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3,000,826

TRANSPARENT METAL WORKING LUBRICANT COMPOSITION

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This invention relates to an aqueous transparent cutting oil possessing outstanding anti-rust properties and lubricity. More particularly, this invention relates to a cutting oil composition which possesses the high heat capacity of water while still retaining the desirable properties of petroleum base cutting oils.

The use of high machine speeds in metal working operations such as cutting, drilling, broaching, drawing, and the like has placed severe demands on the lubricant employed to cool and lubricate the tool and metal work piece. The enormous amount of heat generated at the tool-work piece interface must be quickly dissipated in order to prevent damage to the tool and work piece. The second major requirement of metal working lubricants is the reduction of friction between the tool and work piece to prevent wear, scoring, and welding of the contacting parts. The requirements of cooling and lubricating place severe restrictions on the composition of metal working lubricants. Water is an excellent cooling fluid because of its high heat capacity, but it is almost completely deficient in lubricating properties. Mineral lubricating oils afford excellent lubrication and reduce friction but are relatively poor coolants.

A number of metal working lubricants have been formulated to provide both lubricity and high heat capacity. One effective approach has been the development of soluble oils, which are mineral oil base lubricants containing a substantial concentration of emulsifying agents so that they form oil-in-water emulsions processing both lubricity and good cooling properties. Another approach is disclosed in U.S. 2,692,859 and involves formation of an aqueous, non-corrosive cutting solution. The metal working composition of this patent comprises water, 0.01 to 10.0 weight percent each of an alkyl phenol-ethylene oxide reaction product, an alkali metal nitrite and an inorganic metal phosphate. The alkali metal nitrite-inorganic metal phosphate combination is alleged to act as a corrosion inhibitor and to improve metal working efficiency. The alkyl phenol-ethylene oxide product acts as a surface active agent. The metal working lubricant composition of this invention possesses substantial advantages in cooling, lubricity, low temperature stability and anti-rust properties over both the soluble oil formulations and the aqueous cutting fluid of the afore-identified patent.

The metal working lubricant composition of this invention comprises water as the main constituent, 5 to 40 percent polyethylene glycol, polypropylene glycol or a mixture thereof, said glycol having an average molecular weight between 200 and 800, 3 to 18 percent alkali metal nitrite and 2 to 15 percent of a secondary or tertiary alkanol amine. The lubricating composition of the invention is characterized by outstanding anti-rust properties, lubricity and excellent low temperature stability.

The polyalkylene glycol component of the lubricant

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composition of the invention has the following general formula:



wherein R is hydrogen or a methyl radical and n is an integer having a value of 3 to 18. Polyglycols usable in the formulation of the metal working lubricants of the invention are the following wherein the number immediately following the compound indicates the average molecular weight:

Polyethylene glycol-----	200
Do -----	300
Do -----	600
Do -----	800
Do -----	500
Polypropylene glycol-----	200

Hereafter in the description of the invention the average molecular weight of the polyglycol component will be indicated by the number immediately succeeding the compound designation.

It is necessary for the polyalkylene glycol component to have an average molecular weight between about 200 and 800 in order for the resulting lubricant composition to possess lubricating properties and transparency. Aqueous compositions containing polyglycols such as diethylene glycol having a molecular weight below 200 tend to be deficient in lubricity. At the other end of the scale compositions prepared with polyethylene or polypropylene glycol having a molecular weight above 800 are hazy and cannot be classified as transparent cutting oils. Polyethylene glycols having average molecular weights between 400 and 700 are the preferred materials for the formulation of the metal working lubricants of the invention.

The concentration of the polyalkylene glycol component is also an important factor in the production of satisfactory metal working lubricants. The polyalkylene glycol constitutes 5 to 40 weight percent of the lubricant with concentrations of 15 to 35 weight percent normally being employed. If the concentration of the polyglycol component is above 40 weight percent of the lubricant composition, an unstable product results. For example, a product containing approximately 41 percent polyethylene glycol 600, 18.5 percent sodium nitrite and 14.4 percent triethanolamine showed substantial crystalline deposits after only four days of storage at atmospheric temperature; in contrast, a product comprising approximately 39 percent of the polyethylene glycol 600 and approximately the same concentration of sodium nitrite and triethanolamine showed no deposit formation even after several months of storage at atmospheric temperature. A polyglycol concentration of at least 5 percent is necessary for the product to have good lubricating properties. Products with a polyglycol concentration below about 5 weight percent are deficient in lubricating properties.

The alkali metal nitrite component of the lubricant composition of the invention is preferably sodium nitrite because of its low cost but other alkali metal nitrites such as potassium and lithium nitrite are also used. The lubricants of the invention are usually prepared with between 7 and 15 weight percent alkali metal nitrite but

concentrations as high as 18 percent and as low as 3 percent may be employed.

In order to provide the desired rust protection it is necessary to employ an aliphatic alkanol amine in conjunction with the inorganic metal nitrite. The alkanol amine is a secondary or tertiary alkanol amine of the general formula: $RR'R''N$ wherein R is selected from the group consisting of hydrogen, an alkyl radical and a hydroxy-substituted alkyl radical, R' is selected from the group consisting of an alkyl radical, a hydroxy-substituted alkyl radical or an amino-substituted alkyl radical, and R'' is a hydroxy-substituted alkyl radical, said alkyl, hydroxy alkyl and amino alkyl radicals containing 1 to 8 carbon atoms and preferably 1 to 4 carbon atoms.

Examples of alkanol amines useful in the formulation of the transparent cutting fluids of the invention are triethanolamine, diethanolamine, tri(4-hydroxy-n-butyl) amine, di(2-hydroxy-n-butyl) amine, triisopropanolamine, diisopropanolamine, dimethyl ethanolamine, monoethyl ethanolamine, methyl (4-hydroxy-n-butyl) amine, 2-amino-ethyl ethanolamine, amino-methyl ethanolamine and aminoethyl isopropanolamine. Mixtures of secondary and tertiary alkanol amines such as mixed isopropanolamines containing primary, secondary and tertiary isopropanol amines are also usable in the formulation of the transparent cutting fluids of the invention. Particularly preferred alkanol amines are triethanolamine, a mixture of di- and triethanolamines, triisopropanol amine, and aminoethyl ethanolamine. Exceptionally high rust protection is obtained with these alkanol amines.

It is necessary for the alkanol amine to have the prescribed formula since aryl-substituted alkanol amines such as phenyl ethanolamine do not give the desired rust protection.

The alkanol amine prescribed formula constitutes 2 to 15 weight percent of the lubricant composition. The usual concentration falls between approximately 5 and 12 weight percent but concentrations as high as 15 weight percent are employed in concentrates.

The alkanol amine has the dual function of providing anti-rust properties and of improving lubricity. The alkanol amine imparts anti-rust properties in conjunction with the alkali metal nitrite and imparts lubricity in conjunction with the polyglycol of prescribed molecular weight.

The outstanding anti-rust properties of the cutting fluids of this invention in comparison with other aqueous cutting fluids were shown in a rusting test which is specifically designed to evaluate the rust protection afforded by soluble oils and aqueous cutting fluids and which involves the determination of what dilution of a soluble oil or cutting fluid with synthetic hard water causes the rusting of cast iron. The procedure involves placing portions of solutions formed from the cutting fluid in varying amounts of synthetic hard water on a polished cast iron plate 11" x 5½" x ½" which is cross-hatched into 162 equal ⅙" squares. Drops of solutions ranging from a 10:1 dilution to a 90:1 dilution in increments of 5 are placed on different squares of the polished cast iron plate. The plate containing the various dilutions is allowed to stand overnight in an area where there is adequate ventilation, under which conditions the emulsion drops are evaporated in 1 to 2 hours. The squares are examined for signs of rust and the highest dilution showing no rust whatever is noted and reported as "No Rust" and the lowest dilution showing rust is noted and reported as the "Rust" dilution.

The synthetic hard water contains 125 p.p.m. hardness and is prepared by dissolving 2.77 g. of anhydrous calcium chloride and 5 gallons of distilled water and adjusting the pH to 6.5 to 7.5 by the addition of 10 percent of H_2SO_4 or 10 percent $NaHCO_3$.

In Table I there are shown the rust protection afforded

by the following aqueous cutting fluids in the afore-described rusting test:

Composition A comprises:

20% polyethylene glycol 600
9% sodium nitrite
71% water

Composition B comprises:

10% polyethylene glycol 600
20% triethanolamine
70% water

Composition C comprises:

20% polyethylene glycol 600
9% sodium nitrite
7% triethanolamine
64% water

Composition D comprises:

20% polyethylene glycol 600
5% sodium nitrite
7% triethanolamine
68% water

Composition E comprises:

20% polyethylene glycol 600
11% sodium nitrite
7% triethanolamine
62% water

Composition F comprises:

20% polyethylene glycol 600
9% sodium nitrite
11% triethanolamine
60% water

Composition G comprises:

20% polyethylene glycol 600
9% sodium nitrite
5% triethanolamine
66% water

Composition H comprises:

1% Pluronic L-44
0.5% disodium phosphate
0.5% sodium nitrite
98% water

Composition I comprises:

1% Pluronic L-62
0.5% disodium phosphate
0.5% sodium nitrite
98% water

Composition J comprises:

1% Pluronic L-64
0.5% disodium phosphate
0.5% sodium nitrite
98% water

Composition K comprises:

1% ammonium salt of sulfated nonylphenoethylene oxide (4 moles) adduct
0.5% disodium phosphate
0.5% sodium nitrite
98% water

TABLE I
Rusting test

Composition	No Rust	Rust
A-----		10
B-----		10
C-----	70	75
D-----	30	35
E-----	25	30
F-----	80	85
G-----	45	50
H-----		10
I-----		10
J-----		10
K-----		10

The data in Table I clearly demonstrates the necessity of employing a combination of alkali metal nitrite and alkanol amine in order to obtain a cutting fluid of high rust resistance and anti-staining properties. Compositions

A and B in which triethanolamine and sodium nitrite, respectively, were missing, gave rust at 10:1 dilution, whereas the products of the invention as represented by Compositions C through G all provided rust protection up to dilutions of 35 and above. Compositions C and F containing concentrations of sodium nitrite and triethanolamine within the preferred concentration range gave exceptionally high rust protection since rusting was only observed at dilutions of 75:1 and 85:1, respectively.

The data in Table I also establishes the superiority of the aqueous cutting fluids of this invention to the aqueous cutting fluids of the afore-identified Patent 2,692,859 wherein an alkali metal nitrite, inorganic phosphate combination is used as an anti-rust agent in combination with a water-soluble, non-ionic surface active agent such as an alkyl phenol-ethylene oxide adduct. Compositions H through K, representative of the cutting fluids of this patent, gave rust when diluted with 10 parts of water, whereas the compositions of the invention did not exhibit rust until diluted with 35 or more parts of water.

In an effort to determine whether a higher degree of rust protection was possessed by cutting fluids of the type described in U.S. 2,692,859 containing higher concentrations of ingredients, two additional cutting fluids were prepared. One contained 5 percent Pluronic L-62, 5 percent sodium nitrite, 5 percent disodium acid phosphate, and 85 percent water, and the other contained 10 percent Pluronic L-62, 10 percent sodium nitrite and 10 percent disodium acid phosphate. Both of these products separated into two phases and products were too hazy to be considered transparent cutting fluids. Accordingly, neither product was subjected to the rusting test since they evidently did not fulfill the requirements of a transparent cutting fluid.

In Table II there are shown the rusting properties of aqueous cutting fluids prepared with polyglycols of varying molecular weight and with other alkanol amines. The compositions whose anti-rust properties were evaluated in the rusting test in Table II were the following:

Composition L—20% polyethylene glycol 200, 9% sodium nitrite, 7% triethanolamine, 64% water.

Composition M—20% polyethylene glycol 400, 9% sodium nitrite, 7% triethanolamine, 64% water.

Composition N—20% polyethylene glycol 1000, 9% sodium nitrite, 7% triethanolamine, 64% water.

Composition O—20% polyethylene glycol 600, 9% sodium nitrite, 10.5% aminoethyl ethanolamine, 60.5% water.

Composition P—20% polyethylene glycol 600, 9% sodium nitrite, 4% mixed isopropanolamines (mixture of primary, secondary and tertiary isopropanol amines), 67% water.

Composition Q—20% polyethylene glycol 600, 9% sodium nitrite, 2.3% dimethyl ethanolamine, 68.7% water.

Composition R—20% polyethylene glycol 600, 9% sodium nitrite, 5.5% phenyl ethanolamine and 65.5% water.

TABLE II
Rusting test

Composition	Rust	No Rust
L.....	50.....	55.....
M.....	50.....	55.....
N.....	non-transparent	too hazy.
O.....	70.....	75.....
P.....	30.....	35.....
Q.....	30.....	35.....
R.....		10.....

The data in Table II indicate that satisfactory products are obtained with polyethylene glycol 200 and 400 whereas the use of polyethylene glycol 1000 in Composition N results in a non-transparent, hazy product. These data confirm the necessity of employing a polyethylene glycol

of an average molecular weight between 200 and 800 in order to produce transparent cutting fluids of the invention.

With respect to the alkanol amine component, the data in Table II prove the necessity of employing secondary or tertiary amines in which at least one of the nitrogen substituents is an alkanol radical. Compositions O, P, Q, wherein aminoethyl ethanolamine, mixed isopropanolamines and dimethyl ethanolamine, respectively, were used in place of triethanolamine, were all transparent fluids of excellent anti-rust properties. In contrast, Composition R employing phenyl ethanolamine in conjunction with sodium nitrite as an anti-rust agent possessed poor anti-rust properties as evidenced by the production of rust at 10:1 dilution.

Transparent cutting fluids of the invention also possess other characteristics necessary for a highly effective transparent cutting fluid. The product possesses heat stability and is very stable at low temperature. The polyglycol component imparts a low freezing point to the cutting fluid of the invention.

Field evaluation of the metal cutting fluids of the invention has confirmed the excellent results obtained in the laboratory screening test. The use of the cutting fluid of the invention has resulted in excellent tool life and has promoted cutting efficiency. At one location, Composition C comprising 20 percent polyethylene glycol 600, 9 percent sodium nitrite, 7 percent triethanolamine and 64 percent water was evaluated as a lubricant for a Landis crankshaft grinder. Composition C out-performed a commercial soluble oil. Its performance was deemed excellent by the operator from whom the following observation was obtained: Composition C cleaned up the grinder, gave satisfactory finishes, kept the gauges clean, helped speed up inspection by maintaining a clean solution, and in general provided rust-free and corrosion-free performance. At another location, Composition C was evaluated in a Blanchard Cincinnati Filmatic blade sharpening machine and in a Schneider grinder with excellent results. In the opinion of the operators, Composition C was the best grinding coolant they had evaluated. It clearly out-performed commercial soluble oils and even in an 80:1 dilution no rust was obtained and the machines and work pieces remained stain-free. As a result of its excellent performance, Composition C is being used exclusively at this location for all grinding operations.

Obviously, many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and, therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A metal working lubricant composition consisting essentially of water as the main component, 5 to 40 weight percent of a polyglycol selected from a group consisting of polyethylene glycols, polypropylene glycols, and mixtures thereof having an average molecular weight between 200 and 800, 3 to 18 weight percent alkali metal nitrite, and 2 to 15 weight percent of an alkanol amine having the general formula: $RR'R''N$ wherein R is selected from a group consisting of hydrogen, an alkyl radical and a hydroxy alkyl radical; R' is selected from a group consisting of an alkyl radical, a hydroxy alkyl radical and an amino alkyl radical; and R'' is a hydroxy alkyl radical, said alkyl, hydroxy alkyl, and amino alkyl radicals containing 1 to 4 carbon atoms.

2. A metal working lubricant composition according to claim 1 in which the polyglycol has an average molecular weight between 400 and 700 and constitutes 15 to 35 weight percent of the composition.

3. A metal working lubricant composition according to claim 1 containing 7 to 15 weight percent alkali metal nitrite.

4. A metal working lubricant composition according

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to claim 1 containing 5 to 12 weight percent alkanol amine.

5. A metal working lubricant composition consisting essentially of water as the main component, 5 to 40 weight percent polyethylene glycol having an average molecular weight between 200 and 800, 3 to 18 weight percent sodium nitrite and 2 to 15 weight percent triethanolamine.

6. A metal working lubricant composition according to claim 5 containing 15 to 35 weight percent polyethylene glycol having an average molecular weight between 400 and 700, 7 to 15 weight percent sodium nitrite and 5 to 12 weight percent triethanolamine.

7. A metal working lubricant composition consisting essentially of 20 percent polyethylene glycol 600, 9 percent sodium nitrite and 7 percent triethanolamine and the remainder being water.

8. A metal working lubricant composition consisting essentially of 20 percent polyethylene glycol 600, 9 per-

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cent sodium nitrite, 10.5 percent aminoethyl ethanolamine, and the remainder being water.

9. A metal working lubricant composition consisting essentially of 20 percent polyethylene glycol 600, 9 percent sodium nitrite, 2.3 percent dimethylethanolamine and the remainder being water.

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