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3,256,187

CUTTING FLUID

Robert H. Davis, Woodbury, N.J., assignor to Socony Mobil Oil Company, Inc., a corporation of New York
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This invention relates to cutting fluids, and, more particularly, to aqueous compositions adapted for use as lubricants and coolants in metal machining operations.

In machining operations of metals, such as cutting, grinding, turning, milling and the like, it is customary to flood the tool and the work with a coolant for the purpose of carrying off heat from the tool and the work. It is also customary to employ these coolants in combination with various agents having lubricating and extreme pressure properties to reduce friction between tool and work piece, particularly in operations such as tapping and broaching. In this respect, it has heretofore been the practice to employ for such purpose aqueous compositions containing such lubricating agents as emulsified petroleum, or non-petroleum additives. However, such aqueous cutting fluids, in order to perform satisfactorily, should meet certain important requirements.

Among the requirements for a satisfactory cutting fluid are corrosion inhibiting properties for ferrous and cuprous alloys, and stability under the conditions of operation. However, while various cutting fluids may possess such characteristics, there are further important requirements that should also be met. Among these requirements is the avoidance of leaving deposits on the tool and the work, following the machining operation, resulting from subsequent drying of the fluid, which are difficult to remove. Other important requirements include avoiding excessive foam formation, resistance to rancidity, tolerance in hard water solutions so that precipitation of components will not occur, and the avoidance of tacky residues which interfere with the operation of the machine. The cutting fluids known prior to this invention, have not, however, satisfactorily met all of the foregoing requirements.

It is, therefore, an object of the present invention to provide a cutting fluid which is effective as a lubricant and a coolant and having improved characteristics, free from the undesirable features recited above.

Another object of the invention is to provide an improved cutting fluid having corrosion and rust inhibiting properties, and which does not leave hard or insoluble deposits on metal surfaces during machining operations.

Still another object of the invention is to provide an improved cutting fluid which does not cause excessive foam formation during the machining operation.

Still further objects of the invention are to provide improved cutting fluids which are resistant to rancidity, maintain their transparency, do not precipitate in hard water solutions, and avoid the formation of tacky water-insoluble residues during their machining operations.

Other objects and advantages inherent in the invention will become apparent to those skilled in the art from the following disclosure.

It has now been found that a balanced formulation can be obtained in a cutting fluid, having improved lubricating and cooling efficiency, and which, in the course of the machining operation, does not leave deposits on metal, is free from excessive foam formation, is resistant to rancidity, maintains its transparency in hard water solutions, and avoids the formation of tacky water-insoluble residues.

The foregoing objects as more fully hereinafter described, are, in general, realized with aqueous compositions comprising a balanced formulation and containing as essential components the combination of an alkanol-

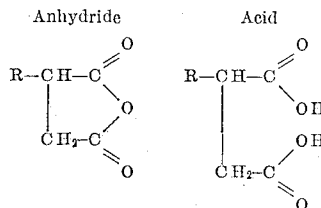
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amine and an organic acid of intermediate molecular weight, viz., an organic acid having from about 6 to about 12 carbon atoms per molecule, and an alkenyl succinic anhydride. In this respect, it is found that the alkanolamine component, in addition to functioning as a corrosion inhibiting agent in which the aforementioned organic acids are soluble, also functions as a plasticizer, in that in the course of use, evaporation of water from the cutting fluid leaves a residue upon machinery parts which is desirably soft or semi-liquid. The function of the organic acid component, in combination with the alkanolamine, is primarily that of a corrosion inhibitor, in the form of the amine acid salt.

The alkanolamine employed in the novel formulation may be of any molecular weight but should preferably be liquid at room temperature. The lower molecular weight compounds are generally preferred, and, for this purpose, it has been found that such alkanolamines as mono-, di-, or tri-ethanolamine, are most effective. Other alkanolamines include isopropanolamines and methyl di-ethanolamine. The alkanolamine may be employed as either a specific compound or as a combination of such compounds, if so desired.

The organic acid component, as previously indicated, is of the type commonly known as the intermediate molecular weight acids, namely those having from about 6 to about 12 carbon atoms per molecule, and may comprise either saturated or unsaturated acids, or mixtures thereof. In this respect, it has been found that the relatively lower molecular weight organic acids, i.e., acids having from 1 to about 5 carbon atoms per molecule, do not satisfactorily function as rust-inhibitors and are also objectionable because of their strong odor. On the other hand, it is found that employing relatively high molecular weight organic acids, i.e., acids having more than about 12 carbon atoms per molecule, for example C₁₃ or higher straight-chain acids, there result high foaming tendencies, poor hard water stability and reduced corrosion inhibiting properties. Of particular utility with respect to the aforementioned intermediate molecular weight organic acids, in the present improved formulation are heptanoic, caprylic, capric, pelargonic, caproic, undecylenic, undecylic and lauric acids.

In combination with the aforementioned alkanolamines and organic acids, there is incorporated in the improved formulation of the present invention the use of alkenyl succinic anhydrides to function as rust-inhibitors, by reason of their synergistic effects with the aforementioned organic acids, as more fully hereinafter described. Any alkenyl succinic acid anhydride or the corresponding acid is utilizable in the improved formulation of the present invention. The general structural formulae of these compounds are:



wherein R is an alkenyl radical. The alkenyl radical can be straight-chain or branched-chain; and it can be saturated at the point of unsaturation by the addition of

a substance which adds to olefinic double bonds, such as hydrogen, sulfur, bromine, chlorine, or iodine. It is obvious, of course, that there must be at least two carbon atoms in the alkenyl radical, but there is no real upper limit to the number of carbon atoms therein. The alkenyl succinic acid anhydrides and the alkenyl succinic acids are interchangeable for the purposes of the present invention. Accordingly, when the term "alkenyl succinic acid anhydride," is used herein, it must be clearly understood that it embraces the alkenyl succinic acids as well as their anhydrides, and the derivatives thereof in which the olefinic double bond has been saturated, as set forth hereinbefore. Non-limiting examples of the alkenyl succinic acid anhydride component are

Ethenyl succinic acid anhydride
 Ethenyl succinic acid
 Ethyl succinic acid anhydride
 Propenyl succinic acid anhydride
 Sulfurized propenyl succinic acid anhydride
 Butenyl succinic acid
 2-methylbutenyl succinic acid anhydride
 1,2-dichloropentyl succinic acid anhydride
 Hexenyl succinic acid anhydride
 Hexyl succinic acid
 Sulfurized 3-methylpentenyl succinic acid anhydride
 2,3-dimethylbutenyl succinic acid anhydride
 3,3-dimethylbutenyl succinic acid
 1,2-dibromo-2-ethylbutyl succinic acid
 Heptenyl succinic acid anhydride
 1,2-diiodooctyl succinic acid
 Octenyl succinic acid anhydride
 Diisobutenyl succinic acid anhydride
 2-methylheptenyl succinic acid anhydride
 4-ethylhexenyl succinic acid
 2-isopropylpentenyl succinic acid anhydride
 Nonenyl succinic acid anhydride
 2-isopropylpentenyl succinic acid anhydride
 Decenyl succinic acid
 Decenyl succinic acid anhydride
 5-methyl-2-isopropyl-hexenyl succinic acid anhydride
 1,2-dibromo-2-ethyloctenyl succinic acid anhydride
 Decyl succinic acid anhydride
 Undecenyl succinic acid anhydride
 1,2-dichloroundecyl succinic acid
 1,2-dichloroundecyl succinic acid anhydride
 Tetrapropenyl succinic acid anhydride
 Tetrapropenyl succinic acid
 Triisobutenyl succinic acid anhydride
 2-propyl-nonenyl succinic acid anhydride
 3-butyloctenyl succinic acid anhydride
 Tridecenyl succinic acid anhydride
 Tetradecenyl succinic acid anhydride
 Hexadecenyl succinic acid anhydride
 Sulfurized octadecenyl succinic acid
 Octadecyl succinic acid anhydride
 1,2-dibromo-2-methylpentadecenyl succinic acid anhydride
 8-propylpentadecyl succinic acid anhydride
 Eicosenyl succinic acid anhydride
 1,2-dichloro-2-methylnonadecenyl succinic acid anhydride
 2-octyldodecenyl succinic acid
 1,2-diiodotetracosenyl succinic acid anhydride
 Hexacosenyl succinic acid
 Hexacosenyl succinic acid anhydride; and
 Hentriacontenyl succinic acid anhydride

The methods of preparing the alkenyl succinic acid anhydrides are well known to those familiar with the art. The most feasible method is by the reaction of an olefin with maleic acid anhydride.

A more detailed description of the alkenyl succinic anhydrides suitable for use in the above formulations and their preparation, is disclosed in Patent No. 2,638,450, issued May 12, 1953. Particularly preferred are alkenyl

succinic anhydrides having from 8 to 12 carbon atoms per molecule.

In combination with the aforementioned alkanolamine, organic acids and alkenyl succinic acid anhydride, an alkali metal nitrite may also be employed in the formulation in order to impart increased anti-rust properties to the lubricant composition. In this respect, more specific increased resistance to copper corrosion may be obtained by the use of the sodium salt of mercapto-benzothiazole. In addition, the overall performance properties of the lubricant composition may be enhanced by the addition of germicidal agents, particularly phenolic materials such as phenol, sodium salts of orthophenylphenol, chlorinated phenols, such as hexachlorophene, tetrachlorophenol and p-chloro-m-xylene, and also boric acid or oxides of boron. In order to obtain fungus protection, improve the rust protection properties, and also to function as a load-support agent, an alkali metal hydroxide, serving to raise the pH of the system, may be employed. These may include, for example, sodium, lithium or potassium hydroxide. Furthermore, if desired, various water-soluble chelating agents may be employed to soften the water vehicle. Thus, for example, the sodium salt of diethylene triamine pentaacetic acid or salts of ethylenediamine tetraacetic acid or nitrilo-triacetic acid can be used.

The novel cutting and lubricant compositions of the present invention are formulated with certain balanced proportions, expressed in weight percent. Thus, the alkanolamine is employed in an amount from about 5 to about 40 percent, and preferably in an amount from about 20 to about 35 percent, by weight. The organic acid component is employed in an amount from about 0.1 to about 9 percent, and preferably in an amount from about 1 to about 4 percent, by weight. The alkenyl succinic anhydride is employed in an amount from about 0.1 to about 9 percent, and preferably in an amount from about 0.1 to about 4 percent, by weight. The alkali metal nitrite, when included in the formulation, is generally employed in an amount from about 0.1 to about 10 percent, and preferably from about 0.1 to about 5 percent, by weight. When the sodium salt of mercapto-benzothiazole is included in the formulation, this material is generally present in an amount from about 0.1 to about 6 percent, preferably from about 0.1 to about 3 percent, by weight. The germicidal agents disclosed above, when present, are generally employed in an amount from about 0.05 to about 3 percent, and preferably from about 0.05 to about 1.5 percent, by weight. The water-soluble boron additive, e.g., boric acid, when present, is generally employed in an amount from about 0.1 to about 5 percent, and preferably from about 0.1 to about 3 percent, by weight. The alkali metal hydroxide, e.g., sodium hydroxide, is employed in an amount from about 0.1 to about 3 percent, and preferably from about 0.1 to about 1.5 percent, by weight when present. When any of the aforementioned chelating agents are employed, these are generally present in an amount from about 0.1 to about 5 percent, by weight. When any of the aforementioned components are employed in addition to the alkanolamines, the organic acids and the alkenyl succinic acid anhydrides, the quantity of water employed to balance the formulation in each instance, will, of course, be accordingly reduced.

The novel lubricant and cutting compositions contemplated in accordance with the present invention are preferably prepared by a blending procedure which comprises reacting alkaline components with acids and/or anhydrides and about 10 to 20 parts of water, which is to be present in the finished formulation. This blending procedure may be satisfactorily carried out at room temperature. When the resulting solution has become clear, upon standing, the remaining quantity of water required to be present in the finished product, is added, together with any of the aforementioned other desired com-

ponents, such as preformed salts, and any other of the above-described specific materials. It should be noted, however, that if an alkali metal nitrite is to be present in the finished product, such material is added last, for the reason that addition of acids, such as caprylic acid, to a solution of sodium nitrite could result in decomposition of the nitrite, thus reducing or nullifying its rust-inhibiting effects.

The compounding of the novel compositions of the present invention may be illustrated by the preparation of lubricant and cutting fluids from the formulations shown in the following tables and examples, and which also include comparative data and the observations noted when compositions are prepared which do not include the essential components of the present improved formulations. In this respect, as indicated above, among the outstanding properties of the improved lubricant compositions of the present invention are their rust-inhibiting properties and high machining efficiency. Accordingly, these improved compositions were subjected, for the purpose of evaluation, to the following corrosion and machining efficiency tests.

CORROSION TEST

Malleable iron chips are placed in a 50 ml. beaker together with the fluid composition which is to be evaluated. All excess liquid is then drained off, and the beaker is stored in an atmosphere of approximately 90 percent relative humidity and at a temperature between about 70 and about 75° F. The sample is then checked, after a period of 48 hours storage, for the appearance of rust. This test, and a more detailed method for carrying it out, is fully described in Patent No. 3,071,545, issued January 1, 1963.

MACHINING EFFICIENCY

The machining efficiency of the novel improved lubricant compositions of the present invention is evaluated with respect to a series of holes drilled in a test bar made from hot-rolled steel, which are to be tapped. Prior to testing, samples of the novel formulations are diluted by employing 1 part, by weight of the additive concentrate to 5 parts, by weight of distilled water. The fluid is applied to the tap with a polyethylene squeeze-bottle. Four unknown samples are bracketed by two standards. The tapping efficiency is calculated by dividing the torque obtained with the unknown, into the average standard torque, and multiplying by 100. This test, and a more detailed method for carrying it out, is fully described in Patent No. 3,071,545, issued January 1, 1963.

TABLE I.—AQUEOUS RUST INHIBITING SYSTEM CONTAINING AN ALKANOLAMINE SALT OF AN INTERMEDIATE MOLECULAR WEIGHT ORGANIC ACID AND AN ALKENYL SUCCINIC ACID

Ex. No.	Base Formula, Percent Wt.				Malleable Iron Test 1-40 Dil. Dist. Water 48 Hours
	Tri-ethanol-amine	Caprylic Acid	Nonenyl Succinic ¹ Anhydride	Dist. Water	
1-----	24	6	-----	70	Rust.
2-----	24	-----	6	70	Do.
3-----	24	3	3	70	No rust.

¹ Anhydride is converted to the amine salt in presence of triethanolamine and water.

As will be seen from Example 3, there is a definite synergistic effect between the amine salts of nonenyl succinic anhydride and caprylic acid. Thus, the inclusion in the formula of 3 percent caprylic acid and 3 percent of nonenyl succinic anhydride is superior in rust-inhibiting properties to 6 percent of either component when used alone.

TABLE II.—AQUEOUS EXTREME PRESSURE LUBRICANTS CONTAINING AN ALKANOLAMINE SALT OF AN INTERMEDIATE MOLECULAR WEIGHT ORGANIC ACID AND AN ALKENYL SUCCINIC ACID

Ex. No.	Base Formula, Percent Wt.				Tapping ² Efficiency 1-5 Dil. Base Formula-Dist. Water
	Tri-ethanol-amine	Caprylic Acid	Nonenyl Succinic ¹ Anhydride	Dist. Water	
4-----	30	-----	-----	70	75.7
5-----	20	10	-----	70	81.7
6-----	20	3	7	70	94.7

¹ Anhydride is converted to the amine salt in the presence of triethanolamine and water.

² With relationship to a reference cutting fluid such as described in U.S. Patent No. 3,071,545. Results represent average of two tests.

It will be seen from Table II above that neither the triethanolamine, when used alone (Example 4), nor the combination of triethanolamine and caprylic acid (Example 5) are effective load-support agents, as indicated by the respective tapping efficiency in each case, which is below 82 percent. It will be noted, however, that the combination of the aforementioned triethanolamine, caprylic acid and nonenyl succinic anhydride produces a tapping efficiency of 94.7 percent (Example 6). It will, therefore, be apparent that there is a synergistic extreme pressure effect between the succinic acid anhydride and the triethanolamine and caprylic acid components.

While preferred embodiments of the compositions of the present invention and the processes for their preparation have been described for the purpose of illustration, it should be understood that various modifications and adaptations thereof, which will be obvious to those skilled in the art, may be made without departing from the spirit of the invention.

I claim:

1. An aqueous lubricant composition consisting essentially of a salt of a water-soluble alkanolamine selected from the group consisting of monoethanolamine, diethanolamine, and triethanolamine and a fatty organic acid having from about 6 to about 12 carbon atoms per molecule and a salt of said alkanolamine and an alkenyl succinic acid anhydride, obtained from an aqueous mixture consisting essentially of, by weight, from about 5 to about 40 percent of said alkanolamine, from about 0.1 to about 9 percent of said organic acid, and from about 0.1 to about 9 percent of said alkenyl succinic acid anhydride.

2. An aqueous lubricant composition consisting essentially of a salt of a water-soluble alkanolamine selected from the group consisting of monoethanolamine, diethanolamine, and triethanolamine and a fatty organic acid having from about 6 to about 12 carbon atoms per molecule, a salt of said alkanolamine and an alkenyl succinic acid anhydride, and an alkali metal nitrite, obtained from an aqueous mixture consisting essentially of, by weight, from about 5 to about 40 percent of said alkanolamine, from about 0.1 to about 9 percent of said organic acid, from about 0.1 to about 9 percent of said alkenyl succinic acid anhydride, and from about 0.1 to about 10 percent of said alkali metal nitrite.

3. An aqueous lubricant composition consisting essentially of a salt of a water-soluble alkanolamine selected from the group consisting of monoethanolamine, diethanolamine, and triethanolamine and a fatty organic acid having from about 6 to about 12 carbon atoms per molecule, a salt of said alkanolamine and an alkenyl succinic acid anhydride, an alkali metal nitrite, and sodium mercapto benzothiazole, obtained from an aqueous mixture consisting essentially of, by weight, from about 5 to about 40 percent of said alkanolamine, from about 0.1 to about 9 percent of said organic acid, from about 0.1 to about 9 percent of said alkenyl succinic acid anhydride, from about 0.1 to about 10 percent of said alkali

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metal nitrite, and from about 0.1 to about 6 percent of sodium mercapto-benzothiazole.

4. An aqueous lubricant composition consisting essentially of a salt of a water-soluble alkanolamine selected from the group consisting of monoethanolamine, diethanolamine, and triethanolamine and a fatty organic acid having from about 6 to about 12 carbon atoms per molecule and a salt of said alkanolamine and an alkenyl succinic acid anhydride, obtained from an aqueous mixture consisting essentially of, by weight, from about 20 to about 35 percent of said alkanolamine, from about 1 to about 4 percent of said organic acid, and from about 0.1 to about 4 percent of said alkenyl succinic acid anhydride.

5. An aqueous lubricant composition consisting essentially of a salt of a water-soluble alkanolamine selected from the group consisting of monoethanolamine, diethanolamine, triethanolamine and a fatty organic acid having from about 6 to about 12 carbon atoms per molecule, a salt of said alkanolamine and an alkenyl succinic acid anhydride, and an alkali metal nitrite, obtained from an aqueous mixture consisting essentially of, by weight, from about 20 to about 35 percent of said alkanolamine, from about 1 to about 4 percent of said organic acid, from about 0.1 to about 4 percent of said alkenyl succinic acid anhydride, and from about 0.1 to about 5 percent of said alkali metal nitrite.

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6. An aqueous lubricant composition consisting essentially of a salt of a water-soluble alkanolamine selected from the group consisting of monoethanolamine, diethanolamine, and triethanolamine and a fatty organic acid having from about 6 to about 12 carbon atoms per molecule, a salt of said alkanolamine and an alkenyl succinic acid anhydride, an alkali metal nitrite, and sodium mercapto-benzothiazole, obtained from an aqueous mixture consisting essentially of, by weight, from about 20 to about 35 percent of said alkanolamine, from about 1 to about 4 percent of said organic acid, from about 0.1 to about 4 percent of said alkenyl succinic acid anhydride, from about 0.1 to about 5 percent of said alkali metal nitrite, and from about 0.1 to about 3 percent of sodium mercapto-benzothiazole.

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DANIEL E. WYMAN, Primary Examiner.

C. F. DEES, Assistant Examiner.