-15

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/014260

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2011-12249 A	20 January 2011	CN 101906346 A KR 10-2010-0130159 A TW 201111494 A	
WO 2014/136830 A1	12 September 2014	US 2015/0376533 A1 claims 1-10, paragraphs [0002]-[0010], [0024]-[0052], examples 1-6 JP 2014-172950 A EP 2966156 A1 CN 105008505 A KR 10-2015-0127615 A TW 201441361 A	
WO 2018/169008 A1	20 September 2018	JP 2018-154762 A CN 110382673 A TW 201842175 A	
JP 2014-132090 A	17 July 2014	(Family: none)	
JP 56-98294 A	07 August 1981	(Family: none)	
JP 2013-23662 A	04 February 2013	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003082334 A [0004]