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(54) PROCESSING FLUID, PROCESSING FLUID COMPOSITION, AND BRITTLE MATERIAL PROCESSING FLUID COMPOSITION

(57) A working fluid containing a component (A): a compound having a could point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group; a component (B): a compound having a could point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group; a component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less; and a component (D): water, the working fluid containing the component (A), the component (B) and the component (C) each in a specific content.

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Description

Technical Field

[0001] The present invention relates to a working fluid, a composition for working fluid and a brittle material working fluid composition.

Background Art

[0002] In production of semiconductor products, it is important to cut a silicon ingot, which is a brittle material, with high accuracy. Wire saw working is generally used to cut silicon ingots from the viewpoint of working accuracy and productivity.

[0003] In addition, wire saw working is also used to work materials of ceramics, quarts, sapphire, glass and others.

[0004] In general, a working process using a wire saw includes a loose abrasive grain method of working a workpiece with supplying loose abrasive grains to the slide part between a wire and the workpiece, and a fixed abrasive grain method of working a workpiece using a wire that has abrasive grains previously fixed onto the surface thereof.

[0005] In wire saw working of both methods, used is a working fluid (coolant) for the purpose of improving working efficiency in the cutting process, for suppressing friction between a workpiece and a tool to work the workpiece, for reducing the friction heat to be generated by working, for prolonging tool lifetime, for removing chips, and for other purposes.

[0006] The working fluid to be used for the above-mentioned purposes includes an oil-based working fluid that contains, as a main component, a mineral oil, a vegetable or plant oil or a synthetic oil, and a water-based working fluid that has been given water solubility by blending a surface activity performance-having compound thereinto.

[0007] Recently, a water solubility-given working fluid has become used from the viewpoint of safety in working and environmental problems.

[0008] For example, PTL 1 discloses a water-soluble cutting fluid for silicon ingot slices characterized by containing, as essential components, a polyoxyalkylene adduct having a number-average molecular weight of 500 or less and having a specific structure and a mono- or di-aliphatic carboxylic acid having 4 to 10 carbon atoms (including carbon of the carbonyl group) or a salt thereof.

[0009] PTL 2 discloses a water-soluble working fluid composition for wire saws with fixed abrasive grains for use for cutting rare earth magnets, which is characterized by containing a glycol compound, a carboxylic acid, a compound to be basic after dissolved in water, and water each in a specific content (provided that the total content of these components is 100 parts by weight).

[0010] PTL 3 discloses a working fluid for brittle materials, containing at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, a nonionic surfactant of an ethylene oxide adduct having an ethylene oxide addition molar number in the molecular structure of 5 or more and not containing an acetylene group, and a carboxylic acid each in a specific content.

Citation List

Patent Literature

[0011]

PTL 1: JP 2011-68884 A
PTL 2: JP 2003-82335 A
PTL 3: JP 2018-154762 A

Summary of Invention

Technical Problem

[0012] In the wire saw working method of both methods mentioned above, generally used is a multi-wire saw apparatus for cutting out plural silicon wafers all at a time from the above-mentioned silicon ingot. In the multi-wire saw apparatus, a wire is wound around each groove on two or more guide rollers in which a plurality of grooves are engraved at regular intervals, and each wire is held parallel under a constant tension. With that, during the cutting operation, each guide roller is rotated and the working fluid discharged out from nozzles or the like is adhered to the wire, and in that condition,

the wire is run in one direction or in two directions and a silicon ingot is pressed against the wire having the working fluid adhering thereto and cut.

[0013] The working fluid to be used in the wire saw working is put in a tank that the wire saw apparatus has, and from the tank, the working fluid is supplied to a working chamber nozzle via a pump that the wire saw apparatus has, and is then discharged out via the nozzle. The working fluid thus discharged out via the nozzle is supplied as targeted to a working space (space between the wire and the silicon ingot) and is thus used for lubricating the working space, and thereafter this is again returned back to the tank. In that manner, during cutting the silicon ingot, the working fluid circulates in the wire saw apparatus.

[0014] During the cutting operation, in some cases, the working fluid may vigorously scatter owing to the high-speed rotation of the guide roller with increase in the wire linear speed, which may bring about bubbling of the working fluid. In addition, during the cutting operation also in some cases, the working fluid may flow down into the tank positioned below the wire saw apparatus and as a result, the working fluid in the tank may vigorously bubble to overflow from the tank. Further, there are some other problems, one in that fine cutting powder that may be generated during the cutting operation may promote the bubbling of the working fluid, and the other is that the wire saw, cut wafers and the like may be greatly contaminated by the cutting powder and the load for washing them is great.

[0015] In addition, for example, in these years, in the field of producing silicon wafers from silicon ingots, further improvement of productivity is desired, and a fixed abrasive grain method has become used frequently because of the reason that cutting is possible within a shorter period of time than by the loose abrasive grain method and the yield can be improved by using a thinner wire tool.

[0016] As in the above, in addition to the heretofore-required demand of suitable lubricity, the working fluid is further required to be able to suppress bubbling in using it and to improve detergency of cutting powder, which can bring about stabler production and higher working accuracy. Also as mentioned above, in these years, a water solubility-imparted working fluid is required.

[0017] Accordingly, a working fluid more excellent in the balance of lubricity, anti-foaming property and detergency is required.

[0018] The present invention has been made in consideration of the above-mentioned problems, and an object of the present invention is to provide a working fluid excellent in lubricity, anti-foaming property and detergency.

Solution to Problem

[0019] As a result of assiduous studies, the present inventor has found that a working fluid containing water and specific components, in which the content of each component satisfies a specific range, can solve the above-mentioned problems. The embodiments of the present invention have been completed on the basis of this finding. Specifically, according to the embodiments of the present invention, the following [1] to [17] are provided.

[1] A working fluid comprising:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more.

[2] The working fluid according to the above [1], wherein the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.200% by mass or less.

[3] The working fluid according to the above [1] or [2], wherein the content of the component (C) is, based on the

total amount 100% by mass of the working fluid, 0.100% by mass or less.

[4] The working fluid according to any one of the above [1] to [3], wherein the component (A) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[5] The working fluid according to any one of the above [1] to [4], wherein the component (B) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[6] The working fluid according to any one of the above [1] to [5], wherein the ratio of the content of the component (A) to the content of the component (B) [(A)/(B)] is 1.00 or more by mass.

[7] The working fluid according to any one of the above [1] to [6], wherein the ratio of the total content of the component (A) and the component (B) to the content of the component (C) [(A)+(B)/(C)] is 1.00 or more by mass.

[8] The working fluid according to any one of the above [1] to [7], wherein the content of the component (D) is, based on the total amount 100% by mass of the working fluid, 95.000% by mass or more and 99.979% by mass or less.

[9] The working fluid according to any one of the above [1] to [8], wherein the pH is 3.0 or more and 9.0 or less.

[10] The working fluid according to any one of the above [1] to [9], which is used in working a workpiece of a brittle material with a wire.

[11] The working fluid according to the above [10], wherein the wire is a fixed abrasive grain wire.

[12] The working fluid according to the above [10] or [11], wherein the brittle material is crystal silicon, sapphire, silicon carbide, gallium nitride, neodymium magnet, rock crystal or glass.

[13] A method for producing a working fluid of any one of the above [1] to [12], including blending at least:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,
wherein the components are blended to give a working fluid so that:

the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more.

[14] A composition for working fluid, comprising:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, 0.100% by mass or more and 92.000% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the composition for working

fluid, 0.120 % by mass or more.

[15] A method for producing a brittle material working fluid composition of the above [14], including blending at least:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,
wherein the components are blended to give a composition for working fluid so that:

the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, 0.100% by mass or more and 92.000% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, 0.120 % by mass or more.

[16] A brittle material working fluid composition, comprising an additive mixture containing the following components (A) to (C), and the component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, wherein:

in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

[17] A method for producing a brittle material working fluid composition of the above [16], comprising blending at least an additive mixture containing the following components (A) to (C), and component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, wherein the components are blended to give a brittle material working fluid composition so that, in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 %

by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

Advantageous Effects of Invention

[0020] According to the present invention, there can be provided a working fluid excellent in lubricity, anti-foaming property and detergency.

Description of Embodiments

[Working Fluid]

[0021] The working fluid of one embodiment of the present invention is a working fluid containing:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more.

[0022] The working fluid satisfying all the above-mentioned requirements is excellent in the balance of lubricity, anti-foaming property and detergency.

[0023] In the present specification, unless otherwise specifically indicated, "alkylene oxide (hereinafter this may be simply referred to as "AO") adduct" includes not only a compound with a simple compound of alkylene oxide added thereto, but also a compound with plural compounds of alkylene oxide, that is, a polyalkylene oxide added thereto. Hereinafter the same shall apply to "ethylene oxide (hereinafter also simply referred to as "EO") adduct", and "propylene oxide (hereinafter also simply referred to as "PO") adduct".

[0024] The "HLB value" referred to in the present specification means a value of HLB (hydrophilic-lipophilic balance) calculated by a Griffin's method.

[0025] In the present specification, an upper limit and a lower limit stepwise described for a preferred numerical range (for example, a range of content) can be each independently combined. For example, regarding the corresponding numerical range, from a description of a lower limit "preferably 10 or more, more preferably 20 or more, even more preferably 30 or more" and a description of "preferably 90 or less, more preferably 80 or less, even more preferably 60 or less", "a preferred lower limit (10)" and "an even more preferred upper limit (60)" can be combined to be a preferred range of "10 or more, and 60 or less". Similarly, "an even more preferred lower limit (30)" and "a preferred upper limit (90)" can be combined to be a preferred range of "30 or more, and 90 or less".

[0026] Similarly, for example, from a description of "preferably 10 to 90, more preferably 20 to 80, even more preferably 30 to 60", there can be "10 to 60" and "30 to 90".

[0027] Also unless otherwise specifically indicated, a preferred numerical range to merely express "10 to 90" indicates a range of 10 or more and 90 or less.

[0028] Also similarly, a numerical range to be satisfied and a preferred numerical range stepwise expressed can be combined each independently. For example, in the case where a numerical range to be satisfied is 5 or more and 100 or less, the lower limit "5" to be satisfied and the above-mentioned "even more preferred upper limit (60)" can be combined

to be a preferred range of "5 or more and 60 or less". Similarly, "a preferred lower limit (10)" and an upper limit "100" to be satisfied can be combined to be a preferred range of "10 or more and 100 or less". Regarding the combination of a numerical range to be satisfied and a preferred numerical range, a numerical range and a preferred numerical range that simply express "5 to 100" and "preferably 10 to 90" can be combined in the same manner, like the combination of the preferred numerical ranges mentioned above.

[0029] Hereinunder the constituent components contained in the working fluid are described.

<Component (A)>

[0030] The component (A) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group, and is preferably a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[0031] When the cloud point of the component (A), as a 1 mass% aqueous solution thereof, is lower than 20°C, the solubility in water of the component (A) lowers. On the other hand, a type of the component (A) having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower corresponds to the component (B) to be mentioned below, but when the working fluid does not contain the component (A), the lubricity of the working fluid lowers.

[0032] Consequently, from the viewpoint of obtaining a working fluid excellent in lubricity, the cloud point of the component (A), as a 1 mass% aqueous solution thereof, is preferably 22°C or higher, more preferably 25°C or higher, even more preferably 30°C or higher, further more preferably 35°C or higher, and is preferably 49°C or lower, more preferably 48°C or lower, even more preferably 47°C or lower, further more preferably 46°C or lower.

[0033] Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Consequently, though not specifically limited, examples of the combination modes thereof include, as one embodiment of the component (A), the cloud point of the 1 mass% aqueous solution of the component (A) is preferably 22°C or higher and 49°C or lower, more preferably 25°C or higher and 48°C or lower, even more preferably 30°C or higher and 47°C or lower, further more preferably 35°C or higher and 46°C or lower.

[0034] The value of the cloud point of the 1 mass% aqueous solution of the component (A) is a value measured according to the method described in the section of Examples given hereinunder.

[0035] Examples of the compound of the component (A) that contains a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and does not have an acetylene group include a copolymer of EO and AO except EO, or at least one selected from the group consisting of a polyoxyethylene alkylene alkyl ether.

[0036] A copolymer of EO and AO except EO of the component (A) is a copolymer of EO and AO except EO to be mentioned below, and the addition mode of EO and AO except EO may be any of random addition or block addition, and may also be a mixture of random addition and block addition, but a block addition copolymer is preferred.

[0037] Examples of AO except EO for the component (A) include an alkylene oxide having 3 or 4 carbon atoms, such as propylene oxide (PO), oxetane, 1,2-butylene oxide, 2,3-butylene oxide, 1,3-butylene oxide and tetrahydrofuran.

[0038] The copolymer of EO and AO except EO of the component (A) is more preferably a copolymer of EO and PO, even more preferably a block copolymer of EO and PO (also referred to as "a block copolymer having a polyethylene glycol unit and a polypropylene glycol unit"), further more preferably a triblock copolymer of EO and PO (also referred to as "a triblock copolymer having a polyethylene glycol unit and a polypropylene glycol unit). The triblock copolymer of EO and PO can also be a triblock copolymer in which the terminal block is composed of EO and the intermediate block is composed of PO (EO/PO/EO type), or can be a triblock copolymer in which the terminal block is composed of PO and the intermediate block is composed of EO (a so-called reversed type, PO/EO/PO type).

[0039] The polyoxyethylene alkylene alkyl ether of the component (A) includes an adduct of alcohol and EO and AO except EO, and is preferably an adduct of alcohol and EO and PO.

[0040] Examples of the alcohol include an aliphatic alcohol having 1 or more and 24 or less carbon atoms. The carbon number of the alcohol is, from the viewpoint of the balance between hydrophilicity and hydrophobicity, preferably 1 to 14, more preferably 1 to 10, even more preferably 1 to 6, further more preferably 1 to 4, further more preferably 1 or 2, and is especially preferably 1.

[0041] The aliphatic alcohol is preferably a primary alcohol or a secondary alcohol, more preferably a primary alcohol. It can be linear or branched, or cyclic, but is preferably linear.

[0042] Examples of the aliphatic alcohol include a saturated aliphatic alcohol such as methanol, ethanol, propanol, isopropanol, butanol, isobutanol, 2-methyl-2-butanol, pentanol, isopentanol, hexanol, 3-methyl-1-pentanol, heptanol, 2-heptanol, 3-heptanol, octanol, 2-ethylhexanol, nonanol, decanol, undecyl alcohol, lauryl alcohol, tridecyl alcohol, isotridecyl alcohol, myristyl alcohol, pentadecyl alcohol, palmityl alcohol, heptadecanol, stearyl alcohol, isostearyl alcohol, nonadecyl alcohol, and eicosanol; an unsaturated aliphatic alcohol such as octenyl alcohol, decenyl alcohol, dodecenyl alcohol, tridecenyl alcohol, tetradecenyl alcohol, palmitoyl alcohol, oleyl alcohol, gadoleyl alcohol, and linoleyl alcohol;

and a cycloaliphatic alcohol such as ethylcyclohexyl alcohol, propylcylohexyl alcohol, octylcyclohexyl alcohol, nonylcyclohexyl alcohol and adamantyl alcohol.

[0043] Examples of AO except EO in the polyoxyethylene alkylene alkyl ether of the component (A) include an alkylene oxide having 3 or 4 carbon atoms, such as propylene oxide (PO), oxetane, 1,2-butylene oxide, 2,3-butylene oxide, 1,3-butylene oxide, and tetrahydrofuran. Among these, PO is preferred.

[0044] In the copolymerization site between EO and AO except EO in the polyoxyethylene alkylene alkyl ether of the component (A), the addition mode of EO and AO except EO can be any of random addition or block addition, and can be a mixture of random addition and block addition.

[0045] The polyoxyethylene alkylene alkyl ether can be synthetized by adding EO and AO to the above-mentioned alcohol, and addition of EO and AO to the alcohol can be carried out in any known method, and can be carried out in the presence or absence of a catalyst, under atmospheric pressure or under increased pressure, in one stage or in multiple stages.

[0046] The content of the structural unit derived from EO in the copolymerization site between EO and AO except EO of the component (A) is, in the total amount 100 mol% of the structural units constituting the copolymerization site, preferably 15 mol% or more, more preferably 20 mol% or more, even more preferably 25 mol% or more, and is preferably 85 mol% or less, more preferably 80 mol% or less, even more preferably 75 mol% or less.

[0047] The mass-average molecular weight (Mw) of the component (A) is, from the viewpoint of improving lubricity, preferably 500 or more, more preferably 1,000 or more, even more preferably 1,500 or more, further more preferably 2,000 or more. On the other hand, from the viewpoint of improving the biting property of abrasive grains into workpieces, the mass-average molecular weight (Mw) of the component (A) is preferably 10,000 or less, more preferably 9,000 or less, even more preferably 8,000 or less, further more preferably 6,000 or less.

[0048] The value of the mass-average molecular weight (Mw) is a value measured according to the method described in the section of Examples given hereinunder.

[0049] One kind alone of the component (A) can be used, or two or more kinds thereof can be used as combined.

[0050] The content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010% by mass or more. When the content is less than 0.010% by mass, the lubricity of the working fluid is poor.

[0051] Accordingly, from the viewpoint of improving the lubricity of the working fluid, the content of the component (A) is, based on the total amount 100% by mass of the working fluid, preferably 0.015% by mass or more, more preferably 0.020% by mass or more, even more preferably 0.025% by mass or more, further more preferably 0.030% by mass or more, further more preferably 0.035% by mass or more.

[0052] On the other hand, from the viewpoint of improving the anti-foaming property of the working fluid, the content of the component (A) is, based on the total amount 100% by mass of the working fluid, preferably 0.200% by mass or less, more preferably 0.100% by mass or less, even more preferably 0.080% by mass or less, further more preferably 0.075% by mass or less.

[0053] Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Consequently, though not specifically limited, examples of the combination mode are as follows, as one embodiment of the working fluid: the content of the component (A) is, based on the total amount 100% by mass of the working fluid, preferably 0.010% by mass or more and 0.200% by mass or less, more preferably 0.015% by mass or more and 0.200% by mass or less, even more preferably 0.020% by mass or more and 0.200% by mass or less, further more preferably 0.025% by mass or more and 0.100% by mass or less, further more preferably 0.030% by mass or more and 0.080% by mass or less, further more preferably 0.035% by mass or more and 0.075% by mass or less.

<Component (B)>

[0054] The component (B) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group, and is preferably a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[0055] A compound of the component (B) having a cloud point, as a 1 mass% aqueous solution thereof, of 50°C or lower and 20°C or higher corresponds to the above-mentioned component (A). When the working fluid does not contain the component (B), the detergency of the working fluid lowers. Accordingly, from the viewpoint of obtaining a working fluid excellent in detergency, the cloud point of the component (B), as a 1 mass% aqueous solution thereof, is preferably 55°C or higher, more preferably 58°C or higher, even more preferably 60°C or higher.

[0056] On the other hand, when the cloud point of the component (B), as a 1 mass% aqueous solution thereof, is higher than 80°C, the detergency of the working fluid lowers. Accordingly, from the viewpoint of obtaining a working fluid excellent in detergency, the cloud point of the component (B), as a 1 mass% aqueous solution thereof, is preferably 75°C or lower, more preferably 70°C or lower, even more preferably 65°C or lower.

[0057] Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Consequently, though not specifically limited, examples of the combination mode are as follows, as one embodiment of the component (B): the cloud point of the component (B), as a 1 mass% aqueous solution thereof, preferably 55°C or higher and 75°C or lower, more preferably 58°C or higher and 70°C or lower, even more preferably 60°C or higher and 65°C or lower.

[0058] The value of the cloud point of the 1 mass% aqueous solution of the component (B) is a value measured according to the method described in the section of Examples.

[0059] Examples of the compound of the component (B) that contains a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and does not have an acetylene group include a copolymer of EO and AO except EP, or at least one selected from the group consisting of a polyoxyethylene alkylene alkyl ether. Among these, a copolymer of EO and AO except EO is preferred.

[0060] In the copolymer between EO and AO except EO of the component (B), the addition mode of EO and AO except EO can be any of random addition or block addition, and can be a mixture of random addition and block addition. Preferred is a block addition copolymer.

[0061] Examples of AO except EO of the component (B) include an alkylene oxide having 3 or 4 carbon atoms, such as propylene oxide (PO), oxetane, 1,2-butylene oxide, 2,3-butylene oxide, 1,3-butylene oxide, and tetrahydrofuran.

[0062] The copolymer of EO and AO except EO of the component (B) is more preferably a copolymer of EO and PO, even more preferably a block copolymer of EO and PO, further more preferably a triblock copolymer of EO and PO, further more preferably a pluronic-type copolymer of a polypropylene glycol added with ethylene oxide (EO-PO-EO-type triblock copolymer).

[0063] In the copolymer of EO and AO except EO of the component (B), the content of the structural unit derived from EO is, in the total amount 100 mol% of the structural units constituting the copolymer, preferably 25 mol% or more, more preferably 30 mol% or more, even more preferably 35 mol% or more, further more preferably 40 mol% or more, and is preferably 75 mol% or less, more preferably 70 mol% or less, even more preferably 65 mol% or less, further more preferably 60 mol% or less.

[0064] The polyoxyethylene alkylene alkyl ether of the component (B) is the same as that described for the polyoxyethylene alkylene alkyl ether of the component (A), except that the two differ in point of the cloud point, and preferred embodiments are also the same.

[0065] The mass-average molecular weight (Mw) of the component (B) is, from the viewpoint of improving lubricity, preferably 500 or more, more preferably 1,000 or more, even more preferably 1,500 or more, further more preferably 2,000 or more. On the other hand, from the viewpoint of improving the biting property of abrasive grains into workpieces, the mass-average molecular weight (Mw) of the component (B) is preferably 10,000 or less, more preferably 9,000 or less, even more preferably 8,000 or less, further more preferably 6,000 or less.

[0066] The value of the mass-average molecular weight (Mw) is a value measured according to the method described in the section of Examples given hereinunder.

[0067] One kind alone of the component (B) can be used, or two or more kinds thereof can be used as combined.

[0068] The content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more. When the content is less than 0.005% by mass, the detergency of the working fluid is poor.

[0069] Accordingly, from the viewpoint of improving the detergency of the working fluid, the content of the component (B) is, based on the total amount 100% by mass of the working fluid, preferably 0.010% by mass or more, more preferably 0.012% by mass or more, even more preferably 0.015% by mass or more.

[0070] On the other hand, the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.090% by mass or less. When the content is more than 0.090% by mass, the lubricity of the working fluid is poor.

[0071] Accordingly, from the viewpoint of improving the lubricity of the working fluid, the content of the component (B) is, based on the total amount 100% by mass of the working fluid, preferably 0.080% by mass or less, more preferably 0.050% by mass or less, even more preferably 0.030% by mass or less.

[0072] Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Consequently, though not specifically limited, for example, as one embodiment of the working fluid, the combination mode is as follows. The content of the component (B) is, based on the total amount 100% by mass of the working fluid, preferably 0.010% by mass or more and 0.080% by mass or less, more preferably 0.012% by mass or more and 0.050% by mass or less, even more preferably 0.015% by mass or more and 0.030% by mass or less.

[0073] Also from the viewpoint of improving the lubricity of the working fluid, the ratio of the content of the component (A) to the content of the component (B) [(A)/(B)] in the working fluid is preferably 1.00 or more, more preferably 1.50 or more, even more preferably 2.00 or more.

[0074] On the other hand, from the viewpoint of improving the detergency and the working accuracy of the working fluid, the ratio of the content of the component (A) to the content of the component (B) [(A)/(B)] in the working fluid is, as a ratio by mass, preferably 20.00 or less, more preferably 15.00 or less, even more preferably 10.00 or less.

<Component (C)>

[0075] The component (C) is at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less.

[0076] When the working fluid does not contain the component (C), the anti-foaming property and the detergency of the working fluid worsen.

[0077] Here, as mentioned above, also in the case not containing the component (B), the detergency of the working fluid worsens, but any one component could not provide a working fluid having good detergency. Namely, as combined, both the component (B) and the component (C) can provide a working fluid having good detergency.

[0078] Consequently, when containing all the component (A), the component (B) and the component (C) each in a specific amount, the working fluid can have excellent lubricity, anti-foaming property and detergency.

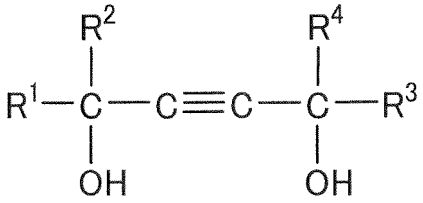
[0079] When the HLB value of the component (C) is less than 4, the solubility in water of the component (C) is poor. Consequently, from the viewpoint of improving the solubility in water of the component (C), the HLB value of the component (C) is preferably 5 or more, more preferably 6 or more, even more preferably 7 or more.

[0080] On the other hand, when the HLB value of the component (C) is more than 12, the anti-foaming property and the detergency of the working fluid worsen. Consequently, from the viewpoint of improving the anti-foaming property and the detergency of the working fluid, the HLB value of the component (C) is preferably 11 or less, more preferably 10 or less, even more preferably 9 or less.

[0081] Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Consequently, though not specifically limited, for example, as one embodiment of the component (C), the combination mode is as follows. The HLB value of the component (C) is preferably 5 or more and 11 or less, more preferably 6 or more and 10 or less, even more preferably 7 or more and 9 or less.

[0082] As mentioned above, the HLB value of the component (C) is a value calculated by a Griffin's method.

[0083] Examples of the acetylene glycol include a compound represented by the following general formula (1).



(1)

[0084] In the general formula (1), R^1 to R^4 each independently represent an alkyl group having 1 or more and 5 or less carbon atoms.

[0085] Specifically, the alkyl group having 1 or more and 5 or less carbon atoms that R^1 to R^4 can take includes a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, a 1-methylbutyl group, a 2-methylbutyl group, a 3-methylbutyl group, a 1,1-dimethylpropyl group, a 1,2-dimethylpropyl group, and a 2,2-dimethylpropyl group.

[0086] Among these, R^1 and R^3 each are preferably an isobutyl group or a 3-methylbutyl group. R^2 and R^4 each are preferably a methyl group.

[0087] The compound represented by the general formula (1) is preferably a compound having a structure in which R^1 and R^3 are the same with each other or having a structure in which R^2 and R^4 are the same with each other, more preferably a compound having a structure in which R^1 and R^3 are the same with each other and R^2 and R^4 are the same with each other.

[0088] The acetylene glycol alkylene oxide adduct is preferably an alkylene oxide adduct of the compound of the general formula (1), which is such that AO is added to the hydroxy group of the compound of the general formula (1), more preferably an alkylene oxide compound of the compound of the general formula (1) added with EO and/or PO, even more preferably an alkylene oxide adduct of the compound of the general formula (1) added with EO. A preferred embodiment of the acetylene glycol that forms the acetylene glycol alkylene oxide adduct is the same as the preferred embodiment of the compound represented by the general formula (1).

[0089] In the case where a structure of an EO-derived structure (e.g., ethylene oxy group or poly(oxyethylene) structure) and a PO-derived structure (e.g., propylene oxy group or poly(oxypropylene) structure) bonding to each other is contained, the structures can bond randomly or can bond as blocks, and preferably bond as blocks.

[0090] The component (C) includes an acetylene glycol represented by the general formula (1), such as 2,5,8,11-tetramethyl-6-dodecyne-5,8-diol, 5,8-dimethyl-6-dodecyne-5,8-diol, 2,4,7,9-tetramethyl-5-dodecyne-4,7-diol, 8-hexadecyne-7,10-diol, 7-tetradecyne-6,9-diol, 2,3,6,7-tetramethyl-4-octyne-3,6-diol, 3,6-diethyl-4-octyne-3,6-diol, 2,5-dimethyl-

3-hexyne-2,5-diol, 2,4,7,9-tetramethyl-5-decyne-4,7-diol, and 3,6-dimethyl-4-octyne-3,6-diol; and an alkylene oxide adduct of the acetylene glycol represented by the general formula (1). The alkylene oxide includes EO and/or PO.

[0091] Among these, preferred is an alkylene oxide adduct of at least one selected from the group consisting of 2,5,8,11-tetramethyl-6-dodecyne-5,8-diol, 5,8-dimethyl-6-dodecyne-5,8-diol, 2,4,7,9-tetramethyl-5-dodecyne-4,7-diol, 8-hexadecyne-7,10-diol, 7-tetradecyne-6,9-diol, 2,3,6,7-tetramethyl-4-octyne-3,6-diol, 3,6-diethyl-4-octyne-3,6-diol, 2,5-dimethyl-3-hexyne-2,5-diol, 2,4,7,9-tetramethyl-5-decyne-4,7-diol, and 3,6-dimethyl-4-octyne-3,6-diol; more preferred is an ethylene oxide adduct of at least one selected from the group consisting of 2,5,8,11-tetramethyl-6-dodecyne-5,8-diol, 5,8-dimethyl-6-dodecyne-5,8-diol, 2,4,7,9-tetramethyl-5-dodecyne-4,7-diol, 8-hexadecyne-7,10-diol, 7-tetradecyne-6,9-diol, 2,3,6,7-tetramethyl-4-octyne-3,6-diol, 3,6-diethyl-4-octyne-3,6-diol, 2,5-dimethyl-3-hexyne-2,5-diol, 2,4,7,9-tetramethyl-5-decyne-4,7-diol, and 3,6-dimethyl-4-octyne-3,6-diol; even more preferred is at least one selected from the group consisting of an ethylene oxide adduct of 2,5,8,11-tetramethyl-6-dodecyne-5,8-diol and an ethylene oxide adduct of 2,4,7,9-tetramethyl-5-decyne-4,7-diol; and further more preferred is an ethylene oxide adduct of 2,5,8,11-tetramethyl-6-dodecyne-5,8-diol.

[0092] One kind alone or two or more kinds of the component (C) can be used either singly or as combined.

[0093] The content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006% by mass or more. When the content is less than 0.006% by mass, the detergency of the working fluid worsens.

[0094] From the viewpoint of obtaining excellent detergency of a working fluid, the content of the component (C) is, based on the total amount 100% by mass of the working fluid, preferably 0.007% by mass or more, more preferably 0.008% by mass or more, even more preferably 0.009% by mass or more.

[0095] On the other hand, from the viewpoint of bettering the solubility in water of the component (C), the content of the component (C) is, based on the total amount 100% by mass of the working fluid, preferably 0.100% by mass or less, more preferably 0.070% by mass or less, even more preferably 0.050% by mass or less, further more preferably 0.030% by mass or less.

[0096] Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Consequently, though not specifically limited, for example, as one embodiment of the working fluid, the combination mode is as follows. The content of the component (C) is, based on the total amount 100% by mass of the working fluid, preferably 0.006% by mass or more and 0.100% by mass or less, more preferably 0.007% by mass or more and 0.070% by mass or less, even more preferably 0.008% by mass or more and 0.050% by mass or less, further more preferably 0.009% by mass or more and 0.030% by mass or less.

[0097] In the working fluid, the ratio of the total content of the component (A) and the component (B) to the content of the component (C) [(A)+(B)/(C)] is, as a ratio by mass, preferably 1.00 or more, more preferably 1.20 or more, even more preferably 1.30 or more, and is preferably 20.00 or less, more preferably 15.00 or less, even more preferably 12.00 or less.

<Component (D)>

[0098] Water of the component (D) is not specifically limited, and can be any of purified water such as distilled water, or ion-exchanged water (deionized water); tap water; and industrial water, and is preferably purified water, more preferably ion-exchanged water (deionized water).

[0099] For example, from the viewpoint of improving the flame retardancy of the working fluid to enhance the safety thereof, and from the viewpoint of reducing the viscosity of the working fluid to enhance the handleability thereof, the content of the component (D) is, based on the total amount 100% by mass of the working fluid, preferably 95.000% by mass or more, more preferably 97.500% by mass or more, even more preferably 99.500% by mass or more, further more preferably 99.600% by mass or more. With that, from the viewpoint of securing the amount of the component (A), the component (B) and the component (C) in the working fluid, the content is 99.979% by mass or less, preferably 99.965% by mass or less, more preferably 99.950% by mass or less, even more preferably 99.945% by mass or less, further more preferably 99.930% by mass or less.

[0100] Here, in the present specification, "additive mixture in the working fluid" indicates all the components excluding water of the component (D) from the working fluid.

<Other Components>

[0101] The working fluid can further contain any other component in addition to the above-mentioned components (A) to (D), within a range not interfering with the objects of the present invention.

[0102] The other component includes additives such as a surfactant except the compounds corresponding to the components (A) to (C), a pH regulator, a water retentiveness improver, an anti-foaming agent, a metal deactivator, a bactericide, a preservative, a rust inhibitor and an antioxidant. One kind alone or two or more kinds of these additives can be used either singly or as combined. Among these additives, preferred is at least one selected from the group

consisting of a surfactant except the components (A) to (C), a pH regulator and a water retentiveness improver, more preferred is at least one selected from the group consisting of a water retentiveness improver and a pH regulator, and even more preferred is a pH regulator.

[0103] One kind alone or two or more kinds of these additives can be used either singly or as combined.

[0104] The surfactant except the compounds corresponding the components (A) to (C) includes an anionic surfactant, a cationic surfactant, a nonionic surfactant except the compounds corresponding to the components (A) to (C), an ampholytic surfactant, and the like.

[0105] The anionic surfactant includes an alkylbenzene sulfonate salt, an alphaolefin sulfonic acid salt, and the like. The cationic surfactant includes a quaternary ammonium salt such as an alkyltrimethylammonium salt, a dialkyldimethylammonium salt, an alkyldimethylbenzylammonium salt, and the like.

[0106] Examples of the nonionic surfactant except the compounds corresponding to the components (A) to (C) include a polyoxyethylene alkyl ether; a polyoxyalkylene alkyl ether (in which the polyoxyalkylene moiety does not contain a structure derived from an ethylene oxide group); an ether such as a polyoxyethylene alkyl phenyl ether; a compound having a cloud point, as a 1 mass% aqueous solution thereof, of lower than 20°C and higher than 80°C, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group; an acetylene glycol having an HLB value of less than 4 and more than 12; alkylene oxide adduct of an acetylene glycol having an HLB value of less than 4 and more than 12; and an amide such as a fatty acid alkanol amide.

[0107] The ampholytic surfactant includes a betaine-type compound such as an alkyl betaine.

[0108] The pH regulator is used mainly for regulating the pH of the working fluid. The pH regulator includes various acid components and base components, and by controlling the content ratio of these components, the pH of the working fluid can be appropriately regulated.

[0109] The acid component and the base component can react with each other to form a salt.

[0110] Consequently, in the case where an acid component and a base component are used as a pH regulator, and when a reaction product of the acid component and the base component exist in the working fluid, as mentioned above, the content of the acid component and the base component having contributed to the reaction and calculated from the content of the reaction product of the acid component and the base component can be calculated. In that case, in place of the reaction product, the working fluid can be considered to have contained the acid component and the base component before reaction.

[0111] Examples of the acid component usable as the pH regulator include various fatty acids such as lauric acid, stearic acid, oleic acid, linolic acid, linoleic acid, neodecanoic acid, isononanoic acid, caprylic acid, and isostearic acid; carboxylic acids such as acetic acid, malic acid, and citric acid; polymer acids such as polyacrylic acid, and salts thereof; and inorganic acids such as phosphoric acid. Among these, fatty acids are preferred, and fatty acids having 12 or less carbon atoms, such as neodecanoic acid, isononanoic acid, caprylic acid and dodecane-diacid are more preferred, and one or more selected from the group consisting of neodecanoic acid, isononanoic acid, caprylic acid and dodecane-diacid are even more preferred.

[0112] Examples of the base component usable as the pH regulator include an alkanolamine such as monoethanolamine, diethanolamine, triethanolamine, monoisopropanolamine, diisopropanolamine, triisopropanolamine, tri-n-propanolamine, tri-n-butanolamine, triisobutanolamine, tri-tert-butanolamine, N-methylethanolamine, N-ethylethanolamine, N-butylethanolamine, N-cyclohexylethanolamine, N-methyldiethanolamine, N-ethyldiethanolamine, N-cyclohexyldiethanolamine, N,N-dimethylethanolamine, and N,N-diethylethanolamine; an alkylamine such as methylamine, dimethylamine, ethylamine, diethylamine, propylamine, and dipropylamine; and ammonia. Among these, a tertiary amine is preferred, and at least one selected from the group consisting of triethanolamine, triisopropanolamine, N-methyldiethanolamine, and N-cyclohexyldiethanolamine is more preferred.

[0113] Examples of the water retentiveness improver include ethylene glycol, propylene glycol, 1,4-butanediol, hexamethylene glycol, neopentyl glycol, diethylene glycol, triethylene glycol, dipropylene glycol, tripropylene glycol, glycerin, ester derivatives thereof, and ether derivatives thereof, polyethylene glycol, and polypropylene glycol.

[0114] Examples of the anti-foaming agent include a silicone oil, a fluorosilicone oil, a polyether polysiloxane and a fluoroalkyl ether.

[0115] Examples of the metal deactivator include imidazoline, a pyrimidine derivative, thiadiazole and benzotriazole.

[0116] Examples of the bactericide and the preservative include paraoxybenzoates (parabens), and also benzoic acid, salicylic acid, sorbic acid, dehydroacetic acid, p-toluenesulfonic acid and salts thereof, as well as phenoxyethanol.

[0117] Examples of the rust inhibitor include an alkylbenzene sulfonate, dinonylnaphthalene sulfonate, an alkenylsuccinate, and a polyalcohol ester.

[0118] Examples of the antioxidant include a phenol-type antioxidant and an amine-type antioxidant.

[0119] In the case where the working fluid contains the other component, the total content of the other component in the working fluid is, based on the total amount 100% by mass of the working fluid, preferably 0.0001% by mass or more, more preferably 0.0002% by mass or more, even more preferably 0.0003% by mass or more, further more preferably

0.0004% by mass or more, and is preferably 0.0800% by mass or less, more preferably 0.0500% by mass or less, even more preferably 0.0100% by mass or less, further more preferably 0.0050% by mass or less, further more preferably 0.0010% by mass or less.

[0120] In the case where the working fluid contains a pH regulator as the other component, the total content of the pH regulator in the working fluid is, based on the total amount 100% by mass of the working fluid, preferably 0.0001% by mass or more, more preferably 0.0002% by mass or more, even more preferably 0.0003% by mass or more, and is preferably 0.0100% by mass or less, more preferably 0.0050% by mass or less, even more preferably 0.0010% by mass or less, further more preferably 0.0008% by mass or less.

[0121] From the viewpoint of improving lubricity, anti-foaming property and detergency, the total content of the component (A), the component (B), the component (C) and the component (D) in the working fluid is, based on the total amount 100% by mass of the working fluid, preferably 99.9200% by mass or more, more preferably 99.9500% by mass or more, even more preferably 99.9900% by mass or more, further more preferably 99.9950% by mass or more, further more preferably 99.9990% by mass or more, and is preferably 100.0000% by mass or less, more preferably 99.9999% by mass or less, even more preferably 99.9998% by mass or less, further more preferably 99.9997% by mass or less, further more preferably 99.9996% by mass or less.

[0122] In the case where the working fluid is used for working brittle materials, the pH of the working fluid is, from the viewpoint of preventing corrosion of wires and working devices to be mentioned below in the section of use of working fluid, preferably 3.0 or more, more preferably 4.0 or more, even more preferably 5.0 or more. On the other hand, the pH of the working fluid is, for example, from the viewpoint of suppressing generation of a large amount of hydrogen from cut powder in working silicon, preferably 9.0 or less, more preferably 8.0 or less, even more preferably 7.0 or less.

[0123] The pH value of the working fluid is a value measured according to the method described in the section of Examples given hereinunder.

[0124] Also for example, in the case where the working fluid is used for working a workpiece formed of a brittle material using a wire to be mentioned below, the surface tension of the working fluid is, from the viewpoint of readily preventing the wire from being cut during curing the brittle material, preferably 35 mN/m or less, more preferably 34 mN/m or less, even more preferably 33 mN/m or less.

[0125] On the other hand, the surface tension of the working fluid is preferably 1 mN/m or more, more preferably 5 mN/m or more, even more preferably 10 mN/m or more.

[0126] The surface tension of the working fluid is a value measured according to the method described in the section of Examples given hereinunder.

[Production Method for Working Fluid]

[0127] The production method for the working fluid is a method for producing a working fluid, including blending at least:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,
wherein the components are blended to give a working fluid so that:

the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more.

[0128] The sequence of blending the component (A) to the component (D) is not specifically limited, and for example, the component (A), the component (B) and the component (C) can be blended sequentially or simultaneously in water of the component (D), or the component (A), the component (B) and the component (C) are previously blended, and the resultant mixture can be added to water of the component (D).

[0129] In the production method, the component (A) to the component (D) are blended, and further any other component can be blended therein, and in that case, the blending sequence, the blending method and the like of the components to be blended is not specifically limited.

[0130] The component (A), the component (B), the component (C), the component (D) and the other components are the same as those described in the section of working fluid, and preferred embodiments thereof are also the same, and therefore the detailed description thereof is omitted here. In addition, the preferred blending amount and the preferred blending ratio of the component (A), the component (B), the component (C), the component (D) and the other components are also the same as the content and the content ratio of the constitutive components described in the section of the working fluid, and therefore the detailed description thereof is omitted here.

[Use of Working Fluid]

[0131] The working fluid is favorably used for wire saw working of a workpiece formed of a brittle material such as a silicon ingot, using the above-mentioned wire saw, preferably a fixed abrasive grain wire saw. Specifically, the working fluid is favorably used in working a workpiece formed of a brittle material with a wire, and is favorably used in working a workpiece formed of a brittle material with a fixed abrasive grain wire.

[0132] Examples of the brittle material include crystalline silicon, sapphire, gallium nitride, silicon carbide, neodymium magnet, rock crystal and glass. From the viewpoint of effectively utilizing the excellent detergency that the working fluid has, the working fluid is more favorably used in working crystalline silicon, sapphire, silicon carbide, gallium nitride, neodymium magnet, rock crystal or glass, and is even more preferably used in working crystalline silicon, sapphire, or silicon carbide.

[Working Method for Brittle Material]

[0133] The working method for a brittle material of one embodiment of the present invention is a method of working a workpiece formed of the above-mentioned brittle material such as a silicon ingot.

[0134] Here, the working fluid is used by applying the working fluid to a workpiece so as to be in contact with the workpiece. The working fluid lubricates between the workpiece and a working tool such as the above-mentioned wire saw. Further, the working fluid is used also for removing cut dust (cut powder), for rust prevention for workpieces, and for cooling working tools and workpieces.

[0135] Specifically, for working the brittle material using the working fluid, various working methods of cutting, grinding, punching, polishing, deep drawing, drawing, rolling or the like are employable. Among these, preferred is cutting or polishing, and more preferred is cutting.

[0136] The brittle material for workpieces includes those mentioned hereinabove.

[0137] Also as described above, the working fluid is favorably used for cutting silicon ingots.

[0138] Here, more specifically, in the two wire saw working methods of a loose abrasive grain method and a fixed abrasive grain method, plural silicon wafers are cut out all at a time from the above-mentioned silicon ingot, and therefore a multi-wire saw apparatus is used as mentioned above. In the multi-wire saw apparatus, each one wire is wound around every groove of at least two guide rollers each having plural grooves engraved at regular intervals, and all the wires are held in parallel to each other under a predetermined tension. With that, in cutting with the apparatus, every guide roller is rotated and, while the working fluid discharged out from nozzles is kept adhered to the wires, the wires are made to run in one direction or in two directions, and a silicon ingot is kept pressed against the wires having the working fluid adhering thereto, and is thus cut. If desired, in working, the working fluid can be directly applied to the workpiece itself such as a silicon ingot being worked.

[0139] The working fluid to be used for working is stored in a tank or the like, and is carried therefrom to the working chamber nozzle via pipelines. The working fluid used in cutting is collected in a tank for collecting used working fluid arranged below the cutting apparatus. As the case may be, the working fluid can be circulated in the apparatus for reuse therein.

[0140] The working fluid of one embodiment of the present invention is excellent in the balance of lubricity, anti-foaming property and detergency, and can contribute to high working accuracy and productivity (yield improvement).

[0141] Accordingly, the working fluid of one embodiment of the present invention is favorably used as a working fluid to be sued in a working method for such brittle materials, and is, above all, further favorably used as a working fluid for use in a working method of cutting out silicon wafers from a silicon ingot, using a fixed abrasive grain wire, and is more favorably used in a working method of cutting out silicon wafers from a silicon ingot, using a multi-wire apparatus that uses fixed abrasive grain wires.

[0142] The working fluid of one embodiment of the present invention can also achieve the above-mentioned excellent effects even in a case of cutting out silicon wafers from a silicon ingot using a wire having a thinner wire diameter (strand diameter) (preferably a fixed abrasive grain wire). Consequently, for example, the working fluid is further favorably used

in a working method of cutting out silicon wafers for solar cells, from silicon ingots.

[0143] Here, the strand diameter of the wire for use for working a brittle material can be appropriately selected depending on the use thereof, and is, for example, preferably 55 μm or less, more preferably 54 um or less, even more preferably 53 μm or less, and is preferably 30 μm or more, more preferably 35 μm or more, even more preferably 38 μm or more.

[Working Apparatus]

[0144] The working apparatus for brittle material of one embodiment of the present invention is a working apparatus that uses the working fluid of one embodiment of the present invention described hereinabove, and is preferably a multi-wire cutting apparatus, even more preferably a multi-wire cutting apparatus equipped with fixed abrasive grain wire saws, further more preferably a multi-wire cutting apparatus equipped with fixed abrasive grain wire saws for cutting silicon ingots.

[Composition for Working Fluid]

[0145] The working fluid of one embodiment of the present invention can be a dilution produced by diluting, for example, a concentrate prepared by reducing water in the working fluid to be concentrated in 20 times or more and 2,000 times or less, or a composition having the same formulation as that of the resultant concentrate, with water.

[0146] Specifically, in carrying out the above-mentioned working operation, a concentrate of the working fluid or a composition for working fluid having the same formulation as that of the concentrate (hereinafter this may be simply referred to as "composition for working fluid") is diluted with water in 20 times or more and 2,000 times or less, and the resultant dilution can be used as the working fluid.

[0147] For example, the working fluid can be formed into a composition for working fluid, and can be used as a form suitable for storage and transportation.

[0148] Here, in the present specification, the "composition for working fluid" includes, as mentioned above, not only one produced by reducing water from the working fluid followed by concentrating the resultant dilution, but also a composition prepared on the assumption that the concentrate may be diluted with water to be a working fluid. The composition prepared on the assumption that the concentrate may be diluted with water to be a working fluid includes one which, though it could not be formed into a working fluid by merely diluting with water, can be used in such a controlled manner that some constituent components are added later to the composition so that the resultant working fluid can have the above-mentioned component range before use for the above-mentioned working operation.

[0149] One embodiment of the composition for working fluid is a composition for working fluid, containing:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid 0.100% by mass or more and 92.000% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, 0.120 % by mass or more.

[0150] The composition for working fluid can further contain any other components, in addition to the above-mentioned components (A) to (D), within a range not interfering with the objects of the present invention.

[0151] The component (A), the component (B), the component (C) and the component (D), and also the other optional components can be added in the composition for working fluid are the same as those described hereinabove in the section of the working fluid, and preferred embodiments thereof are also the same, and therefore the detailed description thereof is omitted here.

[0152] The range of a preferred content of the component (A), the component (B), the component (C), the component

(D) and the other components in the composition for working fluid is, though not specifically limited, preferably such that, in using the composition for working fluid by diluting with water in 20 times or more and 2,000 times or less, the content in the resultant dilution can satisfy the preferred range of the content of the constituent components described hereinabove in the section of the working fluid.

[0153] For example, the composition for working fluid of one embodiment of the present invention includes the following embodiments.

[2-1] A composition for working fluid, containing:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, 0.100% by mass or more and 92.000% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, 0.120 % by mass or more.

[2-2] The composition for working fluid according to the above [2-1], wherein the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, preferably 1.000% by mass or more, more preferably 2.500% by mass or more, even more preferably 5.000% by mass or more, and is preferably 91.780% by mass or less, more preferably 90.900% by mass or less, even more preferably 89.250% by mass or less, further more preferably 86.500% by mass or less.
Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Accordingly, the combination mode is, though not specifically limited, for example, as one embodiment of the composition for working fluid of the above [2-1], the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.200% by mass or more and 91.780% by mass or less, more preferably 1.000% by mass or more and 90.900% by mass or less, even more preferably 2.500% by mass or more and 89.250% by mass or less, further more preferably 5.000% by mass or more and 86.500% by mass or less.

[2-3] The composition for working fluid according to the above [2-1] or [2-2], wherein the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.500% by mass or more, more preferably 1.250% by mass or more, even more preferably 2.500% by mass or more, and is preferably 91.680% by mass or less, more preferably 90.400% by mass or less, even more preferably 88.000% by mass or less, further more preferably 84.000% by mass or less.
Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Accordingly, the combination mode is, though not specifically limited, for example, as one embodiment of the composition for working fluid of the above [2-1] or [2-2], the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.100% by mass or more and 91.680% by mass or less, more preferably 0.500% by mass or more and 90.400% by mass or less, even more preferably 1.250% by mass or more and 88.000% by mass or less, further more preferably 2.500% by mass or more and 84.000% by mass or less.

[2-4] The composition for working fluid according to any one of the above [2-1] to [2-3], wherein the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.600% by mass or more, more preferably 1.500% by mass or more, even more preferably 3.000% by mass or more, and is preferably 91.700% by mass or less, more preferably 90.500% by mass or less, even more preferably 88.250% by mass or less, further more preferably 84.500% by mass or less.

Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Accordingly, the combination mode is, though not specifically limited, for example, as one embodiment of the composition for working fluid of any one of the above [2-1] to [2-3], the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.120% by mass or more and 91.700% by mass or less, more preferably 0.600% by mass or more and 90.500% by mass or less, even more preferably 1.500% by mass or more and 88.250% by mass or less, further more preferably 3.000% by mass or more and 84.500% by mass or less.

[2-5] The composition for working fluid according to any one of the above [2-1] to [2-4], wherein the component (A) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[2-6] The composition for working fluid according to any one of the above [2-1] to [2-5], wherein the component (B) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[2-7] The composition for working fluid according to any one of the above [2-1] to [2-6], wherein the ratio of the content of the component (A) to the content of the component (B) [(A)/(B)] is, as a ratio by mass, preferably 1.00 or more, more preferably 1.50 or more, even more preferably 2.00 or more, and is preferably 20.00 or less, more preferably 15.00 or less, even more preferably 10.00 or less.

[2-8] The composition for working fluid according to any one of the above [2-1] to [2-7], wherein the ratio of the total content of the component (A) and the component (B) to the content of the component (C) [(A)+(B)/(C)] is, as a ratio by mass, preferably 1.00 or more, more preferably 1.20 or more, even more preferably 1.30 or more, and is preferably 20.00 or less, more preferably 15.00 or less, even more preferably 12.00 or less.

[2-9] The composition for working fluid according to any one of the above [2-1] to [2-8], wherein the content of the component (D) is, based on the total amount 100% by mass of the composition for working fluid, preferably 8.000% by mass or more, more preferably 9.000% by mass or more, even more preferably 10.000% by mass or more, further more preferably 12.000% by mass or more, and is preferably 99.580% by mass or less, more preferably 97.900% by mass or less, even more preferably 94.750% by mass or less, further more preferably 89.500% by mass or less.

[2-10] The composition for working fluid according to any one of the above [2-1] to [2-9], wherein, when the composition for working fluid further contains any other components, the total content of the other components in the composition for working fluid is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.002% by mass or more, more preferably 0.004% by mass or more, even more preferably 0.006% by mass or more, further more preferably 0.008% by mass or more, and is preferably 40.000% by mass or less, more preferably 35.000% by mass or less, even more preferably 30.000% by mass or less, further more preferably 27.000% by mass or less, further more preferably 25.000% by mass or less.

[2-11] The composition for working fluid according to any one of the above [2-1] to [2-10], wherein, when the composition for working fluid further contains a pH regulator as the other component, the total content of the pH regulator in the composition for working fluid is, based on the total amount 100% by mass of the composition for working fluid, preferably 0.002% by mass or more, more preferably 0.003% by mass or more, even more preferably 0.004% by mass or more, and is preferably 20.000% by mass or less, more preferably 10.000% by mass or less, even more preferably 2.000% by mass or less, further more preferably 1.600% by mass or less.

[2-12] The composition for working fluid according to any one of the above [2-1] to [2-11], wherein the total content of the component (A), the component (B), the component (C) and the component (D) in the composition for working fluid is, based on the total amount 100% by mass of the composition for working fluid, preferably 60.000% by mass or more, more preferably 65.000% by mass or more, even more preferably 70.000% by mass or more, further more preferably 73.000% by mass or more, further more preferably 75.000% by mass or more, and is preferably 100.000% by mass or less, more preferably 99.998% by mass or less, even more preferably 99.996% by mass or less, further more preferably 99.994% by mass or less, further more preferably 99.992% by mass or less.

[2-13] The composition for working fluid according to any one of the above [2-1] to [2-12], wherein the pH is preferably 3.0 or more, more preferably 4.0 or more, even more preferably 5.0 or more, and is preferably 9.0 or less, more preferably 8.5 or less, even more preferably 8.0 or less.

[2-14] The composition for working fluid according to any one of the above [2-1] to [2-13], which is used in working a workpiece formed of a brittle material, using a wire.

[2-15] The composition for working fluid according to the above [2-14], wherein the wire is a fixed abrasive grain wire.

[2-16] The composition for working fluid according to the above [2-14] or [2-15], wherein the brittle material is crystalline silicon, sapphire, silicon carbide, gallium nitride, neodymium magnet, rock crystal or glass.

[Production Method for Composition for Working Fluid]

[0154] The composition for working fluid can be produced, for example, by the following production method.

[0155] Specifically, the production method for the composition for working fluid of any one of the above [2-1] to [2-16] is a method for producing a composition for working fluid, including blending at least:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,
wherein the components are blended to give a composition for working fluid so that:

- the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
- the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, 0.100% by mass or more and 92.000% by mass or less, and
- the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, 0.120 % by mass or more.

[0156] The sequence of blending the component (A) to the component (D) is not specifically limited, and, for example, the component (A), the component (B) and the component (C) can be blended successively or simultaneously in water as the component (D), or the component (A), the component (B) and the component (C) can be previously blended and the resultant mixture can be blended in water as the component (D).

[0157] In the production method, the component (A) to the component (D) are blended, and further optionally any other components can be blended therein, and in that case, the blending sequence, the blending method, and the like for the constituent components to be blended is not specifically limited.

[0158] The component (A), the component (B), the component (C), the component (D) and the other components are the same as those described hereinabove in the section of the working fluid, and preferred embodiments thereof are also the same, and therefore the detailed description thereof is omitted here. In addition, the preferred blending amount and the preferred blending ratio of the component (A), the component (B), the component (C), the component (D) and the other components are also the same as the content and the content ratio of the constitutive components described in the section of the above-mentioned [2-1] to [2-16], and therefore the detailed description thereof is omitted here.

[Use Method for Composition for Working Fluid]

[0159] The composition for working fluid is, as described above, used for preparing the above-mentioned working fluid mainly by diluting with water.

[0160] Specifically, the use method for the composition for working fluid of one embodiment of the present invention is a use method for a composition for working fluid, which includes diluting the composition for working fluid, for example, with water to prepare a working fluid that contains:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,
wherein the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more, and wherein:
the working fluid is used for use of the working fluid and for the working method for brittle materials as described hereinabove in the section of the working fluid.

[0161] Consequently, the composition for working fluid of the embodiments according to the above [2-1] to [2-16] can be used as the working fluid of one embodiment of the present invention described hereinabove, by further diluting it with water and optionally by controlling the content of the components (A) to (C) therein.

[0162] One embodiment of the working fluid is, for example, the working fluid of the embodiments according to the above [1] to [12] which is obtained by diluting the composition for working fluid of the embodiments according to the above [2-1] to [2-16] with water and optionally controlling the content of the components (A) to (C) therein.

[0163] The dilution rate in diluting the composition for working fluid with water of the component (D) is not specifically limited so far as the working fluid can be produced, but is, in terms of the total amount (mass) of the composition for working fluid, preferably 20 times or more, more preferably 100 times or more, even more preferably 250 times or more, further more preferably 500 times or more, and is preferably 2,000 times or less, more preferably 1,800 times or less, even more preferably 1,500 times or less, further more preferably 1,000 times or less.

[0164] On the other hand, as described above, for example, the composition for working fluid itself of the embodiments according to the above [2-1] to [2-16] can be a concentrate obtained by reducing the amount of water of the component (D) in the working fluid of one embodiment of the present invention. One embodiment of the composition for working fluid is, for example, the composition for working fluid of the embodiments according to the above [2-1] to [2-16] that is obtained by concentrating the working fluid of the embodiments of the above [1] to [12] by reducing the amount of the component (D) therein, for example, by distillation for concentration in a concentration rate of 20 times or more and 2,000 times or less.

[0165] The concentration rate in reducing the amount of water of the component (D) in the working fluid is, though not specifically limited, but is, in terms of the total amount (mass) of the working fluid, preferably 20 times or more, more preferably 100 times or more, even more preferably 250 times or more, further more preferably 500 times or more, and is preferably 2,000 times or less, more preferably 1,800 times or less, even more preferably 1,500 times or less, further more preferably 1,000 times or less.

[0166] The use of the working fluid obtained by using the composition for working fluid according to the above [2-1] to [2-16], the working method for brittle materials using the working fluid obtained by using the composition for working fluid, and the working apparatus are also the same as those described hereinabove in the corresponding items in the section of the working fluid of one embodiment of the present invention, and therefore the detailed description thereof is omitted here.

[Brittle Material Working Fluid Composition]

[0167] The brittle material working fluid composition relating to one embodiment of the present invention is a brittle material working fluid composition mentioned below.

[0168] A brittle material working fluid composition, containing an additive mixture containing the following components (A) to (C), and the component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,

component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, wherein:

in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

[0169] The brittle material working fluid composition can further contain any other components in addition to the above-mentioned components (A) to (D) within a range not interfering with the object of the present invention.

[0170] The component (A), the component (B), the component (C) and the component (D) and other optional components can be added in the brittle material working fluid composition are the same as those described hereinabove in the section of the working fluid, and the preferred embodiments thereof are also the same, and therefore the detailed description thereof is omitted here.

[0171] More specifically, the following embodiments are mentioned as examples of the brittle material working fluid composition relating to one embodiment of the present invention mentioned hereinabove.

[3-1] A brittle material working fluid composition, containing an additive mixture containing the following components (A) to (C), and the component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, wherein:

in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

[3-2] The brittle material working fluid composition according to the above [3-1], wherein the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, preferably 24.00% by mass or more, more preferably 27.00% by mass or more, even more preferably 30.00% by mass or more, further more preferably 40.00% by mass or more, and is preferably 80.50% by mass or less, more preferably 79.50% by mass or less, even more preferably 78.50% by mass or less.
Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Accordingly, the combination mode is, though not specifically limited, for example, as one embodiment of the brittle material working fluid composition of the above [3-1], the content of the component (A) is, based on the total amount, 100% by mass of the additive mixture, preferably 20.00% by mass or more and 80.50% by mass or less, more preferably 24.00% by mass or more and 80.50% by mass or less, even more preferably 27.00% by mass or more and 80.50% by mass or less, further more preferably 30.00% by mass or more and 80.50% by mass or less, further more preferably 40.00% by mass or more and 79.50% by mass or less, further more preferably 40.00% by mass or more and 78.50% by mass or less.

[3-3] The brittle material working fluid composition according to the above [3-1] or [3-2], wherein the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, preferably 6.50% by mass or more, more preferably 8.00% by mass or more, even more preferably 10.00% by mass or more, and is preferably 50.00% by mass or less, more preferably 47.50% by mass or less, even more preferably 45.00% by mass or less.
Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Accordingly, the combination mode is, though not specifically limited, for example, as one embodiment of the brittle material working fluid composition of the above [3-1] or [3-2], the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, preferably 6.50% by mass or more and 50.00% by mass or less, more preferably 8.00% by mass or more and 47.50% by mass or less, even more preferably 10.00% by mass or more and 45.00% by mass or less.

[3-4] The brittle material working fluid composition according to any one of the above [3-1] to [3-3], wherein the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, preferably 6.00% by mass or more, more preferably 6.50% by mass or more, even more preferably 7.00% by mass or more, and is preferably 55.00% by mass or less, more preferably 50.00% by mass or less, even more preferably 47.00% by mass or less, further more preferably 42.00% by mass or less.
Also as mentioned above, the upper limit and the lower limit of these numerical ranges can be each independently combined. Accordingly, the combination mode is, though not specifically limited, for example, as one embodiment of the brittle material working fluid composition of any one of the above [3-1] to [3-3], the content of the component (C) is, based on the total amount, 100% by mass of the additive mixture, preferably 5.00% by mass or more and 55.00% by mass or less, more preferably 6.00% by mass or more and 50.00% by mass or less, even more preferably 6.50% by mass or more and 47.00% by mass or less, further more preferably 7.00% by mass or more and 42.00% by mass or less.

[3-5] The brittle material working fluid composition according to any one of the above [3-1] to [3-4], wherein the component (A) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[3-6] The brittle material working fluid composition according to any one of the above [3-1] to [3-5], wherein the component (B) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

[3-7] The brittle material working fluid composition according to any one of the above [3-1] to [3-6], wherein the ratio of the content of the component (A) to the content of the component (B) [(A)/(B)] is, as a ratio by mass, preferably 1.00 or more, more preferably 1.50 or more, even more preferably 2.00 or more, and is preferably 20.00 or less, more preferably 15.00 or less, even more preferably 10.00 or less.

[3-8] The brittle material working fluid composition according to any one of the above [3-1] to [3-7], wherein the ratio of the total content of the component (A) and the component (B) to the content of the component (C) [(A)+(B)/(C)] is, as a ratio by mass, preferably 1.00 or more, more preferably 1.20 or more, even more preferably 1.30 or more, and is preferably 20.00 or less, more preferably 15.00 or less, even more preferably 12.00 or less.

[3-9] The brittle material working fluid composition according to any one of the above [3-1] to [3-8], wherein, in the additive mixture, the total content of the component (A), the component (B) and the component (C) is, based on the total amount 100% by mass of the additive mixture, preferably 80.00% by mass or more, more preferably 85.00% by mass or more, even more preferably 90.00% by mass or more, further more preferably 95.00% by mass or more, further more preferably 99.00% by mass or more, and is preferably 100.00% by mass or less, more preferably 99.90% by mass or less, even more preferably 99.80% by mass or less, further more preferably 99.75% by mass or less, further more preferably 99.70% by mass or less.

[3-10] The brittle material working fluid composition according to any one of the above [3-1] to [3-9], wherein, when the brittle material working fluid composition further contains any other components, the total content of the other components in the brittle material working fluid composition is, based on the total amount 100% by mass of the additive mixture, preferably 0.10% by mass or more, more preferably 0.20% by mass or more, even more preferably 0.25% by mass or more, further more preferably 0.30% by mass or more, and is preferably 20.00% by mass or less, more preferably 15.00% by mass or less, even more preferably 10.00% by mass or less, further more preferably

5.00% by mass or less, further more preferably 1.00% by mass or less.

[3-11] The brittle material working fluid composition according to any one of the above [3-1] to [3-10], which contains the component (D) in an amount of, based on 100 parts by mass of the additive mixture, preferably 8 parts by mass or more, more preferably 9 parts by mass or more, even more preferably 10 parts by mass or more, further more preferably 11 parts by mass or more, further more preferably 12 parts by mass or more, and is preferably 1,000,000 parts by mass or less, more preferably 500,000 parts by mass or less, even more preferably 250,000 parts by mass or less, further more preferably 200,000 parts by mass or less.

[3-12] The brittle material working fluid composition according to any one of the above [3-1] to [3-11], which contains the component (D) in an amount of, based on 100 parts by mass of the additive mixture, preferably 1,000 parts by mass or more, more preferably 2,000 parts by mass or more, even more preferably 5,000 parts by mass or more, further more preferably 10,000 parts by mass or more, further more preferably 20,000 parts by mass or more, further more preferably 25,000 parts by mass or more, and is preferably 1,000,000 parts by mass or less, more preferably 500,000 parts by mass or less, even more preferably 250,000 parts by mass or less, further more preferably 200,000 parts by mass or less.

[3-13] The brittle material working fluid composition according to any one of the above [3-1] to [3-11], which contains the component (D) in an amount of, based on 100 parts by mass of the additive mixture, preferably 8 parts by mass or more, more preferably 9 parts by mass or more, even more preferably 10 parts by mass or more, further more preferably 11 parts by mass or more, further more preferably 12 parts by mass or more, and is preferably 100,000 parts by mass or less, more preferably 50,000 parts by mass or less, even more preferably 25,000 parts by mass or less, further more preferably 10,000 parts by mass or less, further more preferably 5,000 parts by mass or less, further more preferably 2,000 parts by mass or less, further more preferably 1,000 parts by mass or less.

[3-14] The brittle material working fluid composition according to any one of the above [3-1] to [3-13], wherein the pH is preferably 3.0 or more, more preferably 4.0 or more, even more preferably 5.0 or more, and is preferably 9.0 or less, more preferably 8.0 or less, even more preferably 7.0 or less.

[3-15] The brittle material working fluid composition according to any one of the above [3-1] to [3-14], which is used in working a workpiece formed of a brittle material, using a wire.

[3-16] The brittle material working fluid composition according to the above [3-15], wherein the wire is a fixed abrasive grain wire.

[3-17] The brittle material working fluid composition according to the above [3-15] or [3-16], wherein the brittle material is crystalline silicon, sapphire, silicon carbide, gallium nitride, neodymium magnet, rock crystal or glass.

[Production Method for Brittle Material Working Fluid Composition]

[0172] The brittle material working fluid composition can be produced, for example, by the following production method.

[0173] Specifically, the production method for the brittle material working fluid composition of any one of the above [3-1] to [3-17] is a method for producing a brittle material working fluid composition, including blending at least an additive mixture of the following components (A) to (C) and the component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less,
wherein the components are blended to give a brittle material working fluid composition so that:

in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

[0174] The sequence of blending the component (A) to the component (D) is not specifically limited, and, for example, the component (A), the component (B) and the component (C) can be blended successively or simultaneously in water as the component (D), or the component (A), the component (B) and the component (C) can be previously blended and the resultant mixture can be blended in water as the component (D).

[0175] In the production method, the component (A) to the component (D) are blended, and further optionally any other components can be blended therein, and in that case, the blending sequence, the blending method and the like for the constituent components to be blended is not specifically limited.

[0176] The component (A), the component (B), the component (C), the component (D) and the other components are the same as those described hereinabove in the section of the working fluid, and preferred embodiments thereof are also the same, and therefore the detailed description thereof is omitted here. In addition, the preferred blending amount and the preferred blending ratio of the component (A), the component (B), the component (C), the component (D) and the other components are also the same as the content and the content ratio of the constitutive components described in the section of the above-mentioned [3-1] to [3-17], and therefore the detailed description thereof is omitted here.

[0177] The use of the brittle material working fluid composition of the above [3-1] to [3-17], the brittle material working method using the brittle material working fluid composition, and the working apparatus are also the same as those described hereinabove in the corresponding items in the section of the working fluid of one embodiment of the present invention, and therefore the detailed description thereof is omitted here.

Examples

[0178] Hereinunder one embodiment of the present invention is described more specifically by means of Examples, but the present invention is not whatsoever restricted by these Examples.

[0179] Physical properties of the constituent components and the working fluid were evaluated according to the following methods.

[Cloud Point of 1 mass% aqueous solution]

[0180] The cloud point of the components (A) and (B), as a 1 mass% aqueous solution thereof, was measured as follows. 100 mL of the 1 mass% aqueous solution of the component to be measured was put into a 200-mL beaker, and while the aqueous solution was kept stirred with a magnetic stirrer (length of stirring bar: 30 mm) under the condition of a rotation speed 400 rpm, the aqueous solution was heated at a heating rate of 5°C/min until the temperature of the aqueous solution could be from 15°C to reach the cloud point thereof, and the liquid temperature at which the appearance of the aqueous solution became cloudy was measured.

[0181] "Cloud point" of the compound shown in the following Table 1 and Table 2 indicates the "cloud point of 1 mass% aqueous solution" of the compound.

[HLB Value]

[0182] The HLB value of the component (C) is a value calculated by a Griffin's method.

[Mass-Average Molecular Weight]

[0183] The mass-average molecular weight (Mw) was measured through gel permeation chromatography (GPC). For GPC, two columns of "TSKgel (registered trademark) Super Multipore HZ-M" (by Tosoh Corporation) were used, tetrahydrofuran was used as an eluent, and a refractometric detector was used as an detector for the measurement. Using polystyrene as a standard sample, the mass-average molecular weight (Mw) was determined.

[Surface Tension]

[0184] The surface tension of the working fluid obtained in Examples and Comparative Examples was measured

according to a platinum plate method described in JIS K 2241:2017.

[pH Value]

[0185] The pH of the working fluid obtained in Examples and Comparative Examples was evaluated, using a glass electrode-type hydrogen ion concentration indicator (Model: HM-25R) by DKK-TOA Corporation.

[Silicon (Si) Friction Coefficient]

[0186] The working fluid obtained in Examples and Comparative Examples was tested in a reciprocal friction test according to the following test conditions to measure the friction coefficient thereof.

Reciprocal dynamic friction tester: "F-2100" by Orientec Co., Ltd.
Ball: 3/16 in. SUJ2
Test temperature: 50°C
Test plate: polycrystalline silicon (with mirror-polished surface)
Test plate temperature: 50°C
Sliding speed: 20 mm/s
Sliding length: 2 cm
Reciprocation frequency: 50 times
Load: 200 g

[Evaluation of Anti-Foaming Property]

[0187] The working fluid obtained in Examples and Comparative Examples was evaluated according to the following process.

[0188] 90 mL of the working fluid was put into a 100-mL measuring cylinder, the measuring cylinder was closed with a cap, then vigorously shaken 10 times up and down, thereafter statically left for 20 seconds, and the height of the liquid level was measured.

[0189] The liquid level height was compared at a unit "mL" (at intervals of 0.5 mL), based on the scale of the measuring cylinder.

[0190] At that time, when the sample foams, the liquid level height increases, that is, the value of "mL" increases. Accordingly, a small value (mL) of the liquid level height means excellent anti-foaming property. For example, in the case where the liquid level height has reached 93.5 mL by foaming, 3.5 mL that is the increment from the original height 90.0 mL of the measuring cylinder before shaking is referred to as the liquid level height, and is shown in the following Tables 1 and 2.

[Evaluation of Detergency]

[0191] The working fluid obtained in Examples and Comparative Examples was evaluated according to the following process.

(Evaluation of dirtiness on measuring cylinder wall surface)

[0192] In a 100-mL measuring cylinder, 90 mL of the working fluid and 0.5 g of fine powder ("Graphite Powder" by FUJIFILM Wako Pure Chemical Corporation) were put, then the measuring cylinder was closed with a cap, and vigorously shaken 10 times up and down, and the soiling condition on the upper part of the inner wall of the measuring cylinder was evaluated according to the following criteria.

A: The wall surface of the measuring cylinder was lightly soiled with fine powder, and the background around the liquid level was seen through the wall.
B: The wall surface of the measuring cylinder was heavily soiled with fine powder, and the background around the liquid level could not be seen through the wall.

[Examples 1 to 8, Comparative Examples 1 to 8]

[0193] The components were blended so as to be in the formulation shown in the following Tables 1 and 2 to prepare working fluids of Examples 1 to 8 and Comparative Examples 1 to 8. The working fluids of these Examples and Com-

parative Examples were evaluated according to the evaluation methods mentioned above. The results are shown in the following Tables 1 and 2.

[0194] The components shown in the following Tables 1 and 2 are the following compounds.

<Component (A)>

[0195]

Compound A1: Polyoxyalkylene alkyl ether where the polyoxyalkylene moiety is a random copolymer of ethylene oxide (EO) and propylene oxide (PO) (terminal methyl group (terminal alkyl group moiety), mass-average molecular weight (Mw) = 4,597, EO/PO ratio (molar ratio) = 42/58, cloud point of 1 mass% aqueous solution = 43°C)
Compound A2: Poly(propylene oxide)-poly (ethylene oxide)-poly(propylene oxide)-type block copolymer (mass-average molecular weight (Mw) = 4,261, EO/PO ratio (molar ratio) = 30/70, cloud point of 1 mass% aqueous solution = 38°C)
Compound A3: Poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide)-type block copolymer (cloud point of 1 mass% aqueous solution = 23°C)

<Component (B)>

[0196]

Compound B1: Poly(ethylene oxide)-poly(propylene oxide)-poly(ethylene oxide)-type block copolymer (mass-average molecular weight (Mw) = 5,654, EO/PO ratio (molar ratio) = 48/52, cloud point of 1 mass% aqueous solution = 63°C)
Compound B2: Poly(ethylene oxide)-poly (propylene oxide)-poly (ethylene oxide)-type block copolymer (mass-average molecular weight (Mw) = 5,498, EO/PO ratio (molar ratio) = 52/48, cloud point of 1 mass% aqueous solution = 61°C)

<Component (C)>

[0197] Compound C_1: 2,5,8,11-Tetramethyl-6-dodecyne-5,8-diol EO adduct (acetylene glycol EO adduct, HLB = 8)

<Component (D)>

[0198] Ion-exchanged water

<Other components>

[0199] Compound S1: 2,4,7,9-Tetramethyl-5-decyne-4,7-diol EO adduct (acetylene glycol EO adduct, HLB = 13)

pH regulator 1: Isononanoic acid
pH regulator 2: Triisopropanolamine

Table 1

			unit	Example							
				1	2	3	4	5	6	7	8
Formulation	Component (A)	Compound A1 (cloud point = 43°C)	mass%	0.0540	-	-	0.0300	0.1000	0.0540	0.0540	0.0540
		Compound A2 (cloud point = 38°C)	mass%	-	0.0540	-	-	-	-	-	-
		Compound A3 (cloud point = 23°C)	mass%	-	-	0.0540	-	-	-	-	-
	Component (B)	Compound B1 (cloud point = 63°C)	mass%	0.0180	0.0180	0.0180	0.0180	0.0180	-	0.0500	0.0180
		Compound B2 (cloud point = 61°C)	mass%	-	-	-	-	-	0.0180	-	-
	Component (C)	Compound C1 (HLB = 8)	mass%	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0500
	Component (D)	Ion-exchanged Water	mass%	99.9175	99.9175	99.9175	99.9415	99.8715	99.9175	99.8855	99.8775
	pH Regulator 1		mass%	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	pH Regulator 2		mass%	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
	Total Amount		mass%	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
	Amount of Additive Mixture* 1		mass%	0.0825	0.0825	0.0825	0.0585	0.1285	0.0825	0.1145	0.1225
Properties	Surface Tension		mN/m	31.5	31.6	31.4	31.5	31.6	31.5	31.4	28.5
	pH		-	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Evaluation Results	Si Friction Coefficient		-	0.15	0.15	0.17	0.17	0.15	0.15	0.17	0.15
	Anti-Foaming Property (liquid level height)		mL	3.0	3.0	3.0	3.0	4.0	3.0	3.5	2.0
	Detergency (soil on wall surface)		-	A	A	A	A	A	A	A	A
*1: Total content of the components except ion-exchanged water (component (D) in working fluid											

Table 2

			unit	Comparative Example							
				1	2	3	4	5	6	7	8
Formulation	Component (A)	Compound A1 (cloud point = 43°C)	mass%	-	0.0050	0.0540	0.0540	0.0540	0.0540	0.0540	0.0540
		Compound A2 (cloud point = 38°C)	mass%	-	-	-	-	-	-	-	-
		Compound A3 (cloud point = 23°C)	mass%	-	-	-	-	-	-	-	-
	Component (B)	Compound B 1 (cloud point = 63°C)	mass%	0.0180	0.0180	-	0.0030	0.1000	0.0180	0.0180	0.0180
		Compound B2 (cloud point = 61°C)	mass%	-	-	-	-	-	-	-	-
	Component (C)	Compound C1 (HLB = 8)	mass%	0.0100	0.0100	0.0100	0.0100	0.0100	-	-	0.0050
	Component (D)	Ion-exchanged Water	mass%	99.9715	99.9665	99.9355	99.9325	99.8355	99.9175	99.9275	99.9225
	Compound S1 (HLB = 13)		mass%	-	-	-	-	-	0.0100	-	-
	pH Regulator 1		mass%	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	pH Regulator 2		mass%	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
	Total Amount		mass%	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
	Amount of Additive Mixture*1		mass%	0.0285	0.0335	0.0645	0.0675	0.1645	0.0825	0.0725	0.0775
Properties	Surface Tension		mN/m	31.7	31.6	31.8	31.7	31.4	41.5	40.4	36.0
	pH		-	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Evaluation Results	Si Friction Coefficient		-	0.20	0.20	0.16	0.16	0.19	0.15	0.16	0.15
	Anti-Foaming Property (liquid level height)		mL	2.0	2.0	2.0	3.0	3.0	15.0	17.0	3.0
	Detergency (soil on wall surface)		-	A	A	B	B	A	B	B	B
* 1: Total content of the components except ion-exchanged water (component (D)) in working fluid											

[0200] As shown in Table 1, the working fluids of Examples 1 to 8 contain the component (A) to the component (D), in which the content of the components (A) to the component (C) each is a predetermined one, and therefore, all these working fluids are excellent in lubricity, anti-foaming property and detergency, and were confirmed to be working fluids excellent in the balance of lubricity, anti-foaming property and detergency.

[0201] On the other hand, as shown in Table 2, the working fluids of Comparative Examples 1 to 8 do not contain any of the component (A), the component (B) and the component (C) (Comparative Examples 1, 3, 6 and 7), or do not satisfy the requirement that the working fluid contains the components (A) to (C) each in a predetermined amount (Comparative Examples 2, 4, 5 and 8), and were therefore confirmed to be poor in any characteristic of lubricity, anti-foaming property and detergency.

[0202] Using the working fluid of Example 1 on a fixed abrasive grain-type multiwire saw apparatus, a silicon ingot was cut with a fixed abrasive grain wire having a wire diameter of 52 μm and, as a result, the working fluid was confirmed to be excellent in anti-foaming property and detergency in the cutting operation. In addition, it was confirmed that the cutting accuracy in cutting the silicon ingot was good and the burnout rate of the wire was less than 5%.

[0203] The "cutting accuracy" was evaluated by measuring TTV (total thickness variation), which is a thickness deviation of the cut-out silicon wafers. In Example 1, the TTV average value of the silicon wafers obtained by cutting one ingot was 15 μm or less, and was good. As opposed to this, in Comparative Example 1, the TTV average value of the silicon wafers obtained by cutting one ingot was more than 15 μm.

[0204] The "burnout rate of wire (unit: %)" is a value calculated as "frequency of burnout of wire/number of cut ingots × 100". For example, in cutting 100 silicon ingots, in the case where the wire was burnout in cutting 5 of 100 silicon ingots, the burnout rate was evaluated as 5%.

Industrial Applicability

[0205] The working fluid of one embodiment of the present invention is excellent in the balance of lubricity, anti-foaming property and detergency.

[0206] As excellent in lubricity, the working fluid is expected to be able to improve the cutting efficiency in cutting a workpiece formed of a brittle material such as a silicon ingot, to suppress the friction between the workpiece and tools to work the workpiece, to reduce the frictional heat to be generated by cutting and to prolong the lifetime of the tools. Further, even in the case of working with a thinner wire, the working fluid is expected to attain an excellent working accuracy.

[0207] In addition, for example, in working the above-mentioned workpiece by cutting it, foaming of the working fluid can be suppressed, therefore preventing negative influences such as overflow of the working fluid out of a tank to receive the working fluid, owing to the foaming of the working fluid, and reduction of the working accuracy to be caused by the foaming of the working fluid.

[0208] Further, as excellent in detergency, for example, in working the above-mentioned workpiece by cutting, the working fluid can prevent working machine such as a cutting machine for use for the cutting and also the workpiece such as a workpiece to be cut from being soiled by fine powder such as chips of the workpiece being cut. As a result, the working machines and the worked pieces are easy to wash.

[0209] As described above, the working fluid of one embodiment of the present invention is excellent in the balance of lubricity, anti-foaming property and detergency, and therefore can contribute to improvement of productivity of products to be obtained by cutting a workpiece formed of a brittle material such as a silicon ingot.

[0210] Also as described above, the working fluid of one embodiment of the present invention is favorably used as a working fluid for cutting a brittle material such as a silicon ingot. In addition, the working fluid of one embodiment of the present invention is excellent in the balance of lubricity, anti-foaming property and detergency, and is therefore able to contribute to wire burnout prevention and also contribute to high working accuracy and productivity (improvement of yield), and accordingly, the working fluid is more favorably used as a coolant in cutting silicon wafers out of a silicon ingot, using a fixed abrasive grain wire.

Claims

1. A working fluid comprising:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other

than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more.

2. The working fluid according to claim 1, wherein the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.200% by mass or less.

3. The working fluid according to claim 1 or 2, wherein the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.100% by mass or less.

4. The working fluid according to any one of claims 1 to 3, wherein the component (A) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

5. The working fluid according to any one of claims 1 to 4, wherein the component (B) is a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and a propylene oxide, and not having an acetylene group.

6. The working fluid according to any one of claims 1 to 5, wherein the ratio of the content of the component (A) to the content of the component (B) [(A)/(B)] is 1.00 or more by mass.

7. The working fluid according to any one of claims 1 to 6, wherein the ratio of the total content of the component (A) and the component (B) to the content of the component (C) [(A)+(B)/(C)] is 1.00 or more by mass.

8. The working fluid according to any one of claims 1 to 7, wherein the content of the component (D) is, based on the total amount 100% by mass of the working fluid, 95.000% by mass or more and 99.979% by mass or less.

9. The working fluid according to any one of claims 1 to 8, wherein the pH is 3.0 or more and 9.0 or less.

10. The working fluid according to any one of claims 1 to 9, which is used in working a workpiece of a brittle material with a wire.

11. The working fluid according to claim 10, wherein the wire is a fixed abrasive grain wire.

12. The working fluid according to claim 10 or 11, wherein the brittle material is crystal silicon, sapphire, silicon carbide, gallium nitride, neodymium magnet, rock crystal or glass.

13. A method for producing a working fluid of any one of claims 1 to 12, comprising blending at least:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,

wherein the components are blended to give a working fluid so that:

the content of the component (A) is, based on the total amount 100% by mass of the working fluid, 0.010 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the working fluid, 0.005% by mass or more and 0.090% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the working fluid, 0.006 % by mass or more.

14. A composition for working fluid, comprising:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water, wherein:

the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, 0.100% by mass or more and 92.000% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, 0.120 % by mass or more.

15. A method for producing a composition for working fluid of claim 14, comprising blending at least:

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, and
component (D): water,
wherein the components are blended to give a composition for working fluid so that:

the content of the component (A) is, based on the total amount 100% by mass of the composition for working fluid, 0.200 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the composition for working fluid, 0.100% by mass or more and 92.000% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the composition for working fluid, 0.120 % by mass or more.

16. A brittle material working fluid composition, comprising an additive mixture containing the following components (A) to (C), and the component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other

than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, wherein:

in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

17. A method for producing a brittle material working fluid composition of claim 16, comprising blending at least an additive mixture containing the following components (A) to (C), and component (D): water,

component (A): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of 20°C or higher and 50°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (B): a compound having a cloud point, as a 1 mass% aqueous solution thereof, of higher than 50°C and 80°C or lower, containing a copolymerization site between an ethylene oxide and an alkylene oxide other than an ethylene oxide, and not having an acetylene group,
component (C): at least one selected from the group consisting of an acetylene glycol having an HLB value of 4 or more and 12 or less, and an alkylene oxide adduct of an acetylene glycol having an HLB value of 4 or more and 12 or less, wherein the components are blended to give a brittle material working fluid composition so that, in the additive mixture,
the content of the component (A) is, based on the total amount 100% by mass of the additive mixture, 20.00 % by mass or more,
the content of the component (B) is, based on the total amount 100% by mass of the additive mixture, 5.00% by mass or more and 53.50% by mass or less, and
the content of the component (C) is, based on the total amount 100% by mass of the additive mixture, 5.00 % by mass or more.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/016154

A. CLASSIFICATION OF SUBJECT MATTER

C10M 173/00(2006.01)i; *C10N 30/04*(2006.01)n; *C10N 30/06*(2006.01)n; *C10N 30/18*(2006.01)n; *C10N 40/22*(2006.01)n; ***C10M 107/34***(2006.01)i
FI: C10M107/34; C10M173/00; C10N40:22; C10N30:18; C10N30:04; C10N30:06

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)

C10M173/00; C10N30/04; C10N30/06; C10N30/18; C10N40/22; C10M107/34,H01L21/304,B24B37/00

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.
A	WO 2010/113678 A1 (IDEMITSU KOSAN CO., LTD.) 07 October 2010 (2010-10-07) claims, paragraphs [0016]-[0018], [0026], [0027]	1-17
A	JP 2014-172949 A (IDEMITSU KOSAN CO., LTD.) 22 September 2014 (2014-09-22) claims, examples 1-5	1-17
A	JP 2015-189955 A (IDEMITSU KOSAN CO., LTD.) 02 November 2015 (2015-11-02) table 1, comparative examples 3, 5, 6	1-17
A	JP 2012-201750 A (NICCA CHEMICAL CO., LTD.) 22 October 2012 (2012-10-22) claims, paragraphs [0083]-[0085], [0088], table 1	1-17
A	JP 2013-47319 A (SANYO CHEMICAL INDUSTRIES, LTD.) 07 March 2013 (2013-03-07) claims, example 11	1-17
A	JP 10-110183 A (KYOEISHA CHEMICAL CO., LTD.) 28 April 1998 (1998-04-28) claims, paragraphs [0014], [0017]-[0021]	1-17

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

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 June 2022	**14 June 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.

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INTERNATIONAL SEARCH REPORT

International application No.
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	JP 2004-217814 A (NEC CORP.) 05 August 2004 (2004-08-05) claims	1-17

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/016154

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2010/113678 A1	07 October 2010	US 2012/0058924 A1 claims, paragraphs [0033]-[0036], [0046] EP 2415853 A1 SG 174950 A CN 102369268 A TW 201042028 A KR 10-2012-0006494 A	
JP 2014-172949 A	22 September 2014	(Family: none)	
JP 2015-189955 A	02 November 2015	US 2018/0171255 A1 table 1, comparative examples 3, 5, 6 WO 2015/146909 A1 EP 3124584 A1 TW 201602334 A KR 10-2016-0137982 A CN 106459822 A	
JP 2012-201750 A	22 October 2012	(Family: none)	
JP 2013-47319 A	07 March 2013	WO 2012/132448 A1 CN 103502409 A KR 10-2014-0009333 A	
JP 10-110183 A	28 April 1998	(Family: none)	
JP 2006-49709 A	16 February 2006	US 2006/0030503 A1 claims, paragraphs [0030]	
JP 2004-217814 A	05 August 2004	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2011068884 A **[0011]**
- JP 2003082335 A **[0011]**
- JP 2018154762 A **[0011]**