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CUTTING OIL COMPOSITION

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7 Claims. (Cl. 252—45)

The present invention relates to a cutting oil concentrate, cutting oils containing such a concentrate and characterized by a unique combination of superior cutting ability and absence of the formation of disagreeable odors when in use, and to a method of making the concentrate.

Oils containing sulfur or sulfur compounds dissolved therein have been suggested heretofore as cutting oils. Such oils also frequently contain chlorine and a fat such as lard oil. It is believed that the sulfur, to be effective in improving the cutting ability of a cutting oil, must be in an active form, i. e., not bound to a carbon atom, which can react with metal being machined under the conditions existing at the point of contact between the tool and the machined metal. Heretofore, the amount of active sulfur which could be incorporated into an oil has been dependent largely upon the solubility of free sulfur in the oil and upon the amount of sulfur which can be chemically combined but not bound to a carbon atom.

A great many suggestions have been made heretofore for increasing the active sulfur content of cutting oils. In some instances, these suggestions have resulted in oils having excellent cutting ability but poor odor characteristics and/or stability. In other instances, they have resulted in oils of acceptable odor but of poor cutting ability. In still other instances the oils developed have been found to be too dark or opaque to permit adequate viewing of the work during a machining operation. Generally it has been found that some compromise must be made among odor, stability, optical density and cutting ability factors, the cutting ability being improved with an increase in sulfur content at the expense, however, of odor, stability and opacity. To the best of applicant's knowledge, no cutting oil having optimum cutting ability and odor has ever been developed heretofore.

The odor characteristics of a cutting oil are not necessarily apparent upon an examination of the oil as produced or supplied to a user. In many instances, odors are developed only when the oil is used in machining operations. This is apparently due to the formation of odoriferous compounds under the conditions prevailing at the cutting tool. If the cutting oil develops an unpleasant or obnoxious odor during use, it makes no difference how good the oil is from the standpoint of cutting ability, i. e., the number of pieces that can be machined with a given tool, the wear on the tool and the surface finish of the metal being machined because machinists will refuse to work with it.

Hydrocarbon polysulfides containing one or more alkyl or aryl radicals have been suggested as being suitable for addition to lubricating oils in order to produce cutting oils. Tests have shown that some of this class of hydrocarbon polysulfides, when added to lubricating oils, form compositions having acceptable cutting abilities. Unfortunately, however, most of these hydrocarbon polysulfides, as such and when diluted or blended with a mineral cutting oil base, have obnoxious odors that immediately disqualify them as cutting oil concentrates.

Thus, for example, diamyl tetrasulfide has an exceedingly unpleasant odor that is characteristic of the polysulfide itself rather than of a mercaptan impurity, since it cannot be altered by caustic washing, and diallyl tetrasulfide which, because of its light yellow color, ready miscibility with mineral oil and very high sulfur content appeared very promising, was found to have a nauseating garlic odor. The few polysulfides in this group that do not possess such odors initially, almost without exception develop odors, upon use, that are or soon become so obnoxious as to cause machinists to walk off the job. In some instances the odors developed during use do not seem too unpleaasnt at first but for some reason become intolerable upon continued use due to a subtle accumulation of odors in high speed, automatic, multi-spindle machines, because of the large volumes of oil they require and the heat, violent agitation and splashing to which the oil is subjected.

Proposals to utilize aryl sulfides in cutting oils relate generally to those aryl sulfides in which a sulfur atom or a chain of sulfur atoms is substituted directly on the aromatic nucleus. Thus, for example, proposals have been made to utilize aryl sulfides, such as phenyl-, tolyl-, xylyl-, naphthyl- and anthracene sulfides in cutting oils without suggesting that there are any material defferences among the many aryl sulfides that would make some of them less suitable than others.

It has also been proposed to utilize in cutting oils aryl sulfides wherein the sulfur atoms or a chain of sulfur atoms is connected to the aromatic nucleus by a methene or ethene group. It is believed, however, that no specific suggestion has been made to utilize such aryl sulfides which have substituted on the aromatic nucleus as many as two methyl groups. It appears to be generally believed in the art that monosulfides and disulfides in this more limited class of aryl sulfides are to be preferred over sulfides containing more than two sulfur atoms because of greater solubility in oil of the mono- and disulfides and also because the mono- and disulfides are liquid at ordinary temperatures, whereas some investigators appear to have concluded that similar but more highly sulfurized compounds are not liquid at ordinary temperatures.

The surprising and unexpected discovery has now been made that it is feasible to prepare dimethylbenzyl polysulfides of appreciably higher sulfur content than had hitherto been considered possible and that diluted or undiluted compositions essentially comprising such polysulfides, particularly dimethylbenzyl pentasulfide which is defined herein as having the formula

$$((CH_3)_2C_6H_3CH_2)_2S_x$$

wherein x varies between about 4.5 and 5.5 and preferably averages about 5, are eminently suitable as cutting oil concentrates.

Generally, the method of the invention comprises reacting dimethylbenzyl chloride with sodium tetrasulfide and elemental sulfur at an elevated temperature. The reactants may all be mixed together or the dimethylbenzyl chloride and sodium tetrasulfide may first be reacted to form, as an intermediate reaction product, dimethylbenzyl polysulfide containing an average of at least about three and preferably about four sulfur atoms per molecule, and the intermediate reaction product may then be reacted with elemental sulfur.

In one embodiment of the invention, preferred because of its more economical use of sulfur, dimethylbenzyl chloride, believed to be a mixture of the various isomers of $(CH_3)_2C_6H_3CH_2Cl$, is reacted with an excess of sodium tetrasulfide in the form of an aqueous solution by agitating the reactants at an elevated temperature of the order of about 200° F. for several hours, preferably under

and inert atmosphere such as nitrogen. Upon cooling and settling, the reaction mixture forms an upper organic phase and a lower aqueous phase. The lower aqueous phase is separated and the remainder, i. e., the upper organic phase, is washed with an alkali hydroxide solution by stirring at room temperature. Upon separation of the alkali hydroxide solution, high yields of dimethylbenzyl polysulfide containing an average of at least about three and preferably about four sulfur atoms per molecule are obtained.

The reaction between the chloride and sodium tetrasulfide is preferably carried out in the presence of a diluent having a low viscosity and a high flash point. One such diluent particularly suitable for this purpose is diesel fuel oil. The addition of this hydrocarbon, which does not react with either the reactants, the dimethylbenzyl polysulfide intermediate product or the ultimately desired dimethylbenzyl pentasulfide product, is preferred because mixtures thereof have lower viscosities than either the intermediate or final reaction products, facilitates handling of the reactants and the products, and aids in the separation of any aqueous phase after the reaction. The diluent remains with the organic phase and serves as such in the succeeding reaction step with elemental sulfur.

The dimethylbenzyl polysulfide so obtained, preferably while remaining in the presence of the diluent, is then reacted with an excess, preferably about 5%, of elemental sulfur for 2 to 3 hours at a temperature above about 200° F. and below about 300° F., preferably about 250° F.

In another embodiment of the method of the invention, which involves a higher consumption of sulfur, the dimethylbenzyl pentasulfide is prepared directly by admixing dimethylbenzyl chloride simultaneously with an excess of sodium tetrasulfide and an excess of elemental sulfur and reacting at a temperature between about 150° F. and about 250° F. The temperature and time of reaction preferred, to avoid settling out of sulfur from the product upon prolonged standing, are about 200° F. and about 2½ hours, respectively. This reaction is likewise preferably carried out under an inert atmosphere such as nitrogen to avoid undesirable darkening of the product and in the presence of a diluent such as diesel fuel oil. Upon cooling and settling, the reaction mixture forms an upper organic phase and a lower aqueous phase. The lower aqueous phase is separated and the remainder, i. e., the upper organic phase including a diluent, if any, is washed with a dilute alkali hydroxide solution by stirring at room temperature. Upon separation of the alkali hydroxide solution, high yields of dimethylbenzyl pentasulfide containing about 4.5 or more sulfur atoms per molecule are obtained.

The exact mechanism of the reaction wherein dimethylbenzyl chloride, sodium tetrasulfide and elemental sulfur are simultaneously admixed and brought to an elevated temperature, is not known. It is believed that the pentasulfide is formed either by a successive reaction of the chloride with the sodium tetrasulfide and then of the resulting polysulfide with the elemental sulfur, by addition of the elemental sulfur to the sodium tetrasulfide and subsequent reaction thereof with the chloride, or by a combination of such steps. It is difficult to identfy accurately the number of sulfur atoms in each dimethylbenzyl polysulfide and sodium tetrasulfide molecule. It is possible, however, to determine with accuracy the average number of sulfur atoms in these polysulfides. It is to be understood, therefore, that as used herein the term "dimenthylbenzyl pentasulfide" is not strictly limited to a sulfide containing five sulfur atoms per molecule but is intended to include mixtures of dimethylbenzyl sulfides such as the tri-, tetra-, penta- and hexasulfides wherein the average number of sulfur atoms per molecule is between about 4.5 and 5.5 and is preferably about 5. Similarly, it is to be understood that the term "sodium tetrasulfide," as used herein, is not strictly limited to a sodium sulfide containing four sulfur atoms per molecule but is intended to include mixtures of sodium sulfides such as the di-, tri-, tetra-, and pentasulfides wherein the average number of sulfur atoms per molecule is at least about 3 and preferably about 4.

The treatment, with alkali hydroxide solution, of the sulfiides, i. e., the intermediate reaction product containing an average of at least about three and preferably about four sulfur atoms per molecule obtained in the first step of the preferred method, and the pentasulfide ultimately obtained by either embodiment of the method, is carried out to wash out mercaptans, hydrogen sulfide, and other remaining chlorides. The use of dilute rather than concentrated alkali hydroxide solutions is desirable to avoid extracting appreciable quantities of sulfur, especially from the pentasulfide products. Aqueous sodium hydroxide solutions having concentrations below 10% are preferred.

It is also desirable to after-treat the washed intermediate reaction product, if any, and the pentasulfide reaction product with a material such as Super Filtrol in order to brighten the product and thereby make it more desirable from an aesthetic point of view.

It is particularly surprising and unexpected, in view of the fact that such closely related homologs as unsubstituted benzyl pentasulfide having the formula

$$(C_6H_5CH_2)_2S_x$$

becomes increasingly less miscible in cutting oil bases and more unpleasantly odoriferous as x is increased to 5, that cutting oil concentrates essentially comprising dimethylbenzyl pentasulfide are completely miscible in cutting oil bases. Furthermore, the dimethylbenzyl pentasulfide obtained by the method of this invention by itself or in admixture with say 40% by weight of a diluent such as diesel fuel oil, is stable even to the extent that no sulfur will precipitate although the product be stored at 0° C. for several days.

It is also surprising that cutting oils containing concentrates essentially comprising dimethyl-benzyl pentasulfide are stable, have extremely good cutting ability, and neither have nor develop objectionable odor even after considerable use.

The dimethylbenzyl pentasulfide, diluted or not with a suitable diluent such as diesel fuel oil, may be blended with any mineral cutting oil base, preferably an acid-treated oil having a viscosity between about 75 and 300 SSU at 100° F. and containing free sulfur dissolved therein. The lower limit of viscosity specified is imposed largely by sulfur solubility. Oils having viscosities higher than 300 SSU at 100° F. are not preferred because of difficulties of handling and flowing. Blends containing as little as 1% by weight of dimethylbenzyl pentasulfide have excellent cutting ability and concentrations of dimethylbenzyl pentasulfide as high as 60% or higher in diesel fuel, without being blended with acid-treated oil, have superior cutting ability and excellent odor characteristics. For cutting operations on difficult-to-machine ductile steels, blends of mineral cutting oil base containing dissolved elemental sulfur with between about 2 and 5% by weight of the concentrate are highly satisfactory.

It is to be understood that while the products of this invention consist essentially of dimethylbenzyl pentasulfide, preferably diluted with unsulfurized diesel fuel or blended with a mineral cutting oil base having elemental sulfur dissolved therein, or both, conventional additives such as lard oil, graphite, chlorinated wax and the like may be added in amounts that do not materially alter the character of the products.

Steels that are subjected to machining operations have a wide degree of machinability. Some result in relativcly short tool life and poor finish. These are referred to as difficult-to-machine ductile steels. This class embraces the heat resistant steels and alloys, an example of which is SAE C–1040. Others are easier to machine in the sense that the tool normally lasts longer under proper lubrication. These are referred to as free-machining ductile

steels, an example of which is SAE C–1137. Other steels include the so-called semiabrasive steels, such as SAE A–4140.

Cutting oils consisting essentially of dimethylbenzyl pentasulfide concentrate, i. e., dimethylbenzyl pentasulfide per se and dilutions thereof, or a blend of the concentrate with a mineral cutting oil base containing dissolved elemental sulfur, are far superior to any known cutting oil on difficult-to-machine ductile steels. However, they are somewhat less satisfactory in the cutting of free-machining ductile steels in that they appear to reduce tool life in cutting operations on such steels. It has been found that a blend of cutting oil containing about 1 to 5% dimethylbenzyl pentasulfide concentrate with lard oil in an appreciable amount, i. e., above about 1%, materially reduces tool wear and cutting operations on these free-machining ductile steels. Thus, for example, a cutting oil consisting essentially of a blend of mineral cutting oil base (sulfurized by dissolving 0.8% elemental sulfur) with 1½% by weight of a 60/40 mixture of dimethylbenzyl pentasulfide and diesel fuel oil and 4% by weight lard oil has been found to be entirely satisfactory in the cutting of free-machining ductile steels as a cutting oil consisting essentially of the same base blended with 3% by weight of the dimethylbenzyl pentasulfide concentrate.

The addition of an appreciable amount of lard oil, preferably from about 2 to 10% by weight, to cutting oils containing dimethylbenzyl pentasulfide is, therefore, extremely advantageous where it is desirable to utilize one cutting oil in a variety of machining operations, including the cutting of both difficult-to-machine ductile steels and free-machining ductile steels. Such cutting oils, containing both dimethylbenzyl pentasulfide and lard oil, are also excellent for use in cutting semiabrasive steels. It is to be understood, therefore, that it is within the scope of the invention to blend with dimethylbenzyl pentasulfide-containing cutting oils varying amounts of lard oil which do materially alter the character of the product.

The advantages and utility of the cutting oil concentrate and cutting oil of this invention, particularly as compared with the properties of cutting oils commercially available and with premium cutting oils will become more apparent from the following detailed description in the examples.

EXAMPLE 1

Part A

27 parts by weight of dimethylbenzyl chloride were admixed with 52 parts by weight of a 40% aqueous solution of sodium tetrasulfide (approximately a 35% excess of the tetrasulfide to insure complete reaction of the chloride) and with 21 parts by weight of a diesel fuel oil having a viscosity of 34 SSU at 100° F. and a flash point of 180° F. The mixture was agitated at 200° F. for from 2 to 4 hours. During the reaction, the refractive index at 25° C. of the organic phase increased from a little below 1.50 to about 1.55 and the density of the organic phase increased from 0.94 to nearly 1.00. The mixture was then cooled and allowed to settle. The lower aqueous phase was separated and the remaining organic phase was treated with one part by volume of 3% aqueous sodium hydroxide solution per 5 parts by volume of organic phase and the mixture was stirred at room temperature for 30 minutes, the caustic then being separated. Thereupon 3% Super Filtrol was added and the mixture stirred for 10 minutes. The mixture was then filtered to yield 94 to 98% of the theoretical yield of dimethylbenzyl polysulfide in the diesel fuel oil.

This intermediate product was 60/40 mixture of dimethylbenzyl polysulfide and diesel fuel oil having a total active sulfur content of 9.4% and containing an average of close to four sulfur atoms per molecule of polysulfide.

Part B

3.08 kilograms of the intermediate product were placed in a 4-litre glass beaker and 154 grams of sulfur were added. The mixture was stirred for 2½ hours at 250° F. The product had a total active sulfur content of 14.1%, indicating that the x in the pentasulfide of the formula $((CH_3)C_6H_3CH_2)_2S_x$ was equal to 4.96.

EXAMPLE 2

A cutting oil base was prepared by adding to Diamond Paraffin oil, an acid-treated lubricating oil stock, having an SSU of 100 at 100° F., 0.8% by weight elemental sulfur, i. e., the maximum amount of sulfur soluble in the oil at 0° C. The mixture was heated and stirred at about 200° F. until all of the sulfur was dissolved. This took approximately 1 to 2 hours. A cutting oil was made by blending with the cutting oil base so prepared 3.2% by weight of the 60/40 dimethylbenzyl pentasulfide-diesel fuel oil concentrate prepared as described in Example 1. This cutting oil was compared for cutting ability in a thread cutting operation with a commercial cutting oil which is a sulfurized mineral oil containing about 3% total sulfur, 1.6% active sulfur, and 4% lard oil. This commercial cutting oil is one of the best oils available on the market for ductile steel machining.

The cutting oil of the invention and the commercial oil were subjected to tests on the same ductile steel forgings in a thread cutting operation. The finish was taken as the criterion of tool life, which was considered at an end when either tearing of the thread flank and crest or chip welding at the root of the chaser land occurred. The results are tabulated in Table I immediately below:

TABLE I

Cutting Oil	Percent 60/40 Concentrate in Oil	Percent Active Sulfur	Average No. of Pieces
Oil containing dimethylbenzyl pentasulfide	3.2	1.22	2,400
Commercial cutting oil		1.6	1,500

These results show that for ductile steel machining, the cutting oil of this invention is far superior to the commercial cutting oil considered particularly desirable for such machining operations.

EXAMPLE 3

A cutting oil, referred to in this example as "Cutting Oil No. 1," prepared by blending, with the Diamond Paraffin oil containing 0.8% by weight dissolved elemental sulfur that is described in Example 2, 3.0% by weight of the 60/40 dimethylbenzyl pentasulfide-diesel fuel oil concentrate prepared as described in Example 1, was compared in field tests with a cutting oil, referred to in this example as "Cutting Oil No. 2," prepared by blending, with the same sulfurized Diamond Paraffin oil, 4.8% by weight of the intermediate product prepared as described in Part A of Example 1 and with the commercial cutting oil described in Example 2. The field tests were carried out on a Browne and Sharpe automatic screw machine with ⅜", C 1010 steel tubing. The average lives of the form tool and cut-off tool, the most perishable tools on the machine, with the different cutting oils were used as a basis for comparison. The results are tabulated in Table II immediately below:

TABLE II

Cutting Oil	Percent 60/40 Concentrate in Oil	Total Percent Active Sulfur	Average Form Tool Life, Hrs.	Average Cutting Tool Life, Hrs.
No. 1	3.0	1.22	11–13	6–7
No. 2	4.8	1.23	11	6.4
Commercial		1.6	3	2

This comparison shows that 3% of the cutting oil concentrate of the invention is equivalent to 4.8% of the cutting oil concentrate prepared as described in Part A of Example 1 and further that cutting oils, prepared by a blending of either of these concentrates in Diamond Paraffin oil in amounts sufficient to give them a total active sulfur constant of about 1.22%, are far superior, in lengthening tool life, to commercial cutting oil having a considerably higher (1.6%) total active sulfur content.

EXAMPLE 4

Three cutting oils were prepared by blending, with the sulfurized Diamond Paraffin cutting oil base described in paragraph 1 of Example 2, 1.5, 3.0 and 4.5%, respectively, of the 60/40 mixture of dimethylbenzyl pentasulfide and diesel fuel oil prepared as described in Example 1. These three cutting oils, therefore, had active sulfur contents of 1.01, 1.22 and 1.42%, respectively.

Three other cutting oils were prepared by blending, likewise with the sulfurized Diamond Paraffin cutting oil base described in the first paragraph of Example 2, with 2.3, 4.6 and 6.9%, respectively, of the 60/40 mixture of dimethylbenzyl polysulfide and diesel fuel oil prepared as described in Part A of Example 1. These other three cutting oils, therefore, also had active sulfur contents of 1.01, 1.22 and 1.42%, respectively.

The six cutting oils so prepared were coded and randomized, and so utilized in tests which involved the threading of pipe in a Toledo pipe threading machine capable of threading ⅛" to 2" pipe, in such a manner that the operators did not know which oil was being tested. The oil was changed every time a new nipple was to be cut and after all the oils had been tested once, a duplicate series of tests was run to eliminate the effects of differences in pipe. After all the nipples were cut, they were given code numbers and then graded by three, and in some instances two, independent graders as to finish. The factors considered in evaluating finish were roughness of the land and groove surfaces, nicks, and evenness of height and depth of lands and grooves, respectively.

Of the forty-four ratings made, 27 favored the nipples cut with the cutting oils containing dimethylbenzyl pentasulfide and 17 favored the nipples threaded with the cutting oils containing the concentrate prepared as described in Part A of Example 1. While this may not be justification for concluding that the finish obtainable with a cutting oil having a given active sulfur content and containing dimethylbenzyl pentasulfide is superior to the finish obtainable with another cutting oil having the same active sulfur content and containing dimethylbenzyl tetrasulfide, because the laws of probability indicate that the 27:17 score would be possible one time in four if the oils were equally good, it is believed to provide substantial justification for concluding that a cutting oil containing a given concentration of dimethylbenzyl pentasulfide is at least equal to one containing one-and-a half times said concentration of dimethylbenzyl polysulfide having an average of four sulfur atoms per molecule.

EXAMPLE 5

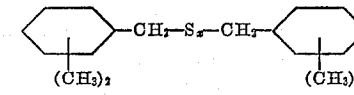
200 grams dimethylbenzyl chloride (1.3 mols), 378 grams 40% sodium tetrasulfide solution (0.88 mol. Na_2S_4), 28 grams elemental sulfur (0.88 mol.), and 89 grams of diesel fuel were heated and stirred at 200° F. for 3 hours. The mixture was then cooled and allowed to settle. The lower aqueous phase was separated and the remaining organic phase was treated with one part by volume of 3% aqueous sodium hydroxide solution to 5 parts by volume of organic phase and the mixture was stirred at room temperature for 30 minutes, the caustic then being separated. Thereupon 3% Super Filtrol was added and the mixture stirred for 10 minutes. The mixture was then filtered to yield 325 grams of a 73/27 mixture of $((CH_3)_2C_6H_3CH_2)_2S_x$ and diesel fuel. 63 grams of diesel fuel was then added to the mixture to raise the concentration of diesel fuel therein to 40%. Tests showed that the active sulfur content of the 60/40 mixture was 12.4%, indicating that the sulfide contained an average of 4.4 sulfur atoms.

The fact that the sulfur content of the sulfide prepared by the method of this example did not equal or more closely approach five sulfur atoms per molecule is apparently due to the fact that the treatment of the organic phase with aqueous sodium hydroxide solution tends to extract a considerably larger proportion of active sulfur than it does in the preparation of the corresponding tetrasulfide. It is apparent, however, that if enough excess elemental sulfur is utilized in the preparation, it may well be possible to prepare by the method of this example, a product in which the number of sulfur atoms per molecule will equal or more closely approach 5.

It is to be understood that many variations and modifications will readily become apparent to those skilled in the art upon reading this description, all such variations and modifications being intended to be included within the scope of this invention as defined in the accompanying claims.

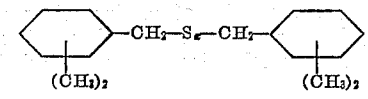
I claim:

1. A cutting oil concentrate consisting essentially of about 60% by weight of a dimethylbenzyl polysulfide having the formula



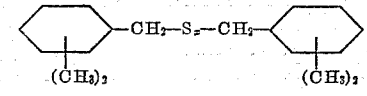
wherein x is within the range from about 4.5 to about 5.5, and 40% by weight of diesel fuel oil.

2. A cutting oil consisting essentially of a mineral hydrocarbon oil base containing up to about 0.8% free sulfur dissolved therein and from about 1 to about 5% by weight of a dimethylbenzyl polysulfide having the formula



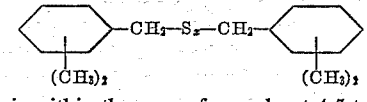
wherein x is within the range from about 4.5 to about 5.5.

3. A cutting oil consisting essentially of a mineral hydrocarbon oil containing up to about 0.8% free sulfur dissolved therein and from about 2 to about 5% by weight of a dimethylbenzyl polysulfide having the formula



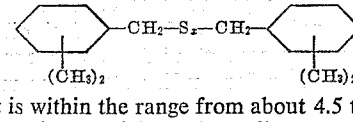
wherein x is within the range from about 4.5 to about 5.5.

4. A cutting oil consisting essentially of a mineral hydrocarbon oil containing up to about 0.8% free sulfur dissolved therein, from about 1 to about 5% by weight of a dimethylbenzyl polysulfide having the formula



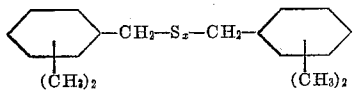
wherein x is within the range from about 4.5 to about 5.5, and above about 1% up to about 10% by weight, of lard oil.

5. A cutting oil consisting essentially of a mineral hydrocarbon oil containing up to about 0.8% free sulfur dissolved therein, at least about 1½% by weight of a dimethylbenzyl polysulfide having the formula



wherein x is within the range from about 4.5 to about 5.5, and about 4% by weight of lard oil.

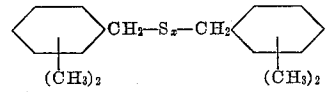
6. A cutting oil consisting essentially of a mineral hydrocarbon oil containing up to about 0.8% free sulfur dissolved therein and having a viscosity at 100° F. between about 75 and 300 SSU and from about 2 to about 5% by weight of a dimethylbenzyl polysulfide having the formula



wherein x is within the range from about 4.5 to about 5.5,

7. A cutting oil concentrate consisting essentially of a solution in an unsulfurized hydrocarbon diluent of at

least about 60% by weight of a dimethylbenzyl polysulfide having the formula



wherein x is within the range from about 4.5 to about 5.5.

References Cited in the file of this patent

UNITED STATES PATENTS

2,185,008	Wojcik	Dec. 26, 1939
2,186,271	Pevere	Jan. 9, 1940
2,273,471	Kimball	Feb. 17, 1942

OTHER REFERENCES

Ephraim: Inorganic Chemistry, fourth edition, 1947, pages 539–40.