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(54) Title: FOOD GRADE LUBRICANT COMPOSITIONS

(57) Abstract: Novel non-aqueous water-soluble food grade lubricant compositions comprising: (a) a polyalkylene glycol having molecular weight greater than 1,500; and (b) a polyethylene glycol having molecular weight of from about 200 to about 600; wherein said lubricating composition has viscosity of about 32 to about 150 cSt at 40°C. The novel non-aqueous water-soluble food grade lubricant compositions are particularly useful in food processing and packaging equipment applications where low viscosity food grade lubricants with low pour points are desired, and in applications where there is a need for equipment and spill cleanup. These food grade lubricant compositions are also environmentally friendly due to their water solubility, rapid biodegradability, and low aquatic toxicity.



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FOOD GRADE LUBRICANT COMPOSITIONS

Background of the Invention

The present invention relates to lubricant compositions and, more specifically, to polyglycol based anhydrous food grade lubricant compositions. The food grade lubricant compositions of the present invention are particularly useful as hydraulic oils, gear oils, and compressor oils for equipment used in the food processing and packaging industry.

The food grade lubricants are considered to be "indirect food additives" used in equipment in food processing and packaging plants where the lubricant compositions may accidentally get in contact with the food being processed. Food grade lubricants are specially blended compositions comprising base fluids and functional additives in the past cleared by the U.S. Food and Drug Administration (FDA) and approved by U.S. Department of Agriculture (USDA) as H-1 lubricants. The H-1 lubricants were regulated in 21 C.F.R. §178 (at 178.3570), 21 C.F.R. §1.72 and 21 C.F.R. §1.82. Today, the lubricant manufacturers and food and beverage processors are themselves responsible to use only lubricants that are generally recognized as safe for use in equipment used for producing, manufacturing, packing, processing, preparing, treating, transporting or holding food since the FDA and USDA are no longer responsible for the assessment and registration of food grade lubricants.

In addition to meeting the food safety requirements, the food grade lubricant compositions must also be effective lubricants. They should lubricate food processing and packaging equipment parts, resist viscosity change, resist oxidation, protect against rust and corrosion, and provide wear protection. The lubricating compositions should also perform effectively under various lubrication conditions ranging from hydrodynamic thick film conditions to boundary thin film conditions.

In general, the food grade lubricant compositions are formulated from at least one base fluid and at least one food grade functional additive employed for its known use. The base fluid can be either a mineral oil or a blend of mineral oils, or a synthetic fluid. Medicinal white oil, corn oil, palm oil, and cottonseed oil are some of the mineral oils that are known to be suitable for use in food grade lubricants.

Polyalphaolefins (PAO), polyalkylene glycols (PAG), and polyethylene glycols (PEG) are synthetic fluids that are known to be suitable for use in food grade lubricants. The synthetic fluids offer superior oil life, load carrying and anti-wear performance and perform well at high and low temperatures. Various known functional additives that are generally recognized as safe for use in food grade lubricants may be added to the base fluid for their known uses.

The 21 C.F.R. §178.3570 regulation allows for polyalkylene glycols (PAG's) of medium and high viscosity to be used for food grade lubricant applications. That is, PAG's having molecular weight greater than 1500 can be used. Low molecular weight PAG's (those having molecular weight less than 1500) cannot be used since they are not recognized by the 21 C.F.R. §178.3570 regulation as being safe for use for food grade lubricant applications.

Low viscosity food grade lubricants can be formulated using polyethylene glycols (PEG's). However, PEG's have a major disadvantage in that they have high pour points. A specific shortcoming of this type of product is the relatively high pour point, (about -9 °C), which can lead to solidification in equipment when the equipment is shut down at low ambient temperatures. When this occurs, the equipment cannot be restarted until the fluid is heated externally. This limits their use as a base fluid for formulating lubricants. Although PEG's are not listed on the 21 C.F.R. §178.3570 regulation, they are generally recognized as safe for use in food and are listed on 21 C.F.R. 178.3910 regulation.

Various types of synthetic food grade lubricants have been described in the literature and used commercially. Examples include water based food grade lubricant containing polyalkylene glycols (PAG's) having molecular weight greater than 1500, polyethylene glycols (PEG's), or polyalphaolefins (PAO) and various additives.

U.S. Patent Application Publication No. US 2002/0115573 A1 (Hei et al) discloses a food grade aqueous lubricating oil for use in conveyor processing of foods (that is, for lubricating the interface between the surface of a can or bottle food container and moving conveyor). The lubricants typically comprise edible oil and can also contain a variety of other functional additives. The lubricant can also contain an

(EO)_x(PO)_y(EO)_z surfactant block copolymer where EO represents ethylene oxide residue, PO represents a propylene oxide residue, and each x, y and z is an integer of about 2 to about 100.

George B. Kelly and George W. Buttrick, Tappi (1970), 53(10), pp. 1900-1904,
5 disclose that polyethylene glycols, methyl ether of polyethylene glycols and random copolymers of ethylene oxide and propylene oxide are each effective lubricants for paper coatings containing starch and starch-latex binder system.

Polish Patent Nos. 149,256 and 154,393 disclose a fire resistant hydraulic-
lubricating fluid comprising diethylene glycol or propylene glycol, an ethylene
10 oxide/propylene oxide polymer, and a major portion of water.

Japanese Patent No. JP 62/121,793 (Daiichi Kogyo Seiyaku Co., Ltd.) discloses
a heat-resistant water-based hydraulic fluid containing (a) water, (b) glycerin-ethylene
oxide-propylene oxide copolymer (MW = 40,000; propylene oxide = 60 wt%), and (c)
propylene glycol-ethylene oxide-propylene oxide copolymer (MW = 600; ethylene
15 oxide = 50 wt%).

U.S. Patent No. 6,087,308 (Butler et al) discloses a food grade lubricating oil
which contains a major amount of a food grade natural or synthetic base oil in
combination with a minor amount of food grade additives including a thickener, an
antioxidant, a rust inhibitor, an anti-wear additive, an antifoam, and a coupling agent.
20 Synthetic base oils disclosed are food grade polyalphaolefins.

U.S. Patent No. 5,538,654 (Lawate et al) discloses a food grade lubricant
comprising (a) a major amount of a genetically modified vegetable oil or synthetic
triglyceride oil, and (b) a minor amount of a performance additive.

U.S. 4,062,785 (Nibert) discloses a non-aqueous food grade lubricant
25 comprising a major amount of a mineral oil and a minor amount of a fatty amide.

We have discovered new non-aqueous food grade lubricant compositions that
overcome the disadvantages of the known food grade lubricants. We have discovered
that the blend of PAG's and PEG's surprisingly provide a lubricant composition with
good lubricity, low viscosity and a pour point of about -22 °C. This lower pour point, ,

which gives a greatly increased margin of protection, is achieved with surprisingly low amounts of ethylene oxide-propylene oxide copolymer to PEG. In addition, good biodegradability and low aquatic toxicity of these new food-grade lubricant compositions makes them very attractive for use in machinery for food processing and packaging applications where environmental friendliness is important. These new non-aqueous food grade lubricant compositions are water-soluble and as such they can be used in any application requiring a water-soluble machine lubricant.

Summary of the Invention

In one aspect the present invention concerns a non-aqueous water-soluble food grade lubricant composition comprising:

- (a) a polyalkylene glycol having molecular weight greater than 1,500, preferably from about 1500 to about 20,000 more preferably from about 1500 to about 4000;
- (b) a polyethylene glycol having molecular weight of from about 200 to about 600, preferably from about 200 to about 400, most preferably from about 200 to about 300; and, optionally,
- (c) at least one functional food grade additive;

and wherein said lubricant composition has viscosity of from about 32 to about 150, preferably from about 32 to about 100, most preferably from about 32 to about 68, cSt at 40 °C,

In another aspect, the present invention concerns a method of lubricating surfaces of the machinery used for processing or packaging food which method comprises the step of applying to the surfaces of the food processing or packaging machinery a non-aqueous water-soluble food grade lubricant composition comprising:

- (a) a polyalkylene glycol having molecular weight greater than 1,500, preferably from about 1500 to about 20000; more preferably from about 1500 to about 4000;

(b) a polyethylene glycol having molecular weight of from about 200 to about 600, preferably from about 200 to about 400, most preferably from about 200 to about 300; and, optionally,

(c) at least one functional food grade additive;

5 and wherein said lubricant composition has viscosity of about 32 to about 150, preferably from about 32 to about 100, most preferably from about 32 to about 68, cSt at 40 °C.

Detailed Description of the Invention

The non-aqueous water-soluble food grade lubricant compositions of the present
10 invention exhibit low viscosities and surprisingly have low pour points. Moreover, due to their water solubility, relatively low toxicity, and good biodegradability they are particularly suitable for use in applications where environmental friendliness is important. The fact that the lubricant compositions of the present invention are non-aqueous means that these fluids are resistant to the performance problems associated
15 with water-containing food grade lubricant compositions such as corrosion, wear and high temperature limitations. Since they are water-soluble, the lubricant composition can also be used in any application requiring a water-soluble machine lubricant.

The non-aqueous water-soluble food grade lubricant compositions of the present invention are conveniently formulated by blending in at least one polyalkylene glycol
20 having molecular weight greater than 1,500, preferably from about 1500 to about 20000, more preferably from about 1500 to about 4000, and at least one polyethylene glycol having molecular weight of from about 200 to about 600, preferably from about 200 to about 400, preferably from about 200 to about 300. The non-aqueous water-soluble food grade lubricant composition of the present invention has viscosity of about
25 32 to about 150, preferably from about 32 to about 100, most preferably from about 32 to about 68, cSt at 40 °C.

If desired, at least one functional food grade additive that is listed as an H-1 additive in 21 C.F.R. §178 (at 178.3570) by USDA or is generally recognized as safe

for use in food grade lubricants can also be blended in the non-aqueous food grade lubricant composition of the present invention.

The blending of the components of the non-aqueous food grade lubricant composition of the present invention is done in conventional blending equipment.

5 The polyalkylene glycols (PAG's) having molecular weight greater than 1,500, component (a), useful in the practice of the present invention are well known in the art and many methods of preparing these compounds are available. Examples of useful PAG's include, but are not limited to, butanol initiated ethylene oxide/propylene oxide(EO/PO) random copolymers having the EO/PO ratio of 1:1, such as Synalox™
10 50-100B, a butanol initiated EO/PO random copolymer having molecular weight of 1700, and Ucon™ 50-HB-660, a butanol initiated EO/PO random copolymer having molecular weight of 1700; diol initiated EO/PO random copolymers having EO content of from about 25 to about 75 per cent by weight, such as, for example, Synalox™ 40 D 100, a diol initiated random EO/PO copolymer having molecular weight of 1700, and
15 Synalox™ 40 D 150, a diol initiated random EO/PO copolymer having molecular weight of 1900; and n-butanol initiated PO homopolymers such as Synalox™ 100-85B, a butanol initiated PO homopolymer having molecular weight of 1750; Synalox™ 100-120B, a butanol initiated PO homopolymer having molecular weight of 2300; Synalox™ 100-150B, a butanol initiated PO homopolymer having molecular weight of
20 2600; Ucon™ LB-625, a butanol initiated PO homopolymer having molecular weight of 1550; Ucon™ LB-1145, a butanol initiated PO homopolymer having molecular weight of 2100; and Ucon™ LB-1715, a butanol initiated PO homopolymer having molecular weight of 2500. The Synalox™ products are available from The Dow Chemical Company and the Ucon™ products are available from Union Carbide
25 Corporation. Typically, the polyalkylene glycol is used in an amount of from about 2 to about 80, preferably from about 5 to about 80, most preferably from about 10 to about 30, percent by weight, based on the total weight of the lubricant composition. A relatively small amount of polyalkylene glycol added to polyethylene glycol can have a significant effect on pour point and freeze point without a large increase in viscosity of
30 the lubricant.

The polyethylene glycols (PEG's) having molecular weight of from about 200 to about 600, component (b), useful in the practice of the present invention are well known in the art and many methods of preparing these compounds are available. Examples of useful PEG's include, but are not limited to, Carbowax Sentry™ 200, a polyethylene glycol having molecular weight of 200; Carbowax Sentry™ 300, a polyethylene glycol having molecular weight of 300; and Carbowax Sentry™ 400, a polyethylene glycol having molecular weight of 400, each available from Union Carbide Corporation. Typically, polyethylene glycol is used in an amount of from about 20 to about 98, preferably from about 20 to about 95, most preferably from about 70 to about 90, percent by weight, based on the total weight of the lubricant composition. Use of a larger amount of the lower molecular weight polyethylene glycol gives a less viscous lubricant.

Various functional food grade additives useful for use in food grade lubricating compositions that are listed as H-1 additives in 21 C.F.R. §178 (at 178.3570) by USDA or are generally recognized as safe for use in food grade lubricants may also be formulated into the non-aqueous water-soluble food grade lubricant composition of the present invention. Such known additives include, but are not limited to, food grade lubricity additives (such as boundary agents, anti-wear agents and extreme pressure agents), food grade corrosion inhibitors, food grade metal passivators, food grade antioxidants, and food grade anti-foaming agents.

Each of the aforementioned additives is used in an amount typical for use of such additive in hydraulic fluids. This amount will vary with the additive used and a person of an ordinary skill in the art would know which additive and what amount of the additive to use depending on the application for which the anhydrous hydraulic fluid composition of the present invention is used.

When used, the food grade lubricity and anti-wear additives are typically used in an amount of from about 0 to about 0.6, percent by weight based on the total weight of the non-aqueous water-soluble food grade lubricant composition.

Examples of anti-wear additives include, but are not limited to, various oil soluble sulfur and/or phosphorous containing materials and fatty acids and their ester,

amine and other derivatives which are known to reduce friction. Thus, sulfur and/or phosphorous containing materials such as triphenyl phosphothionate, alkylphenyl phosphoric acid esters and their amine derivatives, zinc di(alkyl dithiophosphate), zinc di(thiocarbamate) and methylene bis(dithiocarbamate) are useful as anti-wear additives.

5 Examples of lubricity additives include, but are not limited to, fatty acids, and other mono- and dicarboxylic acids, and their amides and amine salts; dithiophosphates, organic amine/phosphate blends (such as Irgalube 349, sold by Ciba Specialty Chemicals Corporation), organo-molybdenum compounds; phosphorothionates; alkylated phosphate esters; triphenyl phosphates; alkylated triphenyl phosphates; and
10 fatty amines (such as Amine-O and Sarkosyl-O, sold by Ciba Specialty Chemicals Corporation)

 When used, the corrosion inhibitors are typically used in an amount of from about 0 to about 0.5, percent by weight based on the total weight of the non-aqueous food grade lubricant composition. Food grade corrosion inhibitors include various
15 ionic and non-ionic surface active agents.

 Examples of ionic corrosion inhibitors include phosphoric acid, mono- and di-hexyl esters, compounds with tetramethyl nonyl amines and C₁₀ to C₁₈ alkyl amines, and also C₁ to C₁₀ alkylated phosphates and phosphites. Examples of ionic corrosion inhibitors include, but are not limited to, phosphoric acid, mono- and di-hexyl esters,
20 compounds with tetramethyl nonyl amines and C₁₀ to C₁₈ alkyl amines, and also C₁ to C₁₀ alkylated phosphates and phosphites. Irgalube 349, an amine phosphate corrosion inhibitor (available from Ciba Specialty Chemicals), is a typical ionic corrosion inhibitor approved for food grade lubricants.

 Examples of non-ionic corrosion inhibitors include food grade fatty acids and
25 their esters. Thus, esters of sorbitan, glycerol, other polyhydric alcohols or polyalkylene glycols may be used. Food grade esters from fatty alcohols alkoxylated with alkylene oxides, or sorbitan alkoxylated with alkylene oxides, or sorbitan ester alkoxylated with alkylene oxides are additional useful examples. Various derivatives of succinic acid or succinic anhydride, formed by reaction with fatty acids and or amines,
30 are also useful corrosion inhibitors. Non-limiting examples of these materials include

sorbitan mono-oleate, ethoxylated vegetable oil, ethoxylated fatty acids, ethoxylated fatty alcohols, fatty glyceride esters, polyoxy ethylene sorbitan mono-oleate, polyoxyethylene sorbitan, glycerol mono oleate, glycerol di oleate, glycerol mono stearate, glycerol di stearate. Span 80 (sorbitan mono-oleate) is a typical non-ionic
5 corrosion inhibitor approved for food grade lubricants.

When used, the metal passivators are typically used in an amount of from about 0 to about 0.1, percent by weight based on the total weight of the non-aqueous food grade lubricant composition of the present invention. Examples of metal passivators include, but are not limited to, various indoles, pyrazoles, imidazoles, thiazoles,
10 triazoles, benzotriazoles, thiadiazoles, dithiophosphates, and dithiocarbamates. Non-limiting examples of these additives include N,N-bis(2-ethylhexyl)-4-methyl-1H-benzotriazole-1-methanamine, N,N-dialkyl derivatives of N-methylamino triazoles and benzotriazoles, 2-mercaptobenzothiazole, 2,5-dimercapto- 1,3,4-thiadiazole derivatives, and NN'-dicalicylidene-1,2-propanediamine. Irgamet 39, a copper passivator,
15 (available from Ciba Specialty Chemicals), is a typical non-ionic corrosion inhibitor approved for food grade lubricants

When used, the antioxidants are typically used in an amount of from about 0 to about 0.6, percent by weight based on the total weight of the non-aqueous food grade lubricant composition. Examples of the antioxidants include, but are not limited to,
20 disodium decanedioate, hexamethylenebis(3,5-ditert-butyl-4-hydroxyhydrocinnamate), phenyl- α -naphthylamine, N-phenylbenzenamine, reaction products of tert-alkyl and primary amines with mono- and diisooctyl esters of phosphoric acid, phenothiazine, propyl gallate, 2,6-di-tert-butyl-4-methylphenol (or butylated hydroxytoluene (BHT), vitamin E, hindered phenolic antioxidants (such as Irgalube L-64, available from Ciba
25 Specialty Chemicals), amine containing antioxidants, and phosphites.

Non-aqueous water-soluble food grade lubricant compositions of the present invention can also be used in non food processing and packaging industrial and commercial applications where low viscosity lubricants with low pour points and good biodegradability or low aquatic toxicity would be advantageous to use.

Non-aqueous water-soluble food grade lubricant compositions of the present invention not only exhibit unexpected low viscosity and pour point properties, but they also exhibit good biodegradability and low aquatic toxicity.

5 All parts, percentages and ratios herein are by weight unless otherwise indicated.

The invention will be further clarified by a consideration of the following examples which are intended to be purely exemplary of the present invention.

The following components are employed in the examples.

Carbowax SentryTM 300 is a polyethylene glycol having molecular weight of
10 300, available from The Dow Chemical Company;

SynaloxTM 40 D 100 is a diol initiated random EO/PO copolymer having molecular weight of 1,700, an EO content of 60 % and a PO content of 40 %, available from The Dow Chemical Company;

15 SynaloxTM 40 D 150 is a diol initiated random EO/PO copolymer having molecular weight of 1900, an EO content of 60 % and a PO content of 40 %, available from The Dow Chemical Company;

Irgalube L64 is an antioxidant which is a mixture of aminic and high molecular weight phenolic anti-oxidants, available from Ciba Specialty Chemicals;

20 Irgalube 349 is a corrosion inhibitor which is liquid mixture of amine phosphates, available from Ciba Specialty Chemicals;

Irgamet 39 is a liquid metal passivator which is tolyltriazole derivative, available from Ciba Specialty Chemicals;

L57 is Irganox L57, an amine containing antioxidant available from Ciba Specialty Chemicals;

25 PANA is phenyl-alphanaphylamine, available from Bayer Crop Science; and Sarkosyl O is N-oleyl sarcosine available from Ciba Specialty Chemicals.

Example 1 to Example 5 and Comparative Example C1

The non-aqueous water-soluble lubricant compositions were formulated by blending the components in a glass beaker with mechanical stirring device. Blending speed and time were not critical, as the components were readily miscible. The order of addition of the components was not important. The components and the weight percentage of each component in the formulated non-aqueous water-soluble lubricant composition are given in Table 1 below.

Table 1

Composition	C1*	Example1	Example2	Example 3	Example 4	Example 5
E-300	100%	95%	90%	85%	75%	50%
40D150	0%	5%	10%	15%	25%	50%
<u>Physical Properties:</u>						
Freeze point	-12C	-26C	-27C	-31C	-30C	-35C
Frozen Solid	Not recorded	-55C	-57C	-61C	-59C*	-60C*
Pour Point	-11C	-19C	-19C	-22C	-22C	-26C

- *not an Example of the present invention

- E-300 is Carbowax SentryTM300

- 40D150 is SynaloxTM 40 D 150

As can be seen from the data provided in Table 1, each of the compositions of Examples 1 to 5 exhibit unexpectedly lower pour and freeze points than the composition of Comparative Example C1; the relationship between wt % SynaloxTM 40D150 and pour point or freeze point depression was not linear. In particular, when the SynaloxTM 40D150 was added at a 5 % level, the pour point was depressed to the same extent as when 10% of the SynaloxTM 40D150 was used.

Example 6 to Example 11

The non-aqueous water-soluble lubricant compositions were formulated by blending first the base stock components Carbowax Sentry™ 300 and Synalox™ 40 D 150 in a glass beaker with mechanical stirring device and then adding various additives to the blend at 60 °C with stirring for one hour. The order of addition of the additives was not important. The components, the additives and the weight percentage of each component and additive in the formulated non-aqueous water-soluble lubricant composition are given in Table 2 below.

Table 2

Composition	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11
E-300	79.0%	79.4%	79.1%	79.5%	78.3%	78.3%
40D100	19.8%	19.9%	19.8%	19.9%	19.5%	19.6%
PANA					1.0%	1.0%
Irgalube L64	0.6%	0.6%			0.6%	
Irganox L57			0.5%	0.5%		0.5%
Irgalube 349	0.5%		0.5%		0.5%	0.5%
Sarkosyl O						
Irgamet 39	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
500 hours:						
pH	7.4	7.7	5.0	8.8	4.8	4.6
TAN	0.2	0.13	0.44	0.15	0.57	0.62
1000 hours:						
pH	6.2	7.8	5.4	8.6	5.3	4.5
TAN	0.31	0.17	0.49	0.42	0.52	0.60
1770 hours:						
pH	5.8	6.5	5.3	7.1	5.2	4.6
TAN	0.51	0.37	0.84	0.98	0.82	0.96
2780 hours:						
pH	6.2	6.5	5.1	7.0	5.4	4.7
TAN	0.34	0.33	3.37	0.77	2.28	1.06
3780 hours:						
pH	6.0	6.5		6.8		
TAN	0.45	0.48		0.99		

- E-300 is Carbowax Sentry™300
- 40D100 is Synalox™ 40 D 100
- TAN is the Total Acid Number of the lubricant, measured in units of mgKOH/g

As can be seen from data given in Table 2 above, each of the compositions of Examples 7 to Example 11 is still acceptable for use after 1770 hours in a static air oxidation test at 120 °C. The static air oxidation test is performed by inserting 1 inch square coupons of copper, aluminum, and steel into a 100 ml beaker. Each beaker is filled with 90 grams of the selected fluid and the beakers are placed in a forced air oven at 120 °C for the duration of the test. Aliquots of sample are removed periodically for determination of pH and TAN, to verify satisfactory fluid condition. Suitability of the lubricant composition is determined by measurement of pH greater than 5.0 and TAN less than 1.0 mgKOH/g. Table 2 clearly demonstrates that each of the compositions of Examples 6 to 11 meets these requirements.

The non-aqueous water-soluble compositions of the present invention are particularly useful in food processing and packaging equipment applications where low viscosity food grade lubricants with low pour points are desired, and in applications where there is a need for equipment and spill cleanup.

Other embodiments of the invention will be apparent to those skilled in the art from a consideration of this specification or practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with the true scope and spirit of the invention being indicated by the following claims.

WE CLAIM:

1. A non-aqueous water-soluble food grade lubricant composition comprising:
 - (a) a polyalkylene glycol having molecular weight greater than 1,500; and
 - 5 (b) a polyethylene glycol having molecular weight of from about 200 to about 600;wherein said lubricating composition has viscosity of about 32 to about 150 cSt at 40 °C.
- 10 2. The non-aqueous water-soluble food grade lubricant composition according to Claim 1, wherein said lubricating composition has viscosity of about 32 to about 100 cSt at 40 °C.
3. The non-aqueous water-soluble food grade lubricant composition according to Claim 1 wherein said lubricating composition has viscosity of about 32 to about 68 cSt at 40 °C.
- 15 4. The non-aqueous water-soluble food grade lubricant composition according to Claim 1, Claim 2, or Claim 3, wherein the polyalkylene glycol, component (a), has molecular weight from about 1500 to about 20,000.
5. The non-aqueous water-soluble food grade lubricant composition according to Claim 1, Claim 2, or Claim 3, wherein the polyalkylene glycol, component (a), has
20 molecular weight from about 1500 to about 4000
6. The non-aqueous water-soluble food grade lubricant composition according to Claim 1, Claim 2, or Claim 3, wherein the polyethylene glycol, component (b), has molecular weight from about 200 to about 400.
7. The non-aqueous water-soluble food grade lubricant composition according to
25 Claim 1, Claim 2, or Claim 3, wherein the polyethylene glycol, component (b), has molecular weight from about 200 to about 300.

8. The non-aqueous water-soluble food grade lubricant composition according to Claim 7 wherein the polyalkylene glycol is present in an amount of from about 2 to about 80 percent by weight, based on the total weight of the lubricant composition.
9. The non-aqueous water-soluble food grade lubricant composition according to
5 Claim 8 wherein the polyalkylene glycol is present in an amount of from about 10 to about 30 percent by weight, based on the total weight of the lubricant composition.
10. The non-aqueous water-soluble food grade lubricant composition according to Claims 1 further comprising at least one functional food grade additive.
11. The non-aqueous water-soluble food grade lubricant composition according to
10 Claims 10 wherein said at least one functional food grade additive is selected from the group consisting of a food grade lubricity additive, a food grade corrosion inhibitor, a food grade metal passivator, a food grade antioxidant, and a food grade anti-foam agent.

INTERNATIONAL SEARCH REPORT

Inter I Application No
PC1/US2005/023563

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C10M169/04 C10M107/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C10M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 398 (C-538), 21 October 1988 (1988-10-21) & JP 63 142098 A (KAWASAKI HEAVY IND LTD; others: 01), 14 June 1988 (1988-06-14) abstract; examples 1-3	1-11
Y	US 2 425 755 A (ROBERTS FREDERICK H ET AL) 19 August 1947 (1947-08-19) column 10, line 51 - column 11, line 42; table D	1-11
Y	US 2 425 845 A (TOUSSAINT WALTER J ET AL) 19 August 1947 (1947-08-19) table C	1-11
Y	US 2 499 551 A (WHITE CHESTER M) 7 March 1950 (1950-03-07) the whole document	1-11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International Application No
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