

DESCRIPTION

METALWORKING FLUID

TECHNICAL FIELD

[0001]

The present invention relates to a metalworking fluid used for forming a metal material.

BACKGROUND ART

[0002]

Typically, a volatile oil-based metalworking fluid has been used as a lubricant for forming a metal plate such as an aluminum plate and an iron plate. An aluminum plate coated with a water-dispersible silica compound and the like on a surface thereof so as to enhance hydrophilicity has been widely used as an aluminum plate used as a fin material for various heat exchangers and the like. Further, in order to protect this surface layer, it has been proposed that an aluminum plate is coated with polyethylene glycol exhibiting hydrophilicity (see Patent Literature 1).

On the other hand, since the oil-based metalworking fluid requires high-temperature drying by hot air for lack of drying characteristics, the oil-based metalworking fluid also requires protection against fire. Moreover, VOC (Volatile Organic Compounds) impose burdens on an operator and environments. For this reason, a water-soluble metalworking fluid with excellent cooling performance and infiltration capabilities, no danger of fire and low burdens to environments has been frequently used. The water-soluble metalworking fluid may be sometimes used for the aluminum plate having a hydrophilic surface as described above.

CITATION LIST

PATENT LITERATURE

[0003]

Patent Literature 1: JP-A-09-014888

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

The oil-based metalworking fluid does not damage the hydrophilic surface. However, since the water-soluble metalworking fluid is diluted with water in use, the water-soluble metalworking fluid may dissolve a hydrophilic substance on a surface of a metal plate, thereby deteriorating slippage on a metal surface in forming the metal plate.

[0005]

An object of the invention is to provide a metalworking fluid capable of maintaining a sufficient lubricity without damaging hydrophilicity of a hydrophilic surface of a metal material and exhibiting an excellent forming performance of the metal material.

MEANS FOR SOLVING THE PROBLEMS

[0006]

In order to solve the above-mentioned problems, according to an aspect of the invention, there is provided a metalworking fluid described below.

(1) A water-soluble metalworking fluid containing the following components (A), (B), (C) and (D): (A) a carboxylic acid having 8 to 18 carbon atoms; (B) a trialkanolamine; (C) a water soluble polymer having a mass average molecular weight of 200 or more; and (D) water.

(2) The water-soluble metalworking fluid according to (1), in which a mixed amount of each of the components in a total amount of the water-soluble metalworking fluid is as follows: the component (A) is in a range of 20 mass% to 40 mass%; the component (B) is in a range of 20 mass% to 40 mass%; the component (C) is in a range of 1 mass% to 15 mass%; and the component (D) is in a range of 10 mass% to 80 mass%.

(3) The water-soluble metalworking fluid according to (1) or (2), in which the component (C) is a nonionic surfactant.

(4) The water-soluble metalworking fluid according to (3), in which the nonionic surfactant has a polyalkylene glycol structure.

(5) The water-soluble metalworking fluid according to any one of (1) to (4), further containing at least one of an acidic phosphate ester, a phosphite ester and a metal deactivator.

(6)A metalworking fluid provided by diluting the water-soluble metalworking fluid according to any one of (1) to (5) with water a volume of which is 2 to 200 times as much as that of the water-soluble metalworking fluid.

(7) The metalworking fluid according to (6), in which the metalworking is used for processing aluminum.

[0007]

The water-soluble metalworking fluid according to the above aspect of the invention provides excellent lubricity and forming performance to various metal materials when diluted with water in use. Particularly, the water-soluble metalworking fluid is excellent for plastic forming of an aluminum fin. Even when a surface of the aluminum fin is coated with a hydrophilic resin, the water-soluble metalworking fluid can keep a sufficient lubricity to the aluminum fin.

DESCRIPTION OF EXEMPLARY EMBODIMENT

[0008]

A water-soluble metalworking fluid of the invention (hereinafter, occasionally simply referred to as fluid) is a stock solution to be diluted with water for various metal forming. The fluid is provided by mixing the following components (A), (B), (C) and (D): (A) a carboxylic acid having 8 to 18 carbon atoms; (B) a trialkanolamine; (C) a water soluble polymer having a mass average molecular weight of 200 or more; and (D) water.

[0009]

The component (A) is a carboxylic acid having 8 to 18 carbon atoms, preferably having 10 to 16 carbon atoms. When the component (A) is a carboxylic acid having 7 or less carbon atoms, friction modification is reduced, which is unfavorable. On the other hand, when the component (A) is a carboxylic acid having 19 or more carbon atoms, improvement in friction modification is not expected either, which is also economically unfavorable.

The carboxylic acid may be a monocarboxylic acid or a polycarboxylic acid (e.g., a dibasic acid). The carboxylic acid includes an aromatic carboxylic acid and a fatty acid.

The fatty acid (an aliphatic carboxylic acid) is preferable in terms of water solubility and lubricity. The carboxylic acid may be a saturated fatty acid or an unsaturated fatty acid.

Specifically, examples of the saturated fatty acid include caprylic acid (an octane acid), pelargonic acid (a nonane acid), capric acid (a decane acid), lauric acid (a dodecane acid), myristic acid (a tetradecane acid), palmitic acid (a hexadecane acid), margaric acid (a heptadecane acid), and stearic acid (an octadecane acid). The fatty acids are not limited to ones having a linear structure, but include all branched isomers such as isooctane acid and neodecanoic acid. Examples of the unsaturated fatty acid include octene acid, decene acid, docosenoic acid and oleic acid. It is the same as the saturated fatty acids that the unsaturated fatty acids are not limited to ones having a linear structure, but include all branched isomers.

[0010]

In view of antifoaming performance of the fluid when diluted with water in use and stability of hard water, examples of the monocarboxylic acid are lauric acid, caproic acid, nonane acid, isononane acid, decane acid and neodecane acid having 8 to 12 carbon atoms (a mixture of an octane acid, a nonane acid and a decane acid) while examples of dicarboxylic acid are nonane diacid, undecanoic diacid, sebacic acid and dodecanedioic acid having 9 to 12 carbon atoms.

Particularly, when the fluid (the stock solution) is diluted with water, the above-described isononane acid is excellent in reducing formation of solid substances on a fluid surface (i.e., stability of hard water).

Preferable examples of an alkyl group constituting a main chain of the fatty acid are ones having a branched structure in terms of rot resistance.

When used in a form of a salt, the dibasic acid (as the fatty acid) provides an excellent rust resistance. However, in terms of stability (unlikeliness of insolubilization) of

the stock solution, it is also preferable to use the dibasic acid and the monobasic acid in a mixture.

[0011]

A mixed amount of the component (A) is preferably in a range of 20 mass% to 40 mass% of a total amount of the water-soluble metalworking fluid, more preferably in a range of 25 mass% to 35 mass%. When the mixed amount of the component (A) is less than 20 mass%, a synergistic effect (a salt formation) of the component (A) and a later-described component (B) may be poor, so that the fluid may not exhibit a sufficient lubricity when diluted with water. On the other hand, when the mixed amount of the component (A) is more than 40 mass%, the mixed amount of the component (A) is excessive relative to the later-described component (B), so that the fluid may not similarly exhibit a sufficient lubricity as a metalworking fluid.

[0012]

The component (B), which is a trialkanolamine, contributes to improvement in lubricity and odor reduction. Here, although three alkanol groups may be the same or different, each of the three alkanol groups preferably has 1 to 10 carbon atoms. When the trialkanolamine includes an alkanol group having 10 or more carbon atoms, water solubility is unfavorably reduced. The total carbon atoms of the three alkanol groups are preferably in a range of 3 to 12. When the total carbon atoms of the three alkanol groups are less than three, odor may be unfavorably generated. On the other hand, when the total carbon atoms of the three alkanol groups are 13 or more, water solubility is unfavorably reduced.

Examples of the alkanolamine includes triethanolamine, tri-n-propanolamine, tri-i-propanolamine and tri-n-butanolamine, among which triethanolamine is preferable in terms of water solubility.

[0013]

A mixed amount of the component (B) is preferably in a range of 20 mass% to 40 mass% of the total amount of the water-soluble metalworking fluid, more preferably in a range of 25 mass% to 35 mass%. When the mixed amount of the component (B) is less

than 20 mass%, a synergistic effect (a salt formation) of the component (A) and the component (B) is poor, so that the fluid may not exhibit a sufficient lubricity when diluted with water. On the other hand, when the mixed amount of the component (B) is more than 40 mass%, the mixed amount of the component (B) is excessive relative to the component (A), so that the fluid may not similarly exhibit a sufficient lubricity as a metalworking fluid.

[0014]

The component (C), which is a water soluble polymer, provides lubricity to a metal surface when the fluid is diluted with water and used as a metalworking fluid for metalworking. Further, when the metalworking fluid of the invention is applied to a metal plate coated with a hydrophilic substance, the component (C) works for controlling solubility of the hydrophilic substance.

The water soluble polymer usable as the component (C) is not particularly limited as long as a mass average molecular weight thereof is 200 or more. Accordingly, the water soluble polymer of the invention also includes ones having a molecular weight not generally recognized as a polymer. The mass average molecular weight of the water soluble polymer of the invention is preferably in a range of 200 to 70,000, more preferably in a range of 250 to 70,000. When the mass average molecular weight is less than 200, the above-described effect cannot be sufficiently obtained. The mass average molecular weight as described above can be measured by, for instance, gel-chromatography.

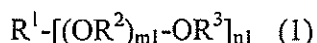
[0015]

Examples of the water soluble polymer include a synthetic polymer such as polyalkylene glycol, polyvinyl alcohol, polyvinylamine, polyvinyl pyrrolidone, polyethyleneimine and polyarylamide. Examples of a natural water-soluble polymer include agar, algin acids (algin acid and alginate), carrageenan, xanthane gum, native gellan gum, deacylated gellan gum, macrophomopsis gum, curdlan, pullulan, galactomannan (guar gum, locust bean gum, tara gum, quassia gum, etc), tamarind seed gum, psyllium seed gum, glucomannan, tragacanth gum, karaya gum, gum arabic, ghatti gum, pectine, cellulose derivatives such as water-soluble hemicellulose, soybean

polysaccharides, methylcellulose (MC), hydroxypropylcellulose (HPC), hydroxypropyl methylcellulose (HPMC), carboxymethyl cellulose (CMC) sodium and hydroxyethyl cellulose (HEC), processed starch, unprocessed starch (raw starch), dextrin and gelatin.

[0016]

Among the water soluble polymers, a polyalkylene glycol is preferable in terms of easy controllability of the molecular weight and solubility in water. Polyalkylene glycols having various structures are usable. Examples of the polyalkylene glycols include a compound represented by the following formula (1).



In the formula, R^1 represents any one of a hydrogen atom, hydrocarbyl group having 1 to 10 carbon atoms, oxygen-containing hydrocarbyl group having 2 to 10 carbon atoms, acyl group having 2 to 10 carbon atoms and hydrocarbyl group having 2 to 6 bonding sites and 1 to 10 carbon atoms. R^2 represents an alkylene group having 2 to 4 carbon atoms. R^3 represents any one of a hydrogen atom, hydrocarbyl group having 1 to 10 carbon atoms, oxygen-containing hydrocarbyl group having 2 to 10 carbon atoms and acyl group having 2 to 10 carbon atoms. $n1$ represents an integer of 1 to 6. $m1$ represents a number determined so that an average value of $m1 \times n1$ is in a range of 6 to 80.

[0017]

In the formula (1), the hydrocarbyl groups represented by R^1 and R^3 each may be linear, branched or cyclic. The hydrocarbyl group is specifically exemplified by an alkyl group such as a methyl group, ethyl group, n-propyl group, isopropyl group, butyl group, pentyl group, hexyl group, heptyl group, octyl group, nonyl group, decyl group, cyclopentyl group and cyclohexyl group. When the number of the carbon atoms contained in the hydrocarbyl group exceeds 10, compatibility of the water soluble polymer with refrigerant is deteriorated, so that a phase separation may occur. The hydrocarbyl group preferably has 1 to 6 carbon atoms. The oxygen-containing hydrocarbyl group is exemplified by a tetrahydrofurfuryl group.

In addition, alkyl groups of the acyl groups represented by R^1 and R^3 each may be linear, branched or cyclic. Examples of the alkyl groups of the acyl groups are the same

groups as listed in the above description of the alkyl groups. The examples of the alkyl groups of the acyl groups each have 1 to 9 carbon atoms.

When R^1 and R^3 each represent a hydrocarbyl group, an oxygen-containing hydrocarbyl group or an acyl group, R^1 and R^3 may be mutually the same or different.

In addition, when $n1$ is 2 or more, plural R^3 included in one molecule may be the same or mutually different.

[0018]

When R^1 is a hydrocarbyl group having 2 to 6 bonding sites and 1 to 10 carbon atoms, the hydrocarbyl group may be linear or cyclic. The hydrocarbyl group having 2 bonding sites is exemplified by an alkylene group such as an ethylene group, propylene group, butylene group, pentylene group, hexylene group, heptylene group, octylene group, nonylene group, decylene group, cyclopentylene group and cyclohexylene group. The hydrocarbyl group having 3 to 6 bonding sites is exemplified by a residue formed by eliminating hydroxyl groups from multivalent alcohol such as trimethylolpropane, glycerin, pentaerythritol, sorbitol, 1,2,3-trihydroxycyclohexane and 1,3,5-trihydroxycyclohexane.

[0019]

In the formula (1), R^2 represents an alkylene group having 2 to 4 carbon atoms. Examples of an oxyalkylene group, which is a repeating unit of the alkylene group, are an oxyethylene group, oxypropylene group and oxybutylene group. Although a plurality of oxyalkylene groups included in one molecule may be mutually the same or different, at least one oxypropylene unit is preferably included in one molecule. More preferably, an oxypropylene unit is contained in an oxyalkylene unit with a content of 50 mol% or more.

In the formula (1), $n1$, which represents an integer in a range of 1 to 6, is determined in accordance with the number of the bonding sites of R^1 . For instance, $n1$ is 1 when R^1 is an alkyl group or an acyl group while $n1$ is 2, 3, 4, 5 or 6 when R^1 is an aliphatic hydrocarbon group having 2, 3, 4, 5 or 6 bonding sites respectively. $m1$ is a number determined so that an average value of $m1 \times n1$ is in a range of 6 to 80.

[0020]

The polyalkylene glycol represented by the formula (1) includes a polyalkylene glycol having a hydroxyl group at its terminal. Examples of the polyalkylene glycol are polypropylene glycol, polyethylene glycol, pentaerythritol polyethylene glycol ether and a polyoxypropylene-polyoxyethylene copolymer. When the polyalkylene glycol is a copolymer formed by a polyoxypropylene (PO) unit and a polyoxyethylene (EO) unit, the copolymer may be a random copolymer or a block copolymer.

A polyalkylene glycol having a mass average molecular weight of 200 or more is preferably usable for the above polyalkylene glycol among polyalkylene glycols known as a non-ionic surfactant.

[0021]

A mixed amount of the water soluble polymer (the component (C)) according to the invention is preferably in a range of 1 mass% to 15 mass% of the total amount of the fluid, more preferably in a range of 5 mass% to 10 mass%. When the mixed amount of the water soluble polymer is less than 1 mass%, friction modification is not expected, which is unfavorable. On the other hand, when the mixed amount of the water soluble polymer exceeds 15 mass%, effects is not expected for the mixed amount, which is also economically unfavorable.

[0022]

The component (D) is water for preparing the fluid (the stock solution). The component (D) may be tap water, but preferably distilled water or ion-exchange water. A ratio of water for preparing the stock solution is preferably in range of 10 mass% to 80 mass%. When the ratio of water is less than 10 mass%, the components (A) to (C) are difficult to be dissolved, which complicates preparation of the stock solution. When the ratio of water exceeds 80 mass%, a storage amount and a transport amount of the stock solution become excessive, thereby reducing handleability. Accordingly, the mixed amount of water in the stock solution is preferably in a range of 20 mass% to 60 mass%.

The water-soluble metalworking fluid (the stock solution) according to the invention is diluted in use with water a volume of which is 2 to 200 times as much as that of the stock solution, preferably 5 to 100 times.

[0023]

The water-soluble metalworking fluid according to the invention may be further mixed with an acidic phosphate ester and a phosphite ester for improving lubricity.

Examples of the acidic phosphate esters include 2-ethylhexyl acid phosphate, ethyl acid phosphate, butyl acid phosphate, oleyl acid phosphate, tetracosyl acid phosphate, isodecyl acid phosphate, lauryl acid phosphate, tridecyl acid phosphate, stearyl acid phosphate and isostearyl acid phosphate.

[0024]

Examples of the phosphite ester include triethyl phosphite, tributyl phosphite, triphenyl phosphite, tricresyl phosphite, tri(nonylphenyl)phosphite, tri(2-ethylhexyl)phosphite, tridecyl phosphite, trilauryl phosphite, triisooctyl phosphite, diphenylisodecyl phosphite, tristearyl phosphite and trioleyl phosphite.

The acidic phosphate esters and the phosphite esters may be used singly or in combination. A total amount of the acidic phosphate esters and the phosphite esters to be mixed in the fluid is preferably approximately in a range of 1 mass% to 15 mass%.

[0025]

The water-soluble metalworking fluid according to the invention may be further mixed with a metal deactivator (an anticorrosion agent), an antioxidant, an oiliness agent and an antifoaming agent as long as an object of the invention is not impaired.

Examples of the metal deactivator are benzotriazole, imidazoline, pyrimidine derivatives and thiadiazole. One of the above metal deactivators may be used alone or a combination of two or more thereof may be used. A mixed amount of the metal deactivator is preferably in a range of 0.01 mass% to 1 mass% in the total amount of the fluid.

[0026]

As the antioxidant, a known phenolic antioxidant and amine antioxidant are usable.

Examples of the phenolic antioxidant are: monocyclic phenols such as 2,6-di-tert-butyl-4-methylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,4,6-tri-tert-butylphenol, 2,6-di-

tert-butyl-4-hydroxymethylphenol, 2,6-di-tert-butylphenol, 2,4-dimethyl-6-tert-butylphenol, 2,6-di-tert-butyl-4-(N,N-dimethylaminomethyl)phenol, 2,6-di-tert-amyl-4-methylphenol and n-octadecyl-3-(4-hydroxy-3,5-di-tert-butylphenyl)propionate; and polycyclic phenols such as 4,4'-methylenebis(2,6-di-tert-butylphenol), 4,4'-isopropylidenebis(2,6-di-tert-butylphenol), 2,2'-methylenebis(4-methyl-6-tert-butylphenol), 4,4'-bis(2,6-di-tert-butylphenol), 4,4'-bis(2-methyl-6-tert-butylphenol), 2,2'-methylenebis(4-ethyl-6-tert-butylphenol), 4,4'-butylidenebis(3-methyl-6-tert-butylphenol), 2,2'-thiobis(4-methyl-6-tert-butylphenol) and 4,4'-thiobis(3-methyl-6-tert-butylphenol).

[0027]

Examples of the amine antioxidant are a diphenylamine antioxidant, diphenylamine of which is exemplified by diphenylamine and alkylated diphenylamine having an alkyl group having 3 to 20 carbon atoms such as monooctyl diphenylamine, monononyl diphenylamine, 4,4'-dibutyl diphenylamine, 4,4'-dihexyl diphenylamine, 4,4'-dioctyl diphenylamine, 4,4'-dinonyl diphenylamine, tetrabutyl diphenylamine, tetrahexyl diphenylamine, tetraoctyl diphenylamine or tetranonyl diphenylamine, or a naphthylamine antioxidant, naphthylamine of which is exemplified by α -naphthylamine, phenyl- α -naphthylamine and alkyl-substituted phenyl- α -naphthylamine having 3 to 20 carbon atoms such as butylphenyl- α -naphthylamine, hexylphenyl- α -naphthylamine, octylphenyl- α -naphthylamine or nonylphenyl- α -naphthylamine. Among the above, the diphenylamine antioxidant is more preferable than the naphthylamine antioxidant in view of effects. Particularly, alkylated diphenylamine having an alkyl group having 3 to 20 carbon atoms is preferable. Further, 4,4'-di(C₃ to C₂₀ alkyl) diphenyl amine is more preferable.

In the invention, one or more antioxidants selected from the phenol antioxidants and the amine antioxidants are useable as the antioxidant. A mixed amount of the antioxidant is approximately in a range of 0.01 mass% to 5 mass% of the total amount of the composition in terms of effect of antioxidant and economical balance.

[0028]

Examples of the oiliness agent include: aliphatic alcohol; a fatty acid compound such as a fatty acid and a fatty acid metal salt; an ester compound such as a polyol ester,

sorbitan ester and glyceride; and an amine compound such as aliphatic amine. Examples of the antifoaming agent are methylsilicone oil, fluorosilicone oil and polyacrylate.

[0029]

The water-soluble metalworking fluid according to the invention, which is diluted as necessary with water so that its concentration is adjusted suitably for the usage, is preferably applicable in various metalworking fields such as pressing, cutting, grinding, polishing, squeezing, drawing and flatting. The water-soluble metalworking fluid according to the invention, which is excellent in lubricity irrespective of a dilute concentration, is also suitable to not only a soft aluminum plate such as an aluminum fin material but also a hard iron plate (e.g., an S45C thin plate) such as carbon steel. Further, even when a surface of the aluminum fin material and the like is coated with a hydrophilic substance, the water-soluble metalworking fluid does not impair lubricity.

[Examples]

[0030]

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

[Examples 1 to 2, Comparatives 1 to 3 and Reference]

The water-soluble metal working fluid (the stock solution) was prepared in accordance with a blend prescription shown in Table 1. Details of each of the components are as follows.

[0031]

[Table 1]

1) Polyalkylene Glycol A

		Example 1	Example 2	Comparative 1	Comparative 2	Comparative 3	Reference
Stock Solution Composition (mass%)	lauric acid (component A)	14.0	14.0	—	16.5	14.0	—
	neodecane acid (component A)	14.8	14.8	—	—	14.8	—
	maleic acid	—	—	24.6	—	—	—
	triethanolamine (component B)	36.2	36.2	63.1	—	36.2	—
	cyclohexyldiethanolamine	—	—	—	17.2	—	—
	polyalkylene glycol A ¹⁾ (component C)	5.0	—	—	—	—	—
	polyalkylene glycol B ¹⁾ (component C)	—	5.0	—	—	—	—
	oleyl acid phosphate	8.7	8.7	—	—	8.7	—
	benzotriazole	0.2	—	—	—	—	—
	ion-exchange water (component D)	21.1	21.3	12.3	66.3	26.3	100.0
Evaluation	coefficient of kinetic friction	0.153	0.148	0.230	0.300	0.170	0.250
	stock solution stability	A	A	A	A	A	—
	diluted solution stability	A	A	A	A	A	—

A block copolymer represented by $(EO)_n-(PO)_m-(EO)_n$ was used. Herein, $(EO)_n$ is a polymer of ethylene oxides and $(PO)_m$ is a polymer of propylene oxides. n is approximately 5 and m is approximately 35. Both terminal groups are hydroxyl groups.

2) Polyalkylene glycol B (PNT-40 manufactured by NIPPON NYUKAZAI CO., LTD)

Pentaerythritol polyethylene glycol ether was used.

[0032]

The following properties each were evaluated based on the stock solution in accordance with the above blend prescription. Results are shown in Table 1.

(1) Lubricity (Friction Coefficient)

Except for Reference, the stock solution was diluted with ion-exchange water to 50 times (a volume ratio), and was subsequently coated on a test piece. A coefficient of kinetic friction (μ) was obtained by the following reciprocating friction test. For Reference, the same test was also conducted using only ion-exchange water.

[0033]

(Reciprocating Friction Test)

Testing machine: Reciprocating friction testing machine (manufactured by ORIENTEC Co., LTD)

Test piece: Precoated aluminum fin material for a heat exchanger (Polyethylene glycol was coated on a surface as a hydrophilic film.)

Testing conditions:

Fluid temperature: 70 degrees C

Load: 3kgf (29N)

Sliding speed: 20 mm/s

Amplitude: 50 mm

Under these conditions, the highest friction coefficient at the first sliding was read. The friction coefficient was an average value of values obtained when three test pieces in each of Examples, Comparatives and Reference were measured.

[0034]

(2) Stock Solution Stability

The components of the stock solution were put into a beaker and mixed while being stirred by a stirrer to form a uniform solution. After the solution was left to stand still for one night, the solution in the beaker was visually observed. Stability of the stock solution was evaluated according to the following scales.

A: dissolved

B: dispersed (cloudy)

C: clotted

[0035]

(3) Diluted Solution Stability

The components of the stock solution were put into a beaker and mixed while being stirred by a stirrer to form a uniform solution (preparation of the stock solution). 98 mL of water was put into a 100-mL Messzylinder, to which 2 mL of the stock solution was added for dilution. After shaking the Messzylinder up and down three times, the solution was left to stand still for one night. The solution in the Messzylinder was visually observed. Stability of the diluted solution was evaluated according to the following scales.

A: dissolved

B: dispersed (cloudy)

[0036]

Evaluation Result

According to the result in Table 1, when the metalworking fluid of the invention is applied to the aluminum fin material, the metalworking fluid of the invention exhibits an excellent lubricity even when the aluminum fin material has a hydrophilic film on its surface, because a metalworking fluid according to the invention is provided by diluting a predetermined water-soluble metal working fluid with water in use. Moreover, the water-soluble metal working fluid of the invention is favorable in terms of stock solution stability and stability of the diluted solution provided by diluting the water-soluble metal working fluid with water.

On the other hand, the fluids of Comparatives 1 to 3, in which at least one of the essential components (A), (B) and (C) of the invention is lacking, exhibit no lubricity when diluted with water in use.

INDUSTRIAL APPLICABILITY

[0037]

A metalworking fluid according to the invention is preferably usable for forming a metal plate such as an aluminum plate and an iron plate.

CLAIMS

1. A water-soluble metalworking fluid comprising the following components (A), (B), (C), (D) and a metal deactivator:
 - 5 (A) a saturated aliphatic monocarboxylic acid having 8 to 12 carbon atoms and comprising both of lauric acid and neodecane acid;
 - (B) a trialkanolamine;
 - (C) one of a pentaerythritol ether and a polyoxypropylene-polyoxyethylene block copolymer of a polyalkylene glycol having a mass average molecular weight of 200 or
10 more; and
 - (D) water.
2. The water-soluble metalworking fluid according to claim 1, further comprising: at least one of an acidic phosphate ester and a phosphite ester.
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3. A metalworking fluid provided by diluting the water-soluble metalworking fluid according to claim 1 or 2 with a water a volume of which is 2 to 200 times as much as that of the water-soluble metalworking fluid.
- 20 4. The metalworking fluid according to claim 3, wherein the metalworking fluid is used for processing aluminum.