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SOLUBLE OIL

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1

The present application, which is a continuation-in-part of my application, Serial No. 579,495, filed February 23, 1945 (now abandoned), relates to improved soluble-oil compositions and, more specifically, to stable soluble oils which, when dispersed in water, form stable emulsions of unusually high load-carrying capacity.

Soluble oils comprise essentially an oil (generally a mineral oil), a small amount of water, and a soap as an emulsifying agent, the aforesaid ingredients being generally employed in rather well-defined proportionate amounts so that, when the soluble oil is incorporated into relatively large proportionate amounts of water, a stable emulsion or dispersion results that is suitable for use as a lubricant and coolant in metal cutting and other machining operations. In addition, such compositions should possess other desirable properties, as for example, they should be neutral or slightly alkaline to prevent undue corrosion of metal parts used in contact therewith and should be relatively non-toxic to the human skin.

In the production of soluble oils known to the art, difficulties have been encountered in obtaining stable compositions having all of the desired properties and characteristics without sacrifice of other advantages, and such difficulties have especially been encountered when attempts are made to incorporate certain components or ingredients into the soluble oils to impart special desired properties thereto. Such difficulties include instability as evidenced by gelling, development of a cloudy appearance, or separation of components, at low temperatures. Instability of the emulsion, as evidenced by formation of a "cuff" or cream, or oil separation upon standing at normal temperatures, occurs in many instances. In general, relatively large amounts of soap are employed in attempts to improve the stability characteristics of such emulsions, but in many instances, the use of such an expedient does not impart the desired stability characteristics to the soluble oils. It has also been proposed to incorporate certain coupling or blending agents into soluble oils to improve the solubility of various components therein but, as far as I am aware, such heretofore proposed compositions require relatively large proportionate amounts of soap, or have other disadvantages.

It has been particularly difficult to obtain satisfactory soluble oils which, when emulsified,

2

possess high film strength. Attempts to incorporate in soluble oils, certain "extreme pressure" agents in amounts sufficient to impart relatively high load-carrying characteristics has heretofore not been entirely successful, mainly because unstable oils and/or unstable emulsions result. Thus, the usefulness of soluble oil emulsions in heavy duty machining operations, such as the high speed cutting of hard alloy steels and other heavy duty metal cutting operations, has been restricted by the limited amounts of extreme pressure agents possible of incorporation into the known soluble oil compositions without destroying the homogeneity of the emulsion.

The main purpose of this invention is to provide a soluble oil composition which is stable and otherwise free of the above-stated objectionable characteristics, both when in emulsified and unemulsified form. Another purpose is to provide a soluble oil composition of satisfactory stability, containing a relatively small proportionate amount of soap; and a related purpose is to provide such a soluble oil of non-acid character. A further purpose of the invention resides in the production or provision of stable soluble oils containing relatively large proportions of extreme pressure agents which are effective and satisfactory for use as lubricants and coolants in heavy duty metal cutting operations when emulsified with water. Still a further purpose is the provision of a soluble oil, containing a relatively large proportionate amount of extreme pressure agents, that is stable in emulsified and unemulsified form while containing a relatively low proportionate amount of soap. A further objective of the invention is to provide a soluble oil containing a relatively large amount of water in stable solution with the remaining constituents thereof, and which is stable over a relatively wide range of water contents. Other purposes and objectives will become apparent as the detailed description of the invention proceeds.

I have found that the more water, within limits, which can be incorporated into soluble oils in stable solutions, the more stable will be the emulsion comprising these soluble oils and additional water as prepared for use. This is especially true as to the tendency of the emulsion to form a cream or cuff. In some oil compositions, increased amounts of water can be incorporated by increasing the soap content, but use of

such an expedient is undesirable as soap is one of the more expensive ingredients.

According to this invention, stable soluble oils, free of the above-stated objections, are produced by incorporating therein a relatively minor proportional amount by weight of each of two or more particular coupling or blending agents in particular proportionate amounts. The soluble oils of this invention, containing such coupling agents, do not gel or otherwise separate when cooled and do not become cloudy or separate when allowed to stand for long periods at low temperatures. A further advantageous feature is that these soluble oils possess comparatively wide water tolerances, by which is meant the range of water contents within which they are stable. This is important from a manufacturing standpoint in permitting considerably less exactitude in preparing the formula than is the case of soluble oils having lower water tolerances. Another feature of this invention is that by use of two particular types of coupling or blending agents in combination, highly stable soluble oils are provided that contain relatively large amounts of extreme pressure agents and maintain stability in emulsified or unemulsified form with relatively low soap concentration. Hence, by use of the two coupling or blending agents in combination in a manner more fully described hereinafter, soluble oils are provided that have a high water content, greater water tolerance, and generally improved stability both in emulsified and unemulsified form without necessitating use of relatively large proportionate amounts of soap; and of considerable importance is the fact that these results can be obtained in soluble oils containing high proportions of extreme pressure agents.

In accordance with this invention, the composite coupling or blending agent employed comprises as one component, certain polyhydroxy alcohols, as for example, ethylene glycol or diethylene glycol and as another component, alcohol-ethers such as monoalkyl or aryl ethers of polyhydroxy alcohols, as for example, ethylene glycol monobutyl ether, monoethyl ether of diethylene glycol, monophenyl ether of ethylene glycol, and the like.

The following example will serve to illustrate the invention in one specific embodiment comprising an extreme pressure or high load-carrying, soluble oil containing sulfurized sperm oil as the extreme pressure agent. The ingredient shown as "soap solution," as used herein and including the following examples, comprises about 60% of the water-soluble sodium salts of mahogany acids derived from petroleum, about 5% of water, and the balance mineral oil. The ingredients are shown in formula amounts, soaps being formed by action of the sodium hydroxide with the wood fatty acids prior to blending with the remaining constituents. Proportions are by weight:

Composition A	Per Cent
Mineral Oil (100 S. U. S. at 100° F.)	53.0
Sulfurized Sperm Oil (non-corrosive)	25.0
"Soap Solution"	13.5
Wood fatty acids	2.15
NaOH (50 Bé.)	1.05
Diethylene glycol	1.14
Ethylene glycol monobutyl ether	2.18
Water	1.98
	100.00

The foregoing composition is of alkaline nature and will not gel or cloud when held at 40° F. for 16 hours. The total water content of the foregoing extreme pressure agent-containing soluble oil is about 3% and its water tolerance is about 1%. As explained earlier herein, water tolerance is the variation in water content which is permissible without affecting stability. Obtainment of a soluble oil of this character, having water tolerance as high as 1%, represents a substantial improvement in ease of manufacture over certain heretofore known soluble oils of this type which generally have substantially lower tolerances, for example, 0.1 to 0.3%, and which require exercise of very great care in their preparation. Of additional and considerable importance, is that the foregoing composition, containing 25% of the extreme pressure agent, is stable in emulsified and unemulsified form even though the soap content is only about 11%, i. e., markedly less than the total concentration of the extreme pressure agent.

The proportions of the various ingredients of the above-exemplified composition may be varied somewhat. However, it has been found that for obtainment of both satisfactory water tolerance and stability as regards the soluble oil and stability of its emulsion, the ratio by weight of the alcohol-ether agent to the polyhydroxy alcohol should be at least one to one. Use of an amount of ethylene glycol monobutyl ether substantially less than the amount of diethylene glycol in oils containing certain special ingredients, particularly extreme pressure agents, results in soluble oils which do not form stable emulsions when mixed with the required amounts of water and which give rise to manufacturing difficulties because of their low water tolerance. On the other hand, higher ratios of these coupling agents are satisfactory, ratios up to about five to one or somewhat higher giving good results in these respects. Preferably, the dihydroxy alcohol coupling agent component should be present in the soluble oil in amounts corresponding to over about 0.3% by weight of diethylene glycol. Amounts of this material ranging up to about 2% have been found to give satisfactory results. While greater amounts of this agent may be useful, for example, up to about 3% such as in certain instances when an exceedingly high concentration of extreme pressure agent is employed, satisfactory results are obtained with better economy at the lower proportions indicated.

In order to further illustrate the invention, the following Table I sets forth several soluble oil compositions that were prepared by blending, in the proportions set forth, a mineral oil, sulfurized sperm oil as an extreme pressure agent, and a concentrate having the following composition, the ratio of the polyhydroxy alcohol to alcohol-ether being 1 to 2.31:

Concentrate	Per Cent by Weight
"Soap solution"	64.6
Wood fatty acids	5.2
NaOH (50 Bé.)	3.0
Diethylene glycol	5.5
Ethylene glycol monobutyl ether	12.7
Water	9.0
	100.0

Table I

Soluble Oil Composition, Per Cent by Weight			Per Cent by weight of Soap in Soluble Oil Composition	Ratio of Sulfurized Sperm Oil:Soap	Emulsion Characteristic (10% soluble oil composition in water)
Mineral Oil (100 SUS at 100° F.)	Sulfurized Sperm Oil	Concentrate			
55	25	20	9.3	2.7:1	Good.
57	25	18	8.4	3:1	Do.
60	25	15	7.0	3.6:1	Slight oil Separation.
64	20	16	7.5	2.7:1	Good.
67	20	13	6.1	3.3:1	Do.
68	20	12	5.6	3.6:1	Slight oil Separation.
65	15	20	9.3	1.6:1	Good.
67	15	18	8.4	1.9:1	Do.
70	15	15	7.0	2.1:1	Do.
72	15	13	6.1	2.5:1	Do.
74	15	11	5.1	3:1	Slight oil Separation.
75	10	15	7.0	1.4:1	Good.
78	10	12	5.6	1.8:1	Do.
80	10	10	4.7	2.1:1	Slight oil Separation.
80	5	15	7.0	0.7:1	Good.
85	5	10	4.7	0.9:1	Oil Separation.

As is evident from the data in the foregoing table, highly stable soluble oils are set forth that contain a relatively high proportionate amount of extreme pressure agent, i. e., from 10 to 25%, and in each case, the soluble oils containing such high proportionate amounts of sulfurized sperm oil were stable in emulsified as well as unemulsified form while having soap concentrations considerably less than the total concentration of extreme pressure agent. Thus, as shown, when the concentration of sulfurized sperm oil was 25%, a stable soluble oil was obtained by using a soap concentration down to about 7.0%, when using 20% of the extreme pressure agent, a soap concentration down to about 5.6% could be satisfactorily used; with a total concentration of 15% of extreme pressure agent, stability of the soluble oil was maintained by using a soap concentration down to about 5.1%; and with 10% of extreme pressure agent, stability was maintained with a soap concentration down to as low as about 4.7%.

Whereas the foregoing table sets forth soluble oils, as embodied herein, containing sulfurized sperm oil as the extreme pressure agent, the following Table II sets forth compositions similar thereto except that instead of sulfurized sperm oil, the extreme pressure agent was a commercially available phosphorus-containing extreme pressure agent known as "Ortholeum 153" understood to be comprised predominantly of tricresyl phosphate. As is shown by the data in Table II, the results obtained by the use of the phosphorus-containing extreme pressure were substantially similar to those set forth in Table I wherein sulfurized sperm oil was employed:

Table II

Soluble Oil Composition, Per Cent by Weight			Per Cent by Weight of Soap in Soluble Oil Composition	Ratio of Extreme Pressure Agent:Soap	Emulsion Characteristics (10% Soluble Oil Composition in Water)
Mineral Oil (100 SUS at 100° F.)	Phosphorus-containing extreme pressure agent	Concentrate			
60	20	20	9.3	2.2:1	Good.
64	20	16	7.5	2.7:1	Do.
65	20	15	7.0	2.9:1	Do.
66	20	14	6.5	3.1:1	Slight oil Separation.
74	10	16	7.5	1.3:1	Good.
76	10	14	6.5	1.5:1	Do.
78	10	12	5.6	1.8:1	Slight oil Separation.
80	5	15	7.0	0.7:1	Good.
83	5	12	5.6	0.9:1	Slight Cuff.
85	5	10	4.7	1.1:1	Oil Separation.

In addition to the soluble oils set forth in the foregoing tables, compositions were prepared that contained, instead of sulfurized sperm oil or the phosphorus-containing extreme pressure agent, a commercially available chlorine-containing extreme pressure agent known as "Angamol 35" having a chlorine content of 24% and understood to contain chlorinated hydrocarbons. As shown in Table III, use of the chlorine-containing extreme pressure agent gave results substantially similar to those obtained by use of the extreme pressure agents in the compositions of Tables I and II.

Table III

Soluble Oil Compositions, Per Cent by Weight			Per Cent by Weight of Soap in Soluble Oil Composition	Ratio of Extreme Pressure Agent:Soap	Emulsion Characteristics (10% Soluble Oil in Water)
Mineral Oil (100 SUS at 100° F.)	Chlorine-containing extreme pressure agent	Concentrate			
62	20	18	8.4	2.4:1	Good.
65	20	15	7.0	2.8:1	Do.
68	20	12	5.6	3.6:1	Slight Oil Separation.
74	10	15	7.0	1.4:1	Good.
78	10	12	5.6	1.8:1	Slight Cuff.
80	5	15	7.0	0.7:1	Good.
82.5	5	12.5	5.8	0.9:1	Oil Separation.
85	5	10	4.7	1.1:1	Do.

In the compositions set forth hereinbefore, illustrating specific embodiments of this invention, the stable soluble oils contained a predominating amount of mineral oil comprising the sum of the added mineral oil (100 S. U. S. at 100° F.) plus the mineral oil (about 35%) present in the "soap solution" of the concentrate. In each case wherein the soluble oil contained at least 10% of extreme pressure agent, irrespective of whether the extreme pressure agent was a sulfur-, phosphorus-, or chlorine-containing compound, the soluble oil had good emulsion characteristics at soap concentrations markedly less than the concentration of extreme pressure agent. Similarly, satisfactory results are obtained, in accordance with this invention, by use of higher concentrations of extreme pressure agents than set forth in the foregoing tables. The following example is illustrative of this aspect of the invention:

Example

A composition was prepared comprising 50% by weight of sulfurized sperm oil and 50% of the concentrate described hereinbefore. Hence, the blend had the following formula based on a breakdown of the "soap solution" into its constituents, i. e., mineral oil, sodium salts of mahogany acids, and water.

Sulfurized sperm oil	50.00
Sodium salts of mahogany acids	19.38
Mineral oil	11.31
Wood fatty acids	2.60
NaOH (50 Bé.)	1.50
Diethylene glycol	2.75
Ethylene glycol monobutyl ether	6.35
Water	6.11
	100.00

The foregoing composition, containing more than twice as much extreme pressure agent as the total concentration of soap, and only 11.31% of mineral oil (i. e., about one-fifth as much mineral oil as the extreme pressure agent) was highly stable both in emulsified and unemulsified form, the attainment of such stability in the high extreme pressure agent-containing, low soap-containing soluble oil being due to the use in combination of the alcohol-ether and polyhydroxy alcohol in the manner disclosed according to this invention. Moreover, it is within the scope of this invention to prepare novel soluble oils, as embodied herein, by incorporating into a suitable mineral oil a concentrate such as set forth in the foregoing example but which is substantially, or wholly, devoid of mineral oil. In illustration thereof, such a concentrate may comprise an extreme pressure agent, a water-soluble soap that is substantially devoid of mineral oil, a polyhydroxyl alcohol such as diethylene glycol and an alcohol-ether such as ethylene glycol monobutyl ether, the ether being present in an amount of from about one to five times that of the polyhydroxy alcohol and the polyhydroxy alcohol being present in an amount whereby a soluble oil, prepared by use of said concentrate, will have a concentration of the polyhydroxy alcohol of from about 0.3 to 3%, the total amount of soap present in the concentrate being less than the amount of extreme pressure agent but in an amount sufficient so that when the concentrate is blended with a mineral oil, a stable composition is obtained. In illustration of such concentrations in the concentrate, the polyhydroxy alcohol and the alcohol-ether in the concentrate may for example, be 2.75 and 6.35% respectively, as shown in the example.

Referring to the soluble oil compositions set forth hereinbefore in illustration of the present invention, and particularly to the compositions in Tables I to III inclusive, it is evident that in each case wherein the soluble oil contained at least 10% of extreme pressure agents, the soluble oils were highly stable with soap concentrations markedly less than the concentration of extreme pressure agent. However, when only 5% of extreme pressure agent was present in the soluble oil, emulsion stability resulted when the concentration of soap was at least substantially equal to the concentration of extreme pressure agent. For example, using 5% of sulfurized sperm oil and 7.0% of soap, good emulsion characteristics were obtained, whereas use of 4.7% of soap resulted in oil separation in the emulsion. Similarly, using 5% of the phosphorus-containing extreme pressure agent, and 7% of soap, good emulsion characteristics were obtained, whereas 4.7% of soap resulted in poor emulsion characteristics. In the examples using 5% of the chlorine-containing extreme pressure agent, 7% of soap gave good results whereas 4.7% of soap resulted in unstable emulsion characteristics. Hence, with respect to the aspect of this invention relating to the preparation of highly stable soluble oils containing a concentration of soap lower than the concentration of extreme pressure agent, the invention relates particularly to such soluble oils that contain more than 5% of an extreme pressure agent, and more particularly, that contain at least 10% of extreme pressure agent, as use of such relatively high concentrations of extreme pressure agents are not only made permissible by use of the aforesaid combination of an alcohol-ether and polyhydroxy alcohol providing a high load-carrying soluble oil, but with such concentrations of extreme

pressure agents, the amount of soap used to maintain emulsion stability may be markedly less than the total concentration of extreme pressure agent.

As aforesaid, in practicing the present invention, essential use is made of a combination of an alcohol-ether and a polyhydroxy alcohol in the stated proportionate amounts in order to provide the novel and advantageous results embodied herein. Whereas it has been shown by the data set forth hereinbefore, that by practicing this invention, high load-carrying soluble oils are provided that contain a concentration of soap lower than that of the extreme pressure agent, similar results are not obtained when, for example, in accordance with certain prior art teachings, the two agents are not employed in combination in a manner disclosed herein. In illustration thereof, the following composition was prepared and tested for emulsion characteristics:

	Per cent by weight
Mineral oil (100 S. U. S. at 100° F.)	72.70
Sulfurized lard oil	10.00
Soap solution:	
Sodium salts of mahogany acids	7.02
Mineral oil	4.09
Diethylene glycol	1.30
Rosin	2.75
Caustic soda	0.50
Water	1.64
	100.00

The foregoing composition containing diethylene glycol (but devoid of an alcohol-ether), 10% of sulfurized lard oil, and a total of about 10% soap, when emulsified with 90% by volume of water, immediately formed a cuff with oil separation evidencing emulsion instability. Hence, whereas by practicing the present invention, soluble oils containing 10% of extreme pressure agent are stable with concentrations of soap markedly less than 10%, as for example, down to about 5.6%, and, in some cases, even down to 4.7% of soap, compositions similar thereto, but devoid of the alcohol-ether, do not exhibit such stability when, as aforeshown, the amount by weight of soap employed is substantially equal to the amount of extreme pressure agent.

As an illustration of the load-carrying effectiveness of the extreme pressure soluble oil compositions of this invention, an emulsion of the composition hereinbefore set forth as composition A was tested on a Falex Tester. This device, which is a well known lubricant testing machine, comprises a steel pin rotatable between two non-rotatable steel jaws carrying V-shaped bearing surfaces, and means for clamping the rotating pin between the bearing surfaces with adjustable force. In conducting the test, the oil emulsion under observation was kept in contact with the revolving pin while the latter was clamped between the bearings with steadily increasing force applied to the jaws. The amount of force, as indicated on the load-gauge of the machine, required to cause seizure between pin and bearings represents failure of the oil by this test.

The following tabulated data indicate the comparative load-carrying capacities of the soluble oil of this invention and certain other soluble oils. In each case, the compositions tested consisted of 10% by volume of soluble oil and 90% by volume of water. Loads were applied gradually during the test while rotating the pin at a constant speed. The torque recorded represents Falex Tester gauge reading and indicates the lubricating effectiveness of the oils at various loads.

Test Oil	Load (*Pounds-Gauge*)	Torque (*Pound-Inches Gauge*)	Results
Composition A of this invention.	700	19	
	1,500	29	Load limit of machine.
	3,000	44	No oil failure.
	4,500	62	
Oil B	700	12	
	1,200	45	Oil Failure.
Oil C	700	18	
	1,500	48	Do.
	1,600	52	
Oil D	700	28	
	1,200	46	Do.
	1,300	52	
Oil E	500	20	
	700	29	Do.
	700	11	
Oil F	1,000	18	
	1,200	27	Do.

Test oil B was prepared from a soluble oil containing a mineral oil, about 9% of soap as an emulsifying agent, water and diethylene glycol as a coupling agent, but no extreme pressure agent and no alcohol-ether. Test oil C was of similar composition to oil B, but contained about 5% of sulfurized sperm oil, which was approximately the maximum amount which could be incorporated in the absence of the two coupling agents of this invention to obtain a stable emulsion. Test oils D to F, inclusive, were commercially available soluble oils containing mineral oil emulsified with soaps but devoid of extreme pressure additives.

From the tabulated test data, it is obvious that the soluble oil composition of this invention is markedly superior in load-carrying capacity as compared with other soluble oils tested. In addition, it should be noted that, at corresponding loads, the soluble oils of this invention offer relatively low frictional resistance, as evidenced by the respective torque readings in the tabulated data of this and the other oils tested.

As is apparent from the foregoing description, the invention is not limited to use of the specific type of extreme pressure agent set forth in the illustrative examples included herein, as evidenced by the fact that when using relatively high proportionate amounts of a sulfur-containing, phosphorus-containing, or chlorine-containing extreme pressure agent, highly stable soluble oils were prepared using concentrations of soap markedly less than the concentration of the extreme pressure agent. Hence, when soluble oil emulsions of high load-carrying capacity are the objective, other known extreme pressure agents may be substituted for those specifically disclosed in practicing this invention, as for example, elemental sulfur either in corrosive or non-corrosive form, sulfur chloride-treated fatty acids, and the like.

The use of rosin or other materials normally tending to impart acidic character is unnecessary in the present invention. The soluble oils of the invention can be made neutral or alkaline without affecting stability, with correspondingly less tendency to corrode metals with which they come into contact in use and better tolerance when emulsified in hard water. Likewise, the mineral oil component may be varied, one of the important features being that all or part of this component may be mineral oil derived from highly paraffinic base crudes. Paraffinic oils, particularly of Pennsylvania crudes, heretofore have

been considered difficult to incorporate in soluble oils without affecting stability.

Although the present invention has been described in conjunction with certain preferred embodiments thereof, those skilled in the art will readily recognize that variation and modifications can be made. Such modifications and variations are to be considered to be within the purview of the specification and scope of the appended claims.

I claim:

1. A stable soluble oil composition comprising a mineral oil, about 5 to about 50% based on the weight of said composition of an extreme pressure agent from the group consisting of sulfur-containing, phosphorus-containing and chlorine-containing extreme pressure agents for said mineral oil, a water-soluble soap as an emulsifying agent, water in an amount sufficient to inhibit said composition against gelation but less than an amount sufficient to induce separation of said composition, about 0.3 to about 3% of a poly-hydroxy alcohol and an amount of an alcohol-ether of from about one to about five times that of the poly-hydroxy alcohol, the total amount of soap being less than the amount of extreme pressure agent but sufficient to stabilize the composition against separation.

2. A stable soluble oil composition comprising a mineral oil, about 5 to about 50% based on the weight of said composition of an oil-soluble extreme pressure agent from the group consisting of sulfur-containing, phosphorus-containing, and chlorine-containing compounds, a water-soluble soap as an emulsifying agent, water in an amount sufficient to inhibit said composition against gelation but less than an amount sufficient to induce separation of said composition, about 0.3 to about 3% of an ethylene glycol and an amount of a glycol ether of from about one to about five times that of the ethylene glycol, the total amount of soap being less than the amount of extreme pressure agent but sufficient to stabilize the composition against separation.

3. A stable soluble oil composition comprising a mineral oil, from about 10% and up to about 50% based on the weight of said composition of an extreme pressure agent from the group consisting of sulfur-containing, phosphorus-containing and chlorine-containing extreme pressure agents for said mineral oil, water in an amount sufficient to inhibit said composition against gelation but less than an amount sufficient to induce separation of said composition, a water-soluble soap as an emulsifying agent, and a coupling agent consisting essentially of from about 0.3 to about 3% of an ethylene glycol and an amount of a glycol ether of from about one to about five times that of the ethylene glycol, the total amount of soap being present in an amount sufficient to stabilize the stated composition against separation but less than that required to stabilize the stated composition against separation in the absence of the said coupling agent.

4. A stable soluble oil composition comprising a mineral oil, from about 5 to about 50% based on the weight of said composition of an extreme pressure agent from the group consisting of sulfur-containing, phosphorus-containing, and chlorine-containing extreme pressure agents for said mineral oil, a water soluble soap as an emulsifying agent, water in an amount sufficient to inhibit said composition against gelation but less than an amount sufficient to induce separation of said composition, and a coupling agent comprising from about 0.3 to about 3% of diethylene glycol and an amount of ethylene glycol monobutyl ether of from about one to about five times that of the ethylene glycol, the total amount of soap being less than the amount of extreme pressure agent but sufficient to stabilize the composition against separation.

5. A stable soluble oil composition comprising a mineral oil having incorporated therein more than about 5% and up to about 50% by weight of an extreme pressure agent from the group consisting of sulfur-containing, phosphorus-containing and chlorine-containing extreme pressure agents for said oil, a water-soluble soap as an emulsifying agent, water in an amount sufficient to inhibit said composition against gelation but less than an amount sufficient to induce separation of said composition, and a coupling agent comprising from about 0.3 to about 2% of an ethylene glycol and an amount of a glycol ether of from about one to about five times that of the ethylene glycol, the total amount of soap being less than the amount of extreme pressure agent but sufficient to stabilize the composition against separation.

6. A stable soluble oil composition comprising a mineral oil having incorporated therein about 25 to about 30% by weight of a sulfur-containing extreme pressure agent, about 12% of a water-soluble soap as an emulsifying agent, water in an amount sufficient to inhibit said composition against gelation but less than an amount sufficient to induce separation of said composition, about 1% of an ethylene glycol, and about 2% of a glycol ether.

7. A concentrate, adapted for use in a mineral oil to form a stable soluble oil composition, which comprises more than about 5% and up to about 50% by weight of an oil-soluble extreme pressure agent from the group consisting of chlorine-containing, phosphorus-containing and sulfur-containing extreme pressure agents, a water-soluble soap, water in an amount sufficient to inhibit gelation but less than an amount sufficient to induce separation of said concentrate upon solution thereof in a mineral oil, about 0.3% to about 3% of a polyhydroxy alcohol, and an alcohol-ether in an amount of from about one to about five times that of the polyhydroxy alcohol, the total amount of soap in said concentrate being less than the amount of extreme pressure agent but in an amount sufficient to provide a stable solution by blending said concentrate with a mineral oil in proportions resulting in a mineral oil composition containing more than about 5% of said extreme pressure agent.

8. A concentrate, suitable for use in a mineral oil to form a stable soluble oil composition, which comprises more than about 5% and up to about 50% by weight of an extreme pressure agent from the group consisting of sulfur-containing, phosphorus-containing, and chlorine-containing extreme pressure agents for mineral oils, a water-soluble soap, water in an amount sufficient to inhibit gelation but less than an amount sufficient to induce separation of said concentrate upon solution thereof in a mineral oil, about 0.3 to about 3% of an ethylene glycol and an amount of a glycol ether of from about one to about five times that of the ethylene glycol, the total amount of soap in said concentrate being less than the amount of extreme pressure agent but in an amount sufficient to provide a stable solution by blending said concentrate with a mineral oil in proportions resulting in a mineral

oil composition containing more than about 5% of said extreme pressure agent.

9. A composition, as defined in claim 1, wherein the extreme pressure agent is sulfurized sperm oil.

10. A composition, as defined in claim 1, wherein the extreme pressure agent is sulfurized sperm oil and the polyhydroxy alcohol is an ethylene glycol.

11. A composition, as defined in claim 1, wherein the alcohol ether is ethylene glycol monobutyl ether.

12. A composition, as defined in claim 1, wherein the extreme pressure agent is present in an amount of about 10 to about 25% based on the weight of said composition.

13. A composition, as defined in claim 1, wherein the soap is a metal salt of petroleum mahogany acids.

14. A composition, as defined in claim 13, wherein the soap is a sodium salt of petroleum mahogany acids.

STANLEY P. WAUGH.

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