United States Patent Application Publication	20250263621
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	RITTIG; Frank

ALKOXYLATED ALCOHOLS FOR INCREASING THE BREAKDOWN VOLTAGE OF A LUBRICANT

Abstract

The present invention relates a lubricant comprising a base stock selected from hydrocarbons, 50 to 1000 ppm water, and an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides. The invention also relates to a method for lubricating a mechanical device in an electric vehicle comprising the step of contacting the lubricant with the mechanical device; to a use of the alkoxylated alcohol for increasing the breakdown voltage of a lubricant comprising the basestock selected from the hydrocarbons; and to a use of the alkoxylated alcohol in a lubricant comprising the base stock selected from the hydrocarbons for reducing the electric discharge machining.

Inventors:	**RITTIG; Frank (Ludwigshafen am Rhein, DE)**
Applicant:	**BASF SE** (Ludwigshafen am Rhein, DE)
Family ID:	**1000008617080**
Appl. No.:	**18/858352**
Filed (or PCT Filed):	**April 11, 2023**
PCT No.:	**PCT/EP2023/059402**

Foreign Application Priority Data

EP	22169383.1	Apr. 22, 2022
EP	22205789.5	Nov. 07, 2022

Publication Classification

Int. Cl.: **C10M145/36** (20060101); **C10M109/00** (20060101); **C10M125/14** (20060101); **C10M169/04** (20060101); **C10N40/00** (20060101); **C10N40/16** (20060101)

U.S. Cl.:

CPC **C10M145/36** (20130101); **C10M109/00** (20130101); **C10M125/14** (20130101); **C10M169/04** (20130101); C10M2201/02 (20130101); C10N2040/16 (20130101); C10N2040/292 (20250501)

Background/Summary

[0001] The present invention relates a lubricant comprising a base stock selected from hydrocarbons, 50 to 1000 ppm water, and an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides. The invention also relates to a method for lubricating a mechanical device in an electric vehicle comprising the step of contacting the lubricant with the mechanical device; to a use of the alkoxylated alcohol for increasing the breakdown voltage of a lubricant comprising the basestock selected from the hydrocarbons; and to a use of the alkoxylated alcohol in a lubricant comprising the base stock selected from the hydrocarbons for reducing the electric discharge machining; and to a lubricant comprising a base stock selected from hydrocarbons which are selected from API Groups I, II, or III base stocks, 50 to 1000 ppm water, and an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides, and where the alcohol is a diol selected from C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol and polytetrahydrofurane.
[0002] The unintended flow of electric current (sometimes also called parasitic currents) in rolling bearings can damage the mechanical components and the lubricant. Typically bearing current events are in the form of arcing discharge current pulses which occur due to capacitive discharge breakdown of the lubricant. Such events are also known as electric discharge machining (EDM). As a result the lubricants get burned or the bearings are worn off.
[0003] In automotive industry frequency inverters are used to control variable speed inverter-fed electric motors and generators, and they may cause damage to the rolling bearings as a result of bearing currents. Typical observations include current-related damages, crater formation in the bearing raceway, the fluting across the raceway, and the oxidation of the lubricant in the contact zone between the rolling element and raceway
[0004] To avoid these problems the construction of bearings or rotating shafts was optimized:
[0005] WO 2022/005935 suggested a grounding brush assembly to mitigate electric current in a rotating shaft in the presence of a viscous medium.
[0006] WO 2013/090997 suggested an earth assembly for an electric motor.
[0007] US2004/0056543 suggested an electromechanical device where a voltage reducing member is secured to a rotatable member.
[0008] The influence of lubricants on parasitic currents was also investigated:
[0009] Bechev et al. “Characterization of electrical lubricant properties for modelling of electrical drive systems with rolling bearings” Bearing World Journal, 2018 (3), 93-106 investigated electrical lubricant properties relevant for parasitic bearing currents.
[0010] Gonda et al. “The Influence of Lubricant Conductivity on Bearing Currents in the Case of Rolling Bearing Greases” Lubricants, 2019 (7), 108-121, investigated the harmful currents in rolling bearings.

Description

[0011] Objects of the present invention was to provide a lubricant to overcome the above problems.
[0012] The objects was solved by a method for lubricating a mechanical device in an electric vehicle comprising the step of contacting the lubricant with the mechanical device, where the lubricant comprises [0013] a base stock selected from hydrocarbons, [0014] 50 to 1000 ppm water, and [0015] an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides.
[0016] The objects was solved by a lubricant comprising [0017] base stock selected from hydrocarbons, [0018] 100 to 1000 ppm water, and [0019] an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides.
[0020] The objects was solved by a lubricant comprising [0021] a base stock selected from hydrocarbons which are selected from API Groups I, II, or III base stocks, [0022] 50 to 1000 ppm water, and [0023] an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides, and where the alcohol is a diol selected from C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol and polytetrahydrofurane.
[0024] The lubricant is usually a substance capable of reducing friction between surfaces (preferably metal surfaces), such as surfaces of mechanical devices. A mechanical device may be a mechanism consisting of a device that works on mechanical principles. The lubricant is usually a lubricating liquid, lubricating oil or lubricating grease.
[0025] The lubricant can be used for various applications such as light, medium and heavy duty engine oils, industrial engine oils, marine engine oils, automotive engine oils, crankshaft oils, compressor oils, refrigerator oils, hydrocarbon compressor oils, very low-temperature lubricating oils and fats, high temperature lubricating oils and fats, wire rope lubricants, textile machine oils, refrigerator oils, aviation and aerospace lubricants, aviation turbine oils, transmission oils, gas turbine oils, spindle oils, spin oils, traction fluids, transmission oils, plastic transmission oils, passenger car transmission oils, truck transmission oils, industrial transmission oils, industrial gear oils, insulating oils, instrument oils, brake fluids, transmission liquids, shock absorber oils, heat distribution medium oils, transformer oils, fats, chain oils, minimum quantity lubricants for metalworking operations, oil to the warm and cold working, oil for water-based metalworking liquids, oil for neat oil metalworking fluids, oil for semi-synthetic metalworking fluids, oil for synthetic metalworking fluids, drilling detergents for the soil exploration, hydraulic oils, in biodegradable lubricants or lubricating greases or waxes, chain saw oils, release agents, molding fluids, gun, pistol and rifle lubricants or watch lubricants and food grade approved lubricants.
[0026] The lubricant comprises usually at least 50, 60, 70, 80 or 90 wt % of the base stock. The lubricant comprises usually up to 80, 90, 95, or 99 wt % of the base stock. The lubricant comprises usually 50-99, 50-95, 60-90 or 70-80 wt % of the base stock.
[0027] The base stock is selected from hydrocarbons. Suitable hydrocarbons are usually mixtures of higher alkanes from a mineral source (e.g. mineral oils), particularly a distillate of petroleum, or from synthetic sources (e.g. polyalphaolefins or GTL oils). Hydrocarbons can be naphthenic, paraffinic or aromatic in chemical structure. In industrial use a base stock normally contains a chemical composition which contains some proportion of all three oils (paraffinic, naphthenic and aromatic).
[0028] Naphthenic hydrocarbons are made up of methylene groups arranged in ring formation with paraffinic side chains attached to the rings. The pour point is generally lower than the pour point for paraffinic oils.
[0029] Paraffinic hydrocarbons comprise saturated, straight chain or branched hydrocarbons. The straight chain paraffins of high molecular weight raise the pour point of oils and are often removed by dewaxing.
[0030] Aromatic hydrocarbons are hydrocarbons of closed carbon rings of a semi-unsaturated character and may have attached side chains. This oil is more easily degraded than paraffinic and

naphthalenic oils leading to corrosive by-products

[0031] In another form the hydrocarbons are GTL (gas-to-liquid) oils, which may be synthesized using the Fischer-Tropsch method of converting natural gas to liquid fuel. The GTL oils may be produced as follows: In the first stage a synthesis gas (a mixture of hydrogen and carbon monoxide) is manufactured from natural gas by partial oxidation. In the second stage the synthesis gas is converted into liquid hydrocarbons using a catalyst. The final stage is cracking and isomerisation, which “tailors” the molecule chains into products with desired properties.

[0032] These GTL oils correspond to API Group 3 base oils, and Shell XHVI is an example of a commercial product.

[0033] Preferably, the hydrocarbon is selected from API Groups I, II, III or IV base stocks, or mixtures thereof. In particular, the hydrocarbon is selected from API Groups I, II, or III base stocks, or mixtures thereof. In another particular form, the hydrocarbon is selected from API Group II base stocks.

[0034] The definitions for the base stocks can be found in the American Petroleum Institute (API) publication “Engine Oil Licensing and Certification System”, Industry Services Department, Fourteenth Edition, December 1996, Addendum 1, December 1998. Said publication categorizes base oils as follows: [0035] a) Group I base oils contain less than 90 percent saturates (ASTM D 2007) and/or greater than 0.03 percent sulfur (ASTM D 2622) and have a viscosity index (ASTM D 2270) greater than or equal to 80 and less than 120. [0036] b) Group II base oils contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120. [0037] c) Group 111 base oils contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 120. [0038] d) Group IV base oils contain polyalphaolefins. Polyalphaolefins (PAO) include known PAO materials which typically comprise relatively low molecular weight hydrogenated polymers or oligomers of alphaolefins which include but are not limited to C2 to about C32 alphaolefins with the C8 to about C16 alphaolefins, such as 1-octene, 1-decene, 1-dodecene and the like being preferred. The preferred polyalphaolefins are poly-1-octene, poly-1-decene, and poly-1-dodecene. [0039] e) Group V base oils contain any base oils not described by Groups I to IV. Examples of Group V base oils include alkyl naphthalenes, alkylene oxide polymers, silicone oils, and phosphate esters.

[0040] The lubricant is usually free of a API Group V base stock. In another form the lubricant is comprises up to 20, 10, 5, or 1 wt % of an API Group V base stock.

[0041] In another form the lubricant is usually free of a API Group IV and V base stocks. In another form the lubricant is comprises up to 20, 10, 5, or 1 wt % of an API Group IV and V base stocks.

[0042] The base stock has usually a breakdown voltage of up to 1000, 500, 250, 150 or 100 Volt. The base stock has usually a breakdown voltage of at least 1, 3, 5, 10, or 20 Volt. The base stock has usually a breakdown voltage in the range of 1-1000 Volt, or 5-500 Volt, or 10-150 Volt. The breakdown voltage of the base stock is usually determined at a water concentration of below 5 ppm, in particular at 0 ppm.

[0043] The breakdown voltage of the base stock may be determined prior its use in the lubricant according to DIN EN 60156 (“Insulating liquids—Determination of the breakdown voltage at power frequency—Test method”).

[0044] The lubricant comprises 50 to 1000 ppm, or 100 to 1000 ppm, or 150 to 900 ppm or 200 to 800 ppm, or 200 to 600 ppm water.

[0045] The water content can be determined by the Karl Fischer method (DIN 51777/1/ASTM D 1744). The water content may be determined at 20° C.

[0046] The water is usually present in dissolved form in the lubricant.

[0047] The water in the lubricant may results from water traces in the base stock, in the lubricant additives or in the alkoxylated alcohol, or from the humidity in the air.

[0048] The water content in the lubricant can be adjusted for example by the use of desiccant breathers, which can be to attach to equipment (e.g. oil reservoir, oil drum). When the humid air gets through the breathers, the moisture in the air is then absorbed by a hygroscopic agent (e.g. a bed of silica gel). The water content in the lubricant may be adjusted by applying a vacuum to the lubricant, or by exluding air or water prior or during mixing of the components of the lubricant.
[0049] The lubricant comprises an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides.
[0050] The alcohol can be a monoalcohol, diol, or polyols with three or more hydroxy groups.
[0051] In one form the alcohol is a monoalcohol selected from C.sub.1-C.sub.22 monoalcohols, which may be linear or branched, such as linear or branched C.sub.1-C.sub.22 alkanols or C.sub.4-C.sub.18 alkanols. Examples for monoalcohols are methanol, ethanol, propanol, butanol, pentanol, hexanol, neopentanol, isobutanol, decanol, 2-ethylhexanol, and higher acyclic alcohols derived from both natural and petrochemical sources with from 11 to 22 carbon atoms.
[0052] In another form the alcohol is a diol selected from C.sub.2-C.sub.12 diol (e.g. C.sub.2-C.sub.5 alkandiols or C.sub.2-C.sub.5 alkandiol), polyethylene glycol, polypropylene glycol and polytetrahydrofuran. Preferably, the alcohol is a diol selected from C.sub.2-C.sub.12 diol and polytetrahydrofuran. Examples for C.sub.2-C.sub.12 diols are monoethylene glycol, monopropylene glycol, butylene glycol, diethylene glycol or dipropylene glycol. In another form the alcohol is polytetrahydrofuran, which may have 2 to 30, 3 to 20, 5 to 20 or 6 to 16 repeating units. In another form the alcohol is polyethylene glycol or a polypropylene glycol, which may have 2 to 30, 3 to 20, 5 to 20 or 6 to 16 repeating units. In particular, the alcohol is a diol selected from C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol and polytetrahydrofurane.
[0053] In another form the alcohol is a polyol with three or more hydroxy groups selected from selected from C.sub.3-C.sub.12 polyols, such as neopentyl glycol, trimethyolpropane and pentaerythritiol.
[0054] The alcohol is preferably a C.sub.1-C.sub.22 monoalcohol, C.sub.2-C.sub.12 diol, polytetrahydrofurane, or C.sub.3-C.sub.12 polyol.
[0055] In another preferred form the alcohol is a C.sub.1-C.sub.22 alkanol, C.sub.2-C.sub.5 alkandiol or polytetrahydrofuran with 3 to 20 repeating units.
[0056] In another preferred form the alcohol is a C.sub.4-C.sub.18 alkanol, C.sub.2-C.sub.6 alkandiol or polytetrahydrofuran with 5 to 20 repeating units.
[0057] The hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides, preferably C.sub.4-C.sub.12 epoxides, such as butylene oxide, pentylene oxide, hexylene oxide, heptylene oxide, 1,2-epoxyoctane; 1,2-epoxynonane, 1,2-epoxydecane; 1,2-epoxyundecane, 1,2-epoxydodecane (also called dodecyl oxide), 1,2-epoxytridecane, 1,2-epoxytetradecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane; 1,2-epoxyheptadecane, 1,2-epoxyoctadecane, or mixtures thereof.
[0058] Preferably, the hydrophobic epoxide is selected from butylene oxide, dodecyl oxide, or a mixture thereof.
[0059] In another preferred form the hydrophobic epoxide is selected from dodecyl oxide. In another preferred form the hydrophobic epoxide is selected from butylene oxide.
[0060] The alcohol can be alkoxylated with the hydrophobic epoxide and optionally in addition with propylene oxide.
[0061] Preferably, the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and optionally in addition with propylene oxide.
[0062] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and in addition with propylene oxide.
[0063] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide, and in addition with propylene oxide.
[0064] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from dodecyl oxide, and in addition with propylene oxide.

[0065] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and optionally in addition with propylene oxide, and the alcohol is a C.sub.1-C.sub.22 monoalcohol, C.sub.2-C.sub.12 diol, polytetrahydrofurane, or C.sub.3-C.sub.12 polyol.
[0066] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and optionally in addition with propylene oxide, and the alcohol is a diol selected from C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol and polytetrahydrofurane.
[0067] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and in addition with propylene oxide, and the alcohol is a C.sub.1-C.sub.22 monoalcohol, C.sub.2-C.sub.12 diol, polytetrahydrofurane, or C.sub.3-C.sub.12 polyol.
[0068] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide, and in addition with propylene oxide, and the alcohol is a C.sub.1-C.sub.22 monoalcohol, C.sub.2-C.sub.12 diol, polytetrahydrofurane, or C.sub.3-C.sub.12 polyol.
[0069] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from dodecyl oxide, and in addition with propylene oxide, and the alcohol is a C.sub.1-C.sub.22 monoalcohol, C.sub.2-C.sub.12 diol, polytetrahydrofurane, or C.sub.3-C.sub.12 polyol.
[0070] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from dodecyl oxide, and in addition with propylene oxide, and the alcohol is a diol selected from C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol and polytetrahydrofurane.
[0071] The propylene oxide may be present up to 90, 80, 70, 65, 60, or 55 wt % based on the total amount of hydrophobic epoxide and propylene oxide. The propylene oxide may be present up to 85, 75, 70, or 65 mol % based on the total amount of hydrophobic epoxide and propylene oxide.S Preferably, the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and optionally in addition with propylene oxide, where the propylene oxide may be present up to 90, 80, 70, 65, 60, or 55 wt % based on the total amount of hydrophobic epoxide and propylene oxide.
[0072] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and optionally in addition with propylene oxide, where the propylene oxide may be present up to 85, 75, 70, or 65 mol % based on the total amount of hydrophobic epoxide and propylene oxide.
[0073] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and in addition with propylene oxide, where the propylene oxide is present up to 90, 80, 70, 65, 60, or 55 wt % based on the total amount of hydrophobic epoxide and propylene oxide.
[0074] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide and dodecyloxide, and in addition with propylene oxide, where the propylene oxide is present up to 85, 75, 70, or 65 mol % based on the total amount of hydrophobic epoxide and propylene oxide.
[0075] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from butylene oxide, and in addition with propylene oxide, where the propylene oxide is present up to 90, 80, 70, 65, 60, or 55 wt % based on the total amount of hydrophobic epoxide and propylene oxide.
[0076] In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from dodecyl oxide, and in addition with propylene oxide, where the propylene oxide is present up to 85, 75, 70, or 65 mol % based on the total amount of hydrophobic epoxide and propylene oxide. In another preferred form the alcohol is alkoxylated with the hydrophobic epoxide selected from dodecyl oxide, and in addition with propylene oxide, where the propylene oxide is present up to 85, 75, 70, or 65 mol % based on the total amount of hydrophobic epoxide and propylene oxide.

[0077] In one form of the alkoxylated alcohol the alcohol is a C.sub.1-C.sub.22 alkanol, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide, and additionally with propylene oxide.

[0078] In another form of the alkoxylated alcohol the alcohol is a C.sub.6-C.sub.18 alkanol, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide, and additionally with propylene oxide, and the weight ratio of butylene oxide to propylene oxide is from 4:1 to 1:4, preferably 2:1 to 1:2.

[0079] In another form of the alkoxylated alcohol the alcohol is a C.sub.8-C.sub.14 alkanol, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide, and additionally with propylene oxide, and the weight ratio of butylene oxide to propylene oxide is from 4:1 to 1:4, preferably 2:1 to 1:2, and the molecular weight of the alkoxylated alcohol is from 300 to 5000 g/mol.

[0080] In another form of the alkoxylated alcohol the alcohol is a C.sub.12 alkanol, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide, and additionally with propylene oxide, and the weight ratio of butylene oxide to propylene oxide is from 3:1 to 1:3, preferably 1.5:1 to 1:1.5, and the molecular weight of the alkoxylated alcohol is from 500 to 3000 g/mol.

[0081] In one form of the alkoxylated alcohol the alcohol is C.sub.2-C.sub.5 alkandiols, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide.

[0082] In another form of the alkoxylated alcohol the alcohol is C.sub.2-C.sub.4 alkandiols, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide, and the molecular weight of the alkoxylated alcohol is from 500 to 10,000 g/mol.

[0083] In another form of the alkoxylated alcohol the alcohol is C.sub.2-C.sub.3 alkandiols, which is alkoxylated with a hydrophobic epoxide selected from butylene oxide, and the molecular weight of the alkoxylated alcohol is from 1,000 to 8,000 g/mol.

[0084] The alkoxylated alcohol is preferably an alkoxylated polytetrahydrofuran. In a preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00001## [0085] wherein [0086] m is an integer in the range of ≥1 to ≤50, [0087] m′ is an integer in the range of ≥1 to ≤50, [0088] (m+m′) is an integer in the range of ≥1 to ≤90, [0089] n is an integer in the range of ≥0 to ≤75, [0090] n′ is an integer in the range of ≥0 to ≤75, [0091] p is an integer in the range of ≥0 to ≤75, [0092] p′ is an integer in the range of ≥0 to ≤75, [0093] k is an integer in the range of ≥2 to ≤30, [0094] R.sup.1 denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms, [0095] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0096] R.sup.3 identical or different, denotes a hydrogen atom or —CH.sub.3, [0097] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure.

[0098] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00002## [0099] wherein [0100] m is an integer in the range of ≥1 to ≤30, [0101] m′ is an integer in the range of ≥1 to ≤30, [0102] (m+m′) is an integer in the range of ≥2 to ≤60, [0103] n is an integer in the range of ≥0 to ≤45, [0104] n′ is an integer in the range of ≥0 to ≤45, [0105] (n+n′) is an integer in the range of ≥0 to ≤80, [0106] p is an integer in the range of ≥0 to ≤25, [0107] p′ is an integer in the range of ≥0 to ≤25, [0108] (p+p′) is an integer in the range of ≥0 to ≤30, [0109] k is an integer in the range of ≥2 to ≤30, [0110] R.sup.1 denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms, [0111] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0112] R.sup.3 identical or different, denotes a hydrogen atom or —CH.sub.3, [0113] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure.

[0114] Preferably the alkoxylated polytetrahydrofurane has a kinematic viscosity in the range of ≥200 mm.sup.2/s to ≤700 mm.sup.2/s, more preferably in the range of ≥250 mm.sup.2/s to ≤650 mm.sup.2/s, at 40° C., determined according to ASTM D 445.
[0115] Preferably the alkoxylated polytetrahydrofurane has a kinematic viscosity in the range of ≥25 mm.sup.2/s to ≤90 mm.sup.2/s, more preferably in the range of ≥30 mm.sup.2/s to ≤80 mm.sup.2/s, at 100° C., determined according to ASTM D 445.
[0116] Preferably the alkoxylated polytetrahydrofurane has a pour point in the range of ≥−60° C. to ≤20° C., more preferably in the range of ≥−50° C. to ≤15° C., determined according to DIN ISO 3016.
[0117] Preferably the alkoxylated polytetrahydrofurane has a weight average molecular weight Mw in the range of 500 to 20000 g/mol, more preferably in the range of 2000 to 10000 g/mol, most preferably in the range of 2000 to 7000 g/mol, even more preferably in the range of 4000 to 7000 g/mol determined, determined according to DIN 55672-1.
[0118] Preferably the alkoxylated polytetrahydrofurane has a polydispersity in the range of 1.05 to 1.60, more preferably in the range of 1.05 to 1.50, most preferably in the range of 1.05 to 1.45, determined according to DIN 55672-1.
[0119] Preferably k is an integer in the range of ≥3 to ≤25, more preferably k is an integer in the range of ≥3 to ≤20, most preferably in the range of ≥5 to ≤20, even more preferably in the range of ≥6 to ≤16.
[0120] Preferably m is an integer in the range of ≥1 to ≤25 and m′ is an integer in the range of ≥1 to ≤25, more preferably m is an integer in the range of ≥1 to ≤20 and m′ is an integer in the range of ≥1 to ≤20.
[0121] Preferably (m+m′) is an integer in the range of ≥3 to ≤65, more preferably (m+m′) is an integer in the range of ≥3 to ≤50, even more preferably (m+m′) is an integer in the range of ≥3 to ≤40.
[0122] Preferably the ratio of (m+m′) to k is in the range of 0.3:1 to 6:1, more preferably in the range of 0.3:1 to 5:1, most preferably in the range of 0.3:1 to 4:1, even more preferably in the range of 0.3:1 to 3:1.
[0123] Preferably n is an integer in the range of ≥6 to ≤40 and n′ is an integer in the range of ≥6 to ≤40, more preferably n is an integer in the range of ≥8 to ≤35 and p′ is an integer in the range of ≥8 to ≤35.
[0124] Preferably (n+n′) is an integer in the range of ≥10 to ≤80, more preferably (n+n′) is an integer in the range of ≥15 to ≤70.
[0125] Preferably p is an integer in the range of ≥5 to ≤25 and p′ is an integer in the range of ≥5 to ≤25, more preferably p is an integer in the range of ≥5 to ≤15 and p′ is an integer in the range of ≥5 to ≤15.
[0126] Preferably (p+p′) is an integer in the range of ≥10 to ≤30, more preferably (p+p′) is an integer in the range of ≥15 to ≤30.
[0127] Preferably R.sup.1 denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms. More preferably R.sup.1 denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11, 12, 13, 14, 15 or 16 carbon atoms. Most preferably R.sup.1 denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms.
[0128] In case the alkoxylated polytetrahydrofurane comprises units, wherein R.sup.2 denotes —CH.sub.2—CH.sub.3, the ratio of (n+n′) to k is in the range of 1.5:1 to 10:1, more preferably in the range of 1.5:1 to 6:1, most preferably in the range of 2:1 to 5:1.
[0129] In case the alkoxylated polytetrahydrofurane comprises units, wherein R.sup.3 denotes —CH.sub.3, the ratio of (p+p′) to k is in the range of 1.2:1 to 10:1, more preferably in the range of 1.2:1 to 6:1.
[0130] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00003## [0131] wherein [0132] m is an integer in the range of ≥1 to ≤30, [0133] m′ is an integer in the range of ≥1 to ≤30, [0134] (m+m′) is an integer in the range of ≥3 to ≤50, [0135] n is an integer in the range of ≥3 to ≤45, [0136] n′ is an integer in the range of ≥3 to ≤45, [0137] (n+n′) is an integer in the range of ≥6 to ≤90, [0138] p is an integer in the range of ≥0 to ≤75, [0139] p′ is an integer in the range of ≥0 to ≤75, [0140] k is an integer in the range of ≥3 to ≤25, [0141] (p+p′) is an integer in the range of ≥0 to ≤30, [0142] k is an integer in the range of ≥3 to ≤25, [0143] R.sup.1 denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms, [0144] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0145] R.sup.3 denotes —CH.sub.3, [0146] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure.

[0147] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00004## [0148] wherein [0149] m is an integer in the range of ≥1 to ≤30, [0150] m′ is an integer in the range of ≥1 to ≤30, [0151] (m+m′) is an integer in the range of ≥3 to ≤50, [0152] n is an integer in the range of ≥3 to ≤45, [0153] n′ is an integer in the range of ≥3 to ≤45, [0154] (n+n′) is an integer in the range of ≥6 to ≤90, [0155] p is an integer in the range of ≥0 to ≤75, [0156] p′ is an integer in the range of ≥0 to ≤75, [0157] k is an integer in the range of ≥3 to ≤25, [0158] (p+p′) is an integer in the range of ≥0 to ≤30, [0159] k is an integer in the range of ≥3 to ≤25, [0160] R.sup.1 denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms, [0161] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0162] R.sup.3 denotes —CH.sub.3, [0163] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure, wherein the ratio of (m+m′) to k is in the range of 0.3:1 to 6:1 and the ratio of (n+n′) to k is in the range of 1.5:1 to 10:1.

[0164] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00005## [0165] wherein [0166] m is an integer in the range of ≥1 to ≤25, [0167] m′ is an integer in the range of ≥1 to ≤25, [0168] (m+m′) is an integer in the range of ≥3 to ≤40, [0169] n is an integer in the range of ≥6 to ≤40, [0170] n′ is an integer in the range of ≥6 to ≤40, [0171] (n+n′) is an integer in the range of ≥12 to ≤70, [0172] p is an integer in the range of ≥0 to ≤25, [0173] p′ is an integer in the range of ≥0 to ≤25, [0174] (p+p′) is an integer in the range of ≥0 to ≤30, [0175] k is an integer in the range of ≥5 to ≤20, [0176] R.sup.1 denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms, [0177] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0178] R.sup.3 denotes —CH.sub.3, [0179] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure, and [0180] wherein the ratio of (m+m′) to k is in the range of 0.3:1 to 4:1 and the ratio of (n+n′) to k is in the range of 1.5:1 to 5:1.

[0181] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00006## [0182] wherein [0183] m is an integer in the range of ≥1 to ≤25, [0184] m′ is an integer in the range of ≥1 to ≤25, [0185] (m+m′) is an integer in the range of ≥3 to ≤50, [0186] n is an integer in the range of ≥0 to ≤45, [0187] n′ is an integer in the range of ≥0 to ≤45, [0188] (n+n′) is an integer in the range of ≥0 to ≤80, [0189] p is an integer in the range of ≥3 to ≤45, [0190] p′ is an integer in the range of ≥3 to ≤45, [0191] (p+p′) is an integer in the range of ≥6 to ≤90, [0192] k is an integer in the range of ≥3 to ≤25, [0193] R.sup.1 denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms, [0194] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0195] R.sup.3 denotes —CH.sub.3, [0196] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure.

[0197] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00007## [0198] wherein [0199] m is an integer in the range of ≥1 to ≤30, [0200] m′ is an integer in the range of ≥1 to ≤30, [0201] (m+m′) is an integer in the range of ≥3 to ≤50, [0202] n is an integer in the range of ≥0 to ≤45, [0203] n′ is an integer in the range of ≥0 to ≤45, [0204] (n+n′) is an integer in the range of ≥0 to ≤80, [0205] p is an integer in the range of ≥3 to ≤45, [0206] p′ is an integer in the range of ≥3 to ≤45, [0207] (p+p′) is an integer in the range of ≥6 to ≤90, [0208] k is an integer in the range of ≥3 to ≤25, [0209] R.sup.1 denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms, [0210] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0211] R.sup.3 denotes —CH.sub.3, [0212] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure, wherein the ratio of (m+m′) to k is in the range of 0.3:1 to 6:1 and the ratio of (p+p′) to k is in the range of 1.5:1 to 10:1, as a lubricant.

[0213] In another preferred form the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I)

##STR00008## [0214] wherein [0215] m is an integer in the range of ≥1 to:≤25, [0216] m′ is an integer in the range of ≥1 to ≤25, [0217] (m+m′) is an integer in the range of ≥3 to ≤50, [0218] n is an integer in the range of ≥0 to ≤45, [0219] n′ is an integer in the range of ≥0 to ≤45, [0220] (n+n′) is an integer in the range of ≥0 to ≤80, [0221] p is an integer in the range of ≥5 to ≤20, [0222] p′ is an integer in the range of ≥5 to ≤20, [0223] (p+p′) is an integer in the range of ≥10 to ≤30, [0224] k is an integer in the range of ≥5 to ≤20, [0225] R.sup.1 denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms, [0226] R.sup.2 denotes —CH.sub.2—CH.sub.3, and [0227] R.sup.3 denotes —CH.sub.3, [0228] whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure, wherein the ratio of (m+m′) to k is in the range of 0.3:1 to 4:1 and the ratio of (p+p′) to k is in the range of 1.5:1 to 5:1.

[0229] The alkoxylated polytetrahydrofuranes are usually obtainable by reacting at least one polytetrahydrofurane block polymer with at least one C.sub.8-C.sub.30 epoxy alkane and optionally at least one epoxide selected from the group consisting of ethylene oxide, propylene oxide and butylene oxide in the presence of at least one catalyst. In case at least one epoxide selected from the group consisting of ethylene oxide, propylene oxide and butylene oxide is used, the at least one C.sub.8-C.sub.30 epoxy alkane and the at least one epoxide selected from the group consisting of ethylene oxide, propylene oxide and butylene oxide can either be added as a mixture of epoxides to obtain a random copolymer or in portions, whereby each portion contains a different epoxide, to obtain a block copolymer.

[0230] Preferably the at least one C.sub.8-C.sub.30 epoxy alkane is selected from the group consisting of 1,2-epoxyoctane; 1,2-epoxynonane; 1,2-epoxydecane; 1,2-epoxyundecane; 1,2-epoxydodecane; 1,2-epoxytridecane; 1,2-epoxytetradecane; 1,2-epoxypentadecane; 1,2-epoxyhexadecane; 1,2-epoxyheptadecane; 1,2-epoxyoctadecane; 1,2-epoxynonadecane; 1,2-epoxyicosane; 1,2-epoxyunicosane; 1,2-epoxydocosane; 1,2-epoxytricosane; 1,2-epoxytetracosane; 1,2-epoxypentacosane; 1,2-epoxyhexacosane; 1,2-epoxyheptacosane; 1,2-epoxyoctacosane; 1,2-epoxynonacosane and 1,2-epoxytriacontane.

[0231] The alkoxylated alcohol is usually oil soluble, which can mean that, when mixed with the hydrocarbons in a weight ratio of 10:90, 50:50 and 90:10, the alkoxylated alcohols do not show phase separation after standing for 24 hours at room temperature for at least two weight rations out of the three weight ratios 10:90, 50:50 and 90:10.

[0232] The lubricant may comprise 2 to 99 wt %, preferably 2 to 50 wt %, or more preferably 10 to 25 wt %, of the alkoxylated alcohol. In another form the lubricant comprises 5 to 99 wt %, 10 to 50 wt %, or 15 to 50 wt % of the alkoxylated alcohol. In another form the lubricant comprises 3 to 40 wt %, 5 to 30 wt %, or 5 to 20 wt % of the alkoxylated alcohol.
[0233] The lubricant is usually free of ionic liquids. Ionic liquids are usually salts having a melting point of less than 100° C. at 1 bar. Ionic liquids can be liquid under normal conditions (1 bar, at room temperature). Ionic liquids may comprise at least one organic compound as cation, such as quaternary ammonium cations, e.g. pyridinium cations, pyridazinium cations, pyrimidinium cations, pyrazinium cations, imidazolium cations, pyrazolium cations, pyrazolinium cations, imidazolinium cations, thiazolium cations, triazolium cations, pyrrolidinium cations and imidazolidinium cations.
[0234] The lubricant may have a kinematic viscosity of 1 to 100 mm.sup.2/s at 100° C., as may be determined according to ASTM D445.
[0235] The lubricant may further comprise in addition to the base stock selected from the hydrocarbons, the water and the alkoxylated alcohol a lubricant additive. Suitable lubricant additives may be selected from viscosity index improvers, polymeric thickeners, corrosion inhibitors, detergents, dispersants, anti-foam agents, dyes, wear protection additives, extreme pressure additives (EP additives), anti-wear additives (AW additives), friction modifiers, metal deactivators, pour point depressants.
[0236] The total combined amount of the lubricant additive in the lubricant may include ranges of 0-25 wt %, or 0.01-20 wt %, or 0.1-15 wt % or 0.5-10 wt %, or 1-5 wt % of the lubricant.
[0237] The viscosity index improvers include high molecular weight polymers that increase the relative viscosity of an oil at high temperatures more than they do at low temperatures. Viscosity index improvers include polyacrylates, polymethacrylates, alkylmethacrylates, vinylpyrrolidone/meth-acrylate copolymers, poly vinylpyrrolidones, polybutenes, olefin copolymers such as an ethylene-propylene copolymer or a styrene-butadiene copolymer or polyalkene such as PIB, styrene/acrylate copolymers and polyethers, and combinations thereof. The most common VI improvers are methacrylate polymers and copolymers, acrylate polymers, olefin polymers and copolymers, and styrenebutadiene copolymers. Other examples of the viscosity index improver include polymethacrylate, polyisobutylene, alpha-olefin polymers, alpha-olefin copolymers (e.g., an ethylenepropylene copolymer), polyalkylstyrene, phenol condensates, naphthalene condensates, a styrenebutadiene copolymer and the like. Of these, polymethacrylate having a number average molecular weight of 10000 to 300000, and alpha-olefin polymers or alpha-olefin copolymers having a number average molecular weight of 1000 to 30000, particularly ethylene-alpha-olefin copolymers having a number average molecular weight of 1000 to 10000 are preferred. The viscosity index increasing agents can be added and used individually or in the form of mixtures, conveniently in an amount within the range of from ≥0.05 to ≤20.0% by weight, in relation to the weight of the base stock.
[0238] Suitable (polymeric) thickeners include, but are not limited to, polyisobutenes (PIB), oligomeric co-polymers (OCPs), polymethacrylates (PMAs), copolymers of styrene and butadiene, or high viscosity esters (complex esters).
[0239] Corrosion inhibitors may include various oxygen-, nitrogen-, sulfur-, and phosphorus-containing materials, and may include metal-containing compounds (salts, organometallics, etc.) and nonmetal-containing or ashless materials. Corrosion inhibitors may include, but are not limited to, additive types such as, for example, hydrocarbyl-, aryl-, alkyl-, arylalkyl-, and alkylaryl-versions of detergents (neutral, overbased), sulfonates, phenates, salicylates, alcoholates, carboxylates, salixarates, phosphites, phosphates, thiophosphates, amines, amine salts, amine phosphoric acid salts, amine sulfonic acid salts, alkoxylated amines, etheramines, polyetheramines, amides, imides, azoles, diazoles, triazoles, benzotriazoles, benzothiadoles, mercaptobenzothiazoles, tolyltriazoles (TTZ-type), heterocyclic amines, heterocyclic sulfides, thiazoles, thiadiazoles,

mercaptothiadiazoles, dimercaptothiadiazoles (DMTD-type), imidazoles, benzimidazoles, dithiobenzimidazoles, imidazolines, oxazolines, Mannich reactions products, glycidyl ethers, anhydrides, carbamates, thiocarbamates, dithiocarbamates, polyglycols, etc., or mixtures thereof.

[0240] Detergents include cleaning agents that adhere to dirt particles, preventing them from attaching to critical surfaces. Detergents may also adhere to the metal surface itself to keep it clean and prevent corrosion from occurring. Detergents include calcium alkylsalicylates, calcium alkylphenates and calcium alkarylsulfonates with alternate metal ions used such as magnesium, barium, or sodium. Examples of the cleaning and dispersing agents which can be used include metal-based detergents such as the neutral and basic alkaline earth metal sulphonates, alkaline earth metal phenates and alkaline earth metal salicylates alkenylsuccinimide and alkenylsuccinimide esters and their borohydrides, phenates, salienius complex detergents and ashless dispersing agents which have been modified with sulphur compounds. These agents can be added and used individually or in the form of mixtures, conveniently in an amount within the range of from ≥0.01 to ≤1.0% by weight in relation to the weight of the base stock; these can also be high total base number (TBN), low TBN, or mixtures of high/low TBN.

[0241] Dispersants are lubricant additives that help to prevent sludge, varnish and other deposits from forming on critical surfaces. The dispersant may be a succinimide dispersant (for example N-substituted long chain alkenyl succinimides), a Mannich dispersant, an ester-containing dispersant, a condensation product of a fatty hydrocarbyl monocarboxylic acylating agent with an amine or ammonia, an alkyl amino phenol dispersant, a hydrocarbyl-amine dispersant, a polyether dispersant or a polyetheramine dispersant. In one embodiment, the succinimide dispersant includes a polyisobutylene-substituted succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of about 400 to about 5000, or of about 950 to about 1600. In one embodiment, the dispersant includes a borated dispersant. Typically, the borated dispersant includes a succinimide dispersant including a polyisobutylene succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of about 400 to about 5000. Borated dispersants are described in more detail above within the extreme pressure agent description.

[0242] Anti-foam agents may be selected from silicones, polyacrylates, and the like. The amount of anti-foam agent in the lubricant compositions described herein may range from ≥0.001 wt.-% to ≤0.1 wt.-% based on the total weight of the formulation. As a further example, an anti-foam agent may be present in an amount from about 0.004 wt.-% to about 0.008 wt.-%.

[0243] Suitable extreme pressure agent is a sulfur-containing compound. In one embodiment, the sulfur-containing compound may be a sulfurised olefin, a polysulfide, or mixtures thereof. Examples of the sulfurised olefin include a sulfurised olefin derived from propylene, isobutylene, pentene; an organic sulfide and/or polysulfide including benzyldisulfide; bis-(chlorobenzyl) disulfide; dibutyl tetrasulfide; di-tertiary butyl polysulfide; and sulfurised methyl ester of oleic acid, a sulfurised alkylphenol, a sulfurised dipentene, a sulfurised terpene, a sulfurised Diels-Alder adduct, an alkyl sulphenyl N′N-dialkyl dithiocarbamates; or mixtures thereof. In one embodiment, the sulfurised olefin includes a sulfurised olefin derived from propylene, isobutylene, pentene or mixtures thereof. In one embodiment the extreme pressure additive sulfur-containing compound includes a dimercaptothiadiazole or derivative, or mixtures thereof. Examples of the dimercaptothiadiazole include compounds such as 2,5-dimercapto-1,3,4-thiadiazole or a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole, or oligomers thereof. The oligomers of hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically form by forming a sulfur-sulfur bond between 2,5-dimercapto-1,3,4-thiadiazole units to form derivatives or oligomers of two or more of said thiadiazole units. Suitable 2,5-dimercapto-1,3,4-thiadiazole derived compounds include for example 2,5-bis(tert-nonyldithio)-1,3,4-thiadiazole or 2-tert-nonyldithio-5-mercapto-1,3,4-thiadiazole. The number of carbon atoms on the hydrocarbyl substituents of the hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically include 1 to 30, or 2 to 20, or 3 to 16.

Extreme pressure additives include compounds containing boron and/or sulfur and/or phosphorus. The extreme pressure agent may be present in the lubricant compositions at 0 wt.-% to about 20 wt.-%, or at about 0.05 wt.-% to about 10.0 wt.-%, or at about 0.1 wt.-% to about 8 wt.-% of the lubricant composition.

[0244] Examples of anti-wear additives include organo borates, organo phosphites such as didodecyl phosphite, organic sulfur-containing compounds such as sulfurized sperm oil or sulfurized terpenes, zinc dialkyl dithiophosphates, zinc diaryl dithiophosphates, phosphosulfurized hydrocarbons and any combinations thereof.

[0245] Friction modifiers may include metal-containing compounds or materials as well as ashless compounds or materials, or mixtures thereof. Metal-containing friction modifiers include metal salts or metal-ligand complexes where the metals may include alkali, alkaline earth, or transition group metals. Such metal-containing friction modifiers may also have low-ash characteristics.

[0246] Transition metals may include Mo, Sb, Sn, Fe, Cu, Zn, and others. Ligands may include hydrocarbyl derivative of alcohols, polyols, glycerols, partial ester glycerols, thiols, carboxylates, carbamates, thiocarbamates, dithiocarbamates, phosphates, thiophosphates, dithiophosphates, amides, imides, amines, thiazoles, thiadiazoles, dithiazoles, diazoles, triazoles, and other polar molecular functional groups containing effective amounts of O, N, S, or P, individually or in combination. In particular, Mo-containing compounds can be particularly effective such as for example Mo-dithiocarbamates, Mo(DTC), Mo-dithiophosphates, Mo(DTP), Mo-amines, Mo (Am), Mo-alcoholates, Mo-alcohol-amides, and the like.

[0247] Ashless friction modifiers may also include lubricant materials that contain effective amounts of polar groups, for example, hydroxyl-containing hydrocarbyl base oils, glycerides, partial glycerides, glyceride derivatives, and the like. Polar groups in friction modifiers may include hydrocarbyl groups containing effective amounts of O, N, S, or P, individually or in combination. Other friction modifiers that may be particularly effective include, for example, salts (both ash-containing and ashless derivatives) of fatty acids, fatty alcohols, fatty amides, fatty esters, hydroxyl-containing carboxylates, and comparable synthetic long-chain hydrocarbyl acids, alcohols, amides, esters, hydroxy carboxylates, and the like. In some instances, fatty organic acids, fatty amines, and sulfurized fatty acids may be used as suitable friction modifiers. Examples of friction modifiers include fatty acid esters and amides, organo molybdenum compounds, molybdenum dialkylthiocarbamates and molybdenum dialkyl dithiophosphates.

[0248] Suitable metal deactivators include benzotriazoles and derivatives thereof, for example 4- or 5-alkylbenzotriazoles (e.g. triazole) and derivatives thereof, 4,5,6,7-tetrahydrobenzotriazole and 5,5′-methylenebisbenzotriazole; Mannich bases of benzotriazole or triazole, e.g. 1-[bis(2-ethylhexyl) aminomethyl) triazole and 1-[bis(2-ethylhexyl) aminomethyl)benzotriazole; and alkoxy-alkylbenzotriazoles such as 1-(nonyloxymethyl)benzotriazole, 1-(1-butoxyethyl) benzotriazole and 1-(1-cyclohexyloxybutyl) triazole, and combinations thereof. Additional non-limiting examples of the one or more metal deactivators include 1,2,4-triazoles and derivatives thereof, for example 3-alkyl(or aryl)-1, 2,4-triazoles, and Mannich bases of 1,2,4-triazoles, such as 1-[bis(2-ethylhexyl) aminomethy1-1, 2,4-triazole; alkoxyalky1-1, 2,4-triazoles such as 1-(1-bu-toxyethyl)-1, 2,4-triazole; and acylated 3-amino-1, 2,4-triazoles, imidazole derivatives, for example 4,4′-methylenebis(2-undecyl-5-methylimidazole) and bis[(N-methyl)imidazol-2-yl]-carbinol octyl ether, and combinations thereof. Further non-limiting examples of the one or more metal deactivators include sulfur-containing heterocyclic compounds, for example 2-mercapto-benzothiazole, 2,5-dimercapto-1, 3,4-thia-diazole and derivatives thereof; and 3,5-bis[di(2-ethylhexyl) aminomethyl]-1, 3,4-thiadiazolin-2-one, and combinations thereof. Even further non-limiting examples of the one or more metal deactivators include amino compounds, for example salicylidenepropylenediamine, salicylami-noguanidine and salts thereof, and combinations thereof. The one or more metal deactivators are not particularly limited in amount in the composition but are typically present in an amount of from about 0.01 to about 0.1, from about 0.05 to about 0.01, or from about 0.07 to about 0.1, wt.-% based on the weight of the composition. Alternatively, the one or more metal deactivators may be present in amounts of less than about 0.1, of less than about 0.7, or less than about 0.5, wt.-% based on the weight of the composition.

[0249] Pour point depressants (PPD) include polymethacrylates, alkylated naphthalene derivatives, and combinations thereof. Commonly used additives such as alkylaromatic polymers and polymethacrylates are also useful for this purpose. Typically, the treat rates range from ≥0.001 wt.-% to ≤1.0 wt.-%, in relation to the weight of the base stock.

[0250] Demulsifiers include trialkyl phosphates, and various polymers and copolymers of ethylene glycol, ethylene oxide, propylene oxide, or mixtures thereof.

[0251] The invention also relates to a method for lubricating a mechanical device in an electric vehicle comprising the step of contacting the lubricant with the mechanical device.

[0252] Suitable electric vehicles are fully electric vehicles and hybrid electric vehicles. An electric vehicle usually comprises a rotary electric machine and an electric power storage device configured to store electric power that is used to drive the rotary electric machine. A hybrid electric vehicle usually travels by using power of a rotary electric machine and a combustion engine.

[0253] Suitable hybrid electric vehicles are full hybrid (also called strong hybrid), plug-in hybrid (also called PHEV) electric vehicles, or range extended electric vehicles (also called REEV). A full hybrid electric vehicle is typically a vehicle that can run only on a combustion engine, only on an electric motor, or a combination of both. A plug-in hybrid electric vehicle is typically a hybrid electric vehicle with rechargeable batteries that can be restored to full charge by connecting a plug to an external electric power source.

[0254] Suitable electric vehicles are battery electric vehicles (also called BEV) or fuel cell electric vehicles. A BEV is typically a type of electric vehicle that uses chemical energy stored in rechargeable battery packs, and uses electric motors and motor controllers instead of internal combustion engines for propulsion. A fuel cell electric vehicle (FCEV) is typically a type of electric vehicle which uses a fuel cell, instead of a battery, or in combination with a battery or supercapacitor, to power its on-board rotary electric machine. Fuel cells in vehicles generate electricity to power the motor, generally using oxygen from the air and compressed hydrogen.

[0255] The term “vehicle” refers to any mobile or stationary platform, wherein mobile platforms are preferred. In particular vehicles are selected from a passenger vehicle, a light-duty or heavy-duty truck, a utility vehicle, an agricultural vehicle, an industrial or warehouse vehicle, or a recreational off-road vehicle.

[0256] The lubrication of a mechanical device in an electric vehicles may refer to lubrication of powertrains, drivelines, transmissions, differentials, gears, gear trains, gear sets, gear boxes, bearings, bushings, axles, turbines, compressors, pumps, hydraulic systems, batteries, capacitors, electric motors, drive motors, generators, AC/DC converters, alternators, transformers, kinetic energy converters, kinetic energy recovery systems. A single lubricant or more than one lubricant may be used in the electric vehicle, for example, one lubricant composition for the transmission and another lubricant composition for another component of the vehicle system.

[0257] The invention also relates to a use of the alkoxylated alcohol for increasing the breakdown voltage of the lubricant comprising a basestock selected from the hydrocarbons.

[0258] Preferably, the breakdown voltage of the lubricant comprising the alkoxylated alcohol is at least 100, 500, 1000, 2000, or 5000 V higher compared to the lubricant without the alkoxylated alcohol.

[0259] Preferably, the use of the alkoxylated alcohol for increasing the breakdown voltage of the lubricant comprising the base stock selected from the hydrocarbons is in an electric vehicle.

[0260] The invention also relates to a use of the alkoxylated alcohol in the lubricant comprising the base stock selected from the hydrocarbons for reducing the electric discharge machining.

EXAMPLES

[0261] Base Stock A: API Group 11 base stock, YUBASE 3 from SK Lubricants Ltd, clear liquid hydrocarbons, mineral oil, kinematic viscosity (ASTM D445) at 40° C. 12.4 mm.sup.2/s, at 100° C. 3.1 mm.sup.2/s, viscosity index 112 (ASTM D2270), sulfur content <10 ppm (ASTM D2622).

[0262] Base Stock B: API Group 11 base stock, YUBASE 6 from SK Lubricants Ltd, clear liquid hydrocarbons, mineral oil, kinematic viscosity (ASTM D445) at 40° C. 36.8 mm.sup.2/s, at 100° C. 6.5 mm.sup.2/s, viscosity index 131 (ASTM D2270), sulfur content <10 ppm (ASTM D2622).

[0263] Additives Pack: An additives package was added comprising commercial additives of the classes of antioxidants, antiwear additive, corrosion inhibitor, metal deactivator, silicon oil.

[0264] Polyalphaolefin 150: a highly branched isoparaffinic polyalphaolefin, kinematic viscosity at 40° C. 1719 mm.sup.2/s, at 100° C. 156 mm.sup.2/s, Synfluid mPAO 150 cST from Chevron Phillips.

[0265] Polymethylacrylate: a polyalkyl methacrylate viscosity index improver, with linear and branched C.sub.12-15 alkyl groups, permanent shear stability index about 20 (20 h KRL; determined according CEC L-45-99).

[0266] Alkoxylate A: a liquid alkoxylated alcohol, where the alcohol was polytetrahydrofuran (mol weight about 650 g/mol) which was randomly alkoxylated with 12 equivalents of dodecyl epoxide and 20 equivalents of proyplene oxide, kinematic viscosity (ASTM D445) at 40° C. about 320-350 mm.sup.2/s

Example 1

[0267] The lubricants A, B, and C were prepared from the Base Stock A, the Additives Pack (1.1 wt % concentration) and either the Base Stock B, the Polymethylacrylate (comparative), the Polyalphaolefin 150 (comparative), or the Alkoxylate A with the amount given in Table 1. The amounts of the the Base Stock B, the Polymethylacrylate, the Polyalphaolefin 150, and the Alkoxylate A were adjusted to achieve a KV100 of 5 mm.sup.2/s in the final lubricant.

[0268] The kinematic viscosity at 40° C. (KV40) and at 100° C. (KV100) was determined according to ASTM D445. The viscosity index VI was calculated from these data. The water content of the final lubricant was determined by the Karl Fischer method (DIN 517771/ASTM D 1744). The breakdown voltage of the final lubricant was determined by DIN EN 60156 ("Insulating liquids —Determination of the breakdown voltage at power frequency—Test method").

[0269] The results are summarized in Table 1 and demonstrate for Lubricant E an increased breakdown voltage. A high breakdown voltage is advantageous because the lubricant acts as an insulator.

[0270] The comparative Lubricant A has a very low water content of 20 ppm. Typically, in hydrocarbons with low water content the breakdown voltage increases, as can also be obseved comparing comparative Lubricants C and D. Surprisingly Lubricant E has a higher breakdown voltage although it has a higher water content of 300 ppm.

TABLE-US-00001 TABLE 1 Lubricant A .sup.a) B .sup.a) C .sup.a) D .sup.a) E Base Stock A 88.0% 83.6% 32.9 32.9 80.8% Base Stock B — — 66.0 66.0 — Polymethylacrylate 10.9% — — — — Polyalphaolefin 150 — 15.3% — — — Alkoxylate A — — — — 18.1% KV40 [mm.sup.2/s] 20.9 22.2 24.5 24.5 21.9 KV100 [mm.sup.2/s] 5.0 5.0 5 5 5.0 VI 179 181 132 132 166 Water content 20 ppm 58 ppm 85 ppm 151 ppm 300 ppm Breakdown voltage 24 kV 30 kV 35 kV 23 kV 56 kV .sup.a) Comparative example

Example 2

[0271] The EDM (electric discharge machining) currents of Lubricants A, B and C from Example 1 were analyzed on a test rig where a common mode voltage was applied to a rotating bearing while the resulting bearing currents were recorded according to R. Pelz et al. "Charakterisierung von E-Fluiden von der Laboranalytik bis zum Prufstand", MTZ—Motorentechnische Zeitschrift, 2021 (10), 46-50. The temperature was varied from 30 to 80° C. and the common mode voltage varied between 5, 10, and 20 Volt.

[0272] The results are summarized in Table 2 and demonstrate for Lubricant C a reduced total EDM currents. A reduced total EDM current is advantageous because the EDM currents result in

damage of the bearings.
TABLE-US-00002 TABLE 2 EDM currents [1/s] are bold, ohmic currents [1/s] are italic. 30° C. 40° C. 50° C. Lubricant 5 V 10 V 20 V 5 V 10 V 20 V 5 V 10 V 20 V A *0* 6486 *56* 12903 1056 *0* 11722 *153* *0* B 14208 1931 *14* 9278 *28* *0* 5389 *28* *0* E 7292 *0* *0* 2528 *0* *0* 2361 *0* *0* 60° C. 70° C. 80° C. total EDM Lubricant 5 V 10 V 20 V 5 V 10 V 20 V 5 V 10 V 20 V currents A 8944 0 0 5264 *14* *0* 5000 *0* *0* 51375 B 6153 97 0 7764 *375* *0* 8708 *361* *0* 53431 E *389* *0* *0* *28* *0* *0* *444* *0* *0* 12181

Claims

1.-**15**. (canceled)
16. A method for lubricating a mechanical device in an electric vehicle comprising the step of contacting the lubricant with the mechanical device, where the lubricant comprises a base stock selected from hydrocarbons, 50 to 1000 ppm water, and an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides.
17. The method according to claim 16 where the hydrophobic epoxide is selected from butylene oxide, dodecyl oxide, or a mixture thereof.
18. The method according to claim 16 where the alcohol is alkoxylated with the hydrophobic epoxide and optionally in addition with propylene oxide.
19. The method according to claim 16 where the alcohol is a selected from C.sub.1-C.sub.22 monoalcohol, C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol, polytetrahydrofurane, or C.sub.3-C.sub.12 polyol.
20. The method according to claim 16 where the lubricant comprises 2 to 50 wt % of the alkoxylated alcohol.
21. The method according to claim 16 where the hydrocarbons are selected from API Groups I, II, III or IV base stocks, or mixtures thereof.
22. The method according to claim 16 where the lubricant is free from API Group V base stocks.
23. The method according to claim 16 where the base stock has a breakdown voltage of up to 500 Volt.
24. The method according to claim 16 where the alkoxylated alcohol is an alkoxylated polytetrahydrofurane of general formula (I) ##STR00009## wherein m is an integer in the range of ≥1 to ≤50, m′ is an integer in the range of ≥1 to ≤50, (m+m′) is an integer in the range of ≥1 to ≤90, n is an integer in the range of ≥0 to ≤75, n′ is an integer in the range of ≥0 to ≤75, p is an integer in the range of ≥0 to ≤75, p′ is an integer in the range of ≥0 to ≤75, k is an integer in the range of ≥2 to ≤30, R.sup.1 denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms, R.sup.2 denotes —CH.sub.2—CH.sub.3, and R.sup.3 identical or different, denotes a hydrogen atom or —CH.sub.3, whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p′, n, n′, m and m′ are distributed to form a block polymeric structure or a random polymeric structure.
25. The method according to claim 16 where the lubricant comprises at least 50 wt % of the base stock.
26. A lubricant as defined in claim 16 comprising a base stock selected from hydrocarbons which are selected from API Groups I, II, or III base stocks, 50 to 1000 ppm water, and an alkoxylated alcohol, where the alcohol is alkoxylated with a hydrophobic epoxide selected from C.sub.4-C.sub.20 epoxides, and where the alcohol is a diol selected from C.sub.2-C.sub.12 diol, polyethylene glycol, polypropylene glycol and polytetrahydrofurane.
27. A use of the alkoxylated alcohol as defined in claim 16 for increasing the breakdown voltage of a lubricant comprising the basestock selected from the hydrocarbons.
28. The use according to claim 27 where the breakdown voltage of the lubricant comprising the

alkoxylated alcohol is at least 100 V higher compared to the lubricant without the alkoxylated alcohol.
29. A use of the alkoxylated alcohol as defined in claim 16 in a lubricant comprising the base stock selected from the hydrocarbons for reducing the electric discharge machining.