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(54) **Bio-lubricating metalworking fluid free of oils and emulsifiers**

(57) Compositions of bio-lubricating fluids for machining operations, free of oils and emulsifiers, that have a high refrigeration and lubricating property with synergistic association of water, biopolymers and proper additives, endowing the product with biodegradability wherein said composition comprises between 0.01 and 5.0%

w/w of a biopolymer, between 0.5 and 25.0% w/w of an anticorrosive additive, and additives that depend on the application of the biolubricating fluid, which may be anticorrosive, biocidal, antifoaming, extreme pressure, pH controlling, complexing, and other additives, and water qsp.

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Description

Field of the Invention

5 **[0001]** This invention relates to formulations of bio-lubricating metalworking fluids free of oils and emulsifiers. More particularly, this invention relates to a bio-lubrication fluid whose lubricating properties are obtained by increasing viscosity of water through proper biopolymers and additives.

Background of the invention

10 **[0002]** Lubricating fluids are used in a wide variety of applications ranging from engines to metalworking operations.

[0003] Specifically, metalworking fluids also known as cutting fluids or cutting "oil" are used to make the metalworking operation easier, mainly, in the tool-workpiece contact area, providing lubricity and refrigeration proper for each type of operation and material involved. Said fluids are classified as straight oils usually made up of mineral oils although they can be composed of oils of animal or vegetable origin free of water, and soluble oils (emulsion or micro-emulsions) that contain water in their formulation.

[0004] Straight metalworking fluids are non-corrosive and last a long time when kept clean (which is rare in practice). However, mainly, oils of mineral origin have numerous disadvantages such as low resistance to microbial attack, poor refrigeration, which does not prevent wear in the area of friction between the workpiece and the tool, damage to plastic parts, elastomers (rubber) and paints, which requires that equipment be stopped for periodic maintenance and replacement, an adverse impact on the work environment caused by the friction between the workpiece and the tool, which forms fog, and also involuntary spills during regular replacement of fluid; an adverse impact on health, considering published technical literature on occupational diseases, an adverse impact on safety due to flammable, combustible, and flame conducting in general, an adverse impact on the environment with residues being classified as Class I (ABNT NBR 10004:2004 - Resíduos Sólidos) which are extremely harmful to the environment.

[0005] Although they have a refrigeration property, soluble metalworking fluids have such problems as corrosion, foaming, and greater susceptibility to microbial attack in the metalworking process.

[0006] Nevertheless, from an environmental and occupational health and safety viewpoint, vegetable-based synthetic oils have big advantages due to elimination of mineral oils, providing a low toxicity and normally biodegradable product that reduces toxic fog in the environment, has a high refrigeration power due to the presence of water in the formulation which reduces tool wear, replacements and production stops, and a high wetting power which makes the operation in the workpiece-tool contact area easier.

[0007] It is thus an object of this invention to provide a formulation of a bio-lubricating fluid that has a high refrigeration and lubricating property with synergistic association of water through proper biopolymers and additives, endowing the product with biodegradability, without oils and emulsifiers.

Summary of the Invention

[0008] In an aspect of the invention there is provided a formulation of a bio-lubricating fluid that comprises a biopolymer, water, and additives endowing water which has an excellent refrigeration property by its nature with lubricity characteristics without oils and emulsifiers.

[0009] In another aspect there is provided a bio-lubricating fluid of high refrigeration and lubricity power.

Detailed Description of the Invention

45 **[0010]** A bio-lubricating metalworking fluid, subject matter of this invention, comprises a formulation that includes a synergistic combination of a biopolymer such as an agent that increases viscosity of water, in order to ensure a behavior of oil in water, but with no addition of oils or synthetic derivatives such as those used in emulsions and therefore without the use of emulsifiers.

[0011] The bio-lubricating metalworking fluid, subject matter of this invention, comprises between 0.01 and 5.0% w/w of a biopolymer, between 0.5 and 25.0% w/w of an anticorrosive additive, and water qsp.

[0012] Preferably, the bio-lubricating fluid comprises between 0.1 and 2.0% w/w of a biopolymer, between 1.5 and 10% w/w of an anticorrosive additive, and water qsp.

[0013] More preferably, the bio-lubricating fluid comprises between 0.5 and 1.8% w/w of a biopolymer, between 2.0 and 7.0% w/w of an anticorrosive additive, and water qsp.

[0014] The additives depend on an application of the bio-lubricant and may be anticorrosive additives, biocidal additives, antifoaming additives, extreme pressure additives, pH controlling additives, complexing agents, and others.

[0015] Optionally, the formulation has between 0.1 and 2.0% of a biocidal additive in order to prevent proliferation of

microorganisms in the fluid, preventing degradation and bad odor and increasing the useful life of the formulation.

[0016] Optionally, the formulation contains between 0.1 and 2.0% of an antifoaming agent to protect against contamination that may generate foam, especially, a more dilute solution is recommendable for the metalworking operation such as saws and grinding machines.

[0017] Optionally, the formulation comprises between 0.5 and 10.0% of an extreme pressure additive potentially useful when the operation requires a greater force load applied to the workpiece to protect tools and make the finish of the machined workpiece easier due to physical expulsion of fluid at the contact point.

[0018] Optionally, the formulation contains between 0.5 and 10.0% of an anticorrosive additive for yellow metals such as copper, brass, and bronze, to prevent adverse impacts on the metal such as corrosion or staining.

[0019] Optionally, the formulation of a bio-lubricating fluid contains between 0.1 and 2.0% of chelant agents.

[0020] Optionally, the formulation contains between 0.5 and 10.0% of a wetting agent or stabilizer to make the workpiece-tool contact easier due to greater stability in order to prevent separation of the tramp oil and water phases.

[0021] The biopolymer is selected among cellulosic thickeners such as hydroxyethylcellulose (HEC) or carboximethylcellulose (CMC), polysaccharides of bacterial origin such as Xanthan or Curdlan gums, and starch or sucrose derivatives.

[0022] The biopolymer to be used must induce viscosity in or thicken water in order to endow the fluid with lubricity. In this case, biopolymers such as polysaccharides have a lot of hydroxyl (-OH) groups capable of forming hydrogen bonds with water, forming a hydration layer that allows sliding between the chains, endowing the fluid with desired lubricity. Therefore, the dilution factor is of importance for the bio-lubricant. High concentrations of a biopolymer (in the order of 3.0% or more) provide the structure with characteristics of paste or gel similar to those of grease. By increasing the dilution, the mixture becomes more fluid maintaining thickening similar to that of oils. In elevated dilutions, lubricity is considerably reduced by physical disengagement of bio-polymeric structures.

Tests

[0023] Field validation tests use three formulations of a bio-lubricating fluid as follows:

Biopolymer (0.1-3.0% w/w), anticorrosive agent (0.5-8.0% w/w) antifoaming agent (0.1-2.0% w/w), extreme pressure additive (0.5-10.0% w/w), and biocidal agent (0.1-2.0% w/w), and water qsp.

Biopolymer (0.1-3.0% w/w), anticorrosive agent (0.5-8.0% w/w), antifoaming agent (0.1-2.0% w/w), extreme pressure additive (0.5-10.0% w/w), biocidal agent (0.1 a 2.0% w/w), anticorrosive additive for yellow metals (0.5-8.0% w/w), and water qsp.

Biopolymer (0.1-3.0% w/w), anticorrosive agent (0.5-8.0% w/w), extreme pressure additive (0.5-10.0% w/w), antifoaming agent (0.1-2.0% w/w), biocidal agent (0.1-2.0% w/w), chelant (0.1-2.0% w/w), wetting agent (0.5-10.0% w/w), and water qsp.

[0024] In the three formulations (A, B, and C), hydroxyethylcellulose (HEC) was preferred to gums and carboximethylcellulose (CMC) for reasons of its ease of processing and productivity.

[0025] All formulations for the field validation test (A, B, and C) are applicable to ferrous materials and aluminum. However, formulation B is recommended for applications with yellow metals and formulation C is recommended for situations when dilution water to be used is possibly harder (Ca, Mg, and other diluted metals that may cause problems to the process and to the quality of the operation).

[0026] In the field evaluations, the formulation was diluted at the ratio of 1:5 (1 part by volume of fluid to 5 parts by volume of water) for machining equipment performing turning operations. In sawing and grinding operations, the dilution in water used varied up to a maximal ratio of 1:8 (by volume). In threading and broaching operations, dilution in water in the order of 1:1 up to 1:5 and pH in the order of 8.0-9.5 were used.

[0027] The bio-lubricating formulations were assessed in field tests for machining of steel (carbon steel), cast iron, aluminum alloys, and copper alloys (brass) using in the operations such equipment as saws, grinding machines, mills, lathes, drills, threading machines, and machining centers. When compared, the performance of the formulation A with the brand name Fluid B90® was better than that of synthetic fluids (a synthetic-based fluid derived from tall oil with the brand name Oil 30® was used as a reference) and a lot better than that of mixed semi-synthetic fluid containing 60% of mineral oil with relation to the synthetic base with the trade name SEP 60®.

[0028] Table 1 shows a qualitative assessment of users perception of performance aspects where VU means Very Unsatisfactory, U -Unsatisfactory, S - Satisfactory, and VS - Very Satisfactory.

Table 1: Comparative Qualitative Assessment of Fluids

Characteristic	Semi-synthetic Fluid (BD- SEP 60®)	100% Synthetic Fluid (BD-Oil 30®)	Bio-lubricating Fluid A (BD-Fluid B90®)
Quality of operation and finish of the workpiece	S	S	VS
Operation speed and tool preservation	U	S	VS
Solution stability	VU	U	VS
Contamination and separation (demulsification) of tramp oil	VU	U	VS
Machined workpiece and tool temperature after the operation	VU	S	VS
Work environment	VU	S	VS
Occupational Health and Safety	VU	S	VS
Generation of residues, effluents and costs of proper disposal	VU	U	VS

[0029] Tables 2 and 3 show the quantitative assessment of fluids in relation to the environmental parameter COD (Chemical Oxygen Demand)

Table 2: Comparative Quantitative COD-based Assessment of fluids

Characteristic	Semi-synthetic Fluid (BD- SEP 60)	100% Synthetic Fluid (BD- Oil 30)	Bio-lubricating Fluid A (BD-Fluid B90)
COD (mg O ₂ /L)	1,165,049	459,406	64,554

Table 3: Comparative quantitative assessment of fluids at maximum dilution to be used on the basis of COD - Chemical Oxygen Demand

Characteristic	Semi-synthetic Fluid (BD- SEP 60) diluted at the proportion 1:20 (fluid:water)	100% Synthetic Fluid BD-Oil 30) diluted in water at the proportion 1:20 (fluid:water)	Bio-lubricating Fluid A (BD- Fluid B90) diluted in water at the proportion 1:5
COD (mg O ₂ /L)	55,479	21,876	10,759

[0030] In its form, the bio-lubricating fluid has a COD of 14% of the value of a synthetic fluid and in the order of 5.5% of that of a semi-synthetic fluid. Considering the respective products diluted in the manner indicated, the biolubricating fluid has a COD of approximately 49% (less than half) of the value of the synthetic fluid.

[0031] As for the semi-synthetic fluid, the bio-lubricating fluid (A) has a COD in the order of 19% (less than 1/5).

[0032] Therefore, it can be asserted that additivation among the products shown in Tables 2 and 3 is similar; however, a COD of the bio-lubricating fluid (A) is low exclusively due to the absence of any oily material in the formulation.

[0033] The analysis of biodegradability by the OECD Method No.301 (*OECD Guidelines for the Testing of Chemicals / Section 3: Degradation and Accumulation Test No. 301: Ready Biodegradability. OECD-Organization for Economic Co-operation and Development*) showed that the biodegradability during a period of 20 days was 93.3%, characterizing it as "readily biodegradable".

[0034] The formulations of bio-lubricants (A), (B), and (C) were subjected to field tests in different situations.

[0035] Formulation (A) was employed in a set of commercial metalworking machines where aluminum alloys were the main material machined. The dilutions varied between 1:3 and 1:8 as shown in the Table 4.

Table 4: Volume of bio-lubricating fluid employed in different machines

Description of the machine	Quantity of Machines	Estimated volume (in liters) of the machine tank	Total of Bio-lubricating Fluid Employed (in liters)
Machining Center ROMI Discovery D 800	21	300	6300
Milling Machine Tooling Machine	55	50	2750
Cylindrical Grinding machine	1	120	120
Tangential and Flat Grinding Machine	6	130	780
Lathe CNC ROMI Centur 30D	20	190	3800
Conventional Mechanical Lathe ROMI T240	55	45	2475
TOTAL	158 machines	---	16, 225 liters

[0036] All tests were assessed for operability and qualitative aspects in accordance with the criteria shown in Table 1. The operation was approved in all aspects assessed. The quality and the finish of workpieces were in accordance with the specifications and designs. The tramp oil demulsified with perfect separation. Corrosion (workpieces or equipment), foaming or proliferation of microorganisms of any nature were not observed. The work environment was clean and organized without fog characteristic of the operation with mineral oils. The preservation of tools was also observed.

[0037] Tests carried out on equipment for machining a beryllium copper alloy showed that the bio-lubricating fluid, subject matter of this invention, provides better performance for the equipment. In this test, the equipment that works at 2500-3000 rpm using a soluble vegetable-based fluid allowed making 116 holes followed by a 30-minute setup to sharpen the drill bit. When the equipment started using the bio-lubricating fluid (formulation B) diluted in water at the volumetric proportion of 1:5 (one part of fluid to five parts of water), it started making 730 holes with no need for sharpening.

[0038] A second machine for machining aluminum worked at 22,000 rpm and used ethyl alcohol. Neither alteration in the process nor increase in temperature was observed when the bio-lubricating fluid (formulation A) was diluted in water at the volumetric proportion of 1:5 (one part of fluid to five parts of water). However, the elimination of ethyl alcohol reduced work environment, health, and safety risks.

[0039] Tests were carried out on a threading machine that usually used straight mineral oil as a fluid for threading of carbon steel bars. This equipment showed all kind of operational health and safety risks and eventually such defects as burrs (with the risk of cutting an operator's hands) as well as dimensional ones due to heating of the workpiece (high temperature usually prevented the immediate handling of the workpiece after the operation, thus reducing productivity and increasing the time of the operation). The same operation was subjected to a test with the bio-lubrication fluid (formulation A) diluted in water at the proportion 1:5 (by volume) for threading of a carbon steel workpiece. The perfect tread from the viewpoint of the dimensional specification free of burrs and completely cold at the end of the operation was obtained, thus allowing the workpiece to be safely touched and handled.

[0040] Similar result was obtained with the bio-lubricating fluid of the formulation (C) in the broaching operation. A broaching machine that used straight mineral oil (showing all drawbacks described above) with an extreme pressure additive was prepared to use the bio-lubricating fluid (formulation C) diluted in water at the proportion of 1:2-1:5 (by volume). The quality of the operation and the quality of the workpiece (cuts of sprockets and carbon steel gears) were obtained with success in accordance with the specifications and without health, safety, and environmental risks resulting from the use of mineral oils.

Claims

1. Bio-lubricating metalworking fluid free of oils and emulsifiers comprising between 0.01 and 5.0%w/w of a biopolymer, between 0.5 and 25.0% w/w of an anticorrosive additive, and water qsp.
2. Bio-lubricating metalworking fluid free of oils and emulsifiers comprising between 0.1 and 2.0% w/w of a biopolymer, between 1.5 and 10% w/w of an anticorrosive additive, and water qsp.

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3. Bio-lubricating metalworking fluid free of oils and emulsifiers comprising between 0.5 and 1.8% w/w of a biopolymer, between 2.0 and 7.0% w/w of an anticorrosive additive, and water qsp.
- 5 4. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1 optionally comprising between 0.1 and 2.0% of a biocidal additive.
5. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1-3 optionally comprising between 0.1 and 2.0% of an antifoaming additive.
- 10 6. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1-3 optionally comprising between 0.5 and 10.0% of an extreme pressure additive.
7. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1- 3 optionally comprising between 0.5 and 10.0% of an anticorrosive additive for yellow metals.
- 15 8. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1-3 optionally comprising between 0.1 and 2.0% of a chelant.
9. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1-3 optionally comprising between 0.5 and 10.0% of a wetting additive or stabilizer.
- 20 10. Bio-lubricating metalworking fluid free of oils and emulsifiers of claims 1 to 3 wherein the biopolymer is selected among cellulosic thickeners, polysaccharides of bacterial origin, and starch or sucrose derivatives.

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EUROPEAN SEARCH REPORT

 Application Number
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Place of search Munich		Date of completion of the search 22 May 2015	Examiner Renoth, Heinz
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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