

LUBRICANT COMPOSITION AND USE THEREOF

TECHNICAL FIELD

The present invention relates to a biodegradable lubricant composition and its use as gear oil, rolling bearing oil, hydraulic oil and sliding bearing oil in the marine field and in the field of inland waters, as well as in on-shore machines and machine elements that can come into contact with water and/or aqueous media.

BACKGROUND

In applications of lubricants or lubricant compositions as gear oil, rolling bearing oil, hydraulic oil and sliding bearing oil in the marine field and in the field of inland waters, that is, in applications in which the lubricants or lubricant compositions are usually used below the waterlines in oil/water interfaces, there is a risk that the marine or water environment will be contaminated by escaping the lubricant, caused for example by leaks. Although attempts are made to seal the water side as best as possible in these applications, lubricant losses are commonplace. Lubricants that are used in on-shore machines and machine elements on land, in particular in the mining industry, in wind power plants and agricultural machinery, can also come into contact with water, for example through rain. In addition, leaks often occur here as well, so that there can be contamination of the environment and soil pollution by chemicals.

In recent years, the protection of the environment, in particular the protection of oceans, has become increasingly important. This is evidenced by various new legislations to protect against pollution of the marine environment, which require the use of lubricants that are harmless to the marine climate. For example, the United States Environmental Protection Agency's Vessel General Permit (VGP) for lubricants used below the waterline requires the use of so-called Environmentally Acceptable Lubricants (EALs), which must meet high requirements in terms of biodegradability and aquatic toxicity.

The selection and usable amount of base oil components and additives for a lubricant is therefore limited. Therefore, common EALs are produced on the basis of natural and synthetic esters instead of conventionally on the basis of mineral oil. However, compared to mineral oil-based lubricants, damage to sealing materials often occurs when using EALs.

In the marine field and in the field of inland waters, as well as in on-shore machines and machine elements, radial shaft sealing rings, which are usually made of elastomer materials such as FKM (fluorine rubber), NBR (nitrile butadiene rubber), HNBR (hydrogenated nitrile butadiene rubber), ACM/AEM (acrylate elastomers/ethylene acrylic elastomers) and polyurethanes, are usually used to seal sliding bearings such as the stern tube, gears such as azipods and linear guides, e.g. in rudder stabilizers. Damages to seals, which ultimately result in leaks, are caused in particular by incompatibility of the lubricant and the sealing material. Therefore, the selection of the base oil component(s) for the lubricant and the carefully coordinated selection of additives are essential in order to ensure not only good biocompatibility but also the material compatibility of the lubricant and thus prevent damages to sealing materials.

WO 2012/173878 A1 describes ester-based lubricant compositions which contain water-soluble polyalkylene glycols based on ethylene oxide and propylene oxide.

WO 2015/139209 A1 describes a lubricant that contains an alcohol-initiated propylene oxide homopolymer and an oil-soluble polyalkylene glycol and that does not require an ester-based base oil.

EP 2 837 674 A1 describes a lubricating oil composition, which may contain a base oil mixture consisting of polyglycol-based synthetic oils and an ester-based synthetic oil and which also contains an asymmetric amine-based antioxidant.

However, there is still a need for ecologically harmless lubricants, which reduce the pollution in oceans, inland waters and soil by chemicals, are highly compatible with sealing materials, in particular elastomeric materials, and further meet the usual requirements for the lubrication of sliding bearings, gears, linear guides, pneumatic components, fittings, rolling bearings,

chains, ropes, springs and screws, etc.

SUMMARY

Therefore, the object of the present invention is to provide lubricants or lubricant compositions which have improved compatibility with sealing materials, in particular elastomers, which have good lubricating properties and good sliding properties, which are biocompatible, that is, readily biodegradable and minimally aquatotoxic, and which are suitable for use as gear oil, rolling bearing oil, hydraulic oil and sliding bearing oil in the marine field and in the field of inland waters, as well as in on-shore machines and machine elements that can come into contact with water and/or aqueous media.

In the sense of the invention, the terms “lubricant composition”, “lubricant”, “lubricating oil” and similar formulation are used synonymously.

One or more of the above objects can be achieved by a lubricant composition, which contains an oil-soluble polyalkylene glycol, an ester compound selected from the group consisting of natural esters and synthetic esters as well as combinations thereof, and a mixture of additives comprising an antioxidant and a corrosion inhibitor, wherein the corrosion inhibitor is selected from neutral alkali and alkaline earth salts of sulfonic acids, carboxylic acids, naphthoic acids, naphthenic acids, benzoic acids and phosphoric acids, as well as derivatives and combinations thereof.

Surprisingly, it was found that in the lubricant composition according to the invention, as defined below, contains an oil-soluble polyalkylene glycol, an ester compound and a mixture of additives as components, wherein the mixture of additives comprises an antioxidant and a neutral corrosion inhibitor, the components interacting synergistically. The lubricant composition according to the invention therefore surprisingly shows the advantage of improved compatibility with sealing materials, in particular elastomer materials such as FKM, NBR, HNBR, ACM/AEM, or polyurethanes. In addition, the lubricant composition according to the invention has good lubricating properties and is also generally characterized by good

biodegradability and/or aquatic toxicity, so that it is excellently suited for use as gear oil, rolling bearing oil, hydraulic oil and sliding bearing oil in the marine field and in the field of inland waters, as well as in on-shore machines and machine elements that can come into contact with water and/or aqueous media.

According to the invention, the lubricant composition contains an oil-soluble polyalkylene glycol (OSP) as the base oil component, wherein mixtures of two or more different oil-soluble polyalkylene glycols are also included within the scope of the invention.

Within the scope of the invention, a polyalkylene glycol is “oil-soluble” if, after mixing it with polyalphaolefin 6 (e.g., available for purchase as Synfluid® PAO 6 cSt or Durasyn® 166 polyalphaolefins) each in the weight ratios 10:90, 50:50 and 90:10 and then allowing the mixtures to stand for 24 hours at room temperature, no phase separation occurs in at least two of the three mixtures.

In a preferred embodiment of the present invention, the oil-soluble polyalkylene glycol is a copolymer selected from polybutylene oxide-polypropylene oxide-copolymers, polybutylene oxide-polyethylene oxide-copolymers, and polybutylene oxide-polypropylene oxide-polyethylene oxide-copolymers, as well as combinations thereof, with polybutylene oxide-polypropylene oxide-copolymers being particularly preferred. Furthermore, it is preferred if the copolymer is alcohol-initiated, i.e., if an alcohol was used as the initiator of the polymerization reaction during its preparation, as is described in more detail below.

Particularly preferred is the oil-soluble polyalkylene glycol being a copolymer selected from polyisobutylene oxide-polyisopropylene oxide-copolymers, polyisobutylene oxide-polyethylene oxide-copolymers, and polyisobutylene oxide-polyisopropylene oxide-polyethylene oxide-copolymers, as well as combinations thereof, with polyisobutylene oxide-polyisopropylene oxide-copolymers being most preferred.

It is particularly preferred here if in the above-mentioned copolymers the proportion of the (polymerized) monomer units (i.e., polybutylene oxide (BO) or polyisobutylene oxide (iBO) units) derived from butylene oxide or isobutylene oxide is 40 percent by weight (wt.%) or

more, more preferably 50 wt.% or more, for example 60 wt.% or more, or 65 wt.% or more, and preferably 80 wt.% or less, more preferably 70 wt.% or less, based on the total weight of all monomer units in the copolymer. Very particularly preferred is a polyalkylene glycol copolymer having 50 wt.% (polymerized) monomer units (i.e., BO or iBO units) derived from butylene oxide or isobutylene oxide and having 50 wt.% monomer units (i.e., polypropylene oxide (PO) or polyisopropylene oxide (iPO) units) derived from propylene oxide, based on the total weight of BO (or iBO) and PO (or iPO) units in the copolymer. This means that BO (or iBO) and PO (or iPO) units are very particularly preferably copolymerized with a weight ratio of 50:50.

According to the invention, the oil-soluble polyalkylene glycol copolymer can be a statistical copolymer, a gradient copolymer, an alternating copolymer, a graft copolymer or a block copolymer, wherein statistical copolymers and block copolymers, and in particular statistical copolymers, are preferred.

Furthermore, it is preferred if the oil-soluble polyalkylene glycol is an alcohol-initiated polyalkylene glycol. That is, the oil-soluble polyalkylene glycol used according to the invention is preferably a polyalkylene glycol produced using an alcohol as an initiator of the polymerization reaction, wherein the alcohol preferably comprises 10-20 carbon atoms, particularly preferably 12-20 carbon atoms, such that the polyalkylene glycol has a C10-C20 alkyl radical (preferred) or C12-C20 alkyl radical (particularly preferred) at at least one terminal end thereof in bound manner, the C10-C20 alkyl radical or the C12-C20 alkyl radical resulting from the start reaction of the alcohol with an alkylene oxide. Furthermore preferably, the alcohol initiator is a linear alcohol, and in particular a primary linear alcohol. In addition, the alcohol initiator can be a mono-, di-, or tri-alcohol, with a mono-alcohol being preferred.

If the alcohol used as a polymerization initiator has 10-20 carbon atoms, or if the alcohol-initiated polyalkylene glycol has a C10-C20-alkyl radical at at least one terminal end in a bound manner, the compounds added as additives, in particular antioxidants and corrosion inhibitors (see below) can be better dissolved therein. A very particularly preferred alcohol initiator in this regard is n-dodecanol.

According to the invention, it is therefore particularly preferred if the oil-soluble polyalkylene glycol is a dodecanoline-initiated polyalkylene glycol copolymer, with a dodecanoline-initiated polybutylene oxide-polypropylene oxide-copolymers being particularly preferred, and polyisobutylene oxide-polyisopropylene oxide-copolymers being very particularly preferred.

Furthermore, it is preferred that the oil-soluble polyalkylene glycol has a number average molecular weight (M_n) of 500 g/mol (grams per mol) or more, particularly preferably 750 g/mol or more, for example 1000 g/mol or more, or 1250 g/mol or more. In addition, it is preferred that the molecular weight of the oil-soluble polyalkylene glycol is 1400 g/mol or less, and particularly preferably M_n is less than 1400 g/mol.

Unless explicitly stated otherwise, “molecular weight” within the scope of this invention refers to “means of molecular weight (M_n)”.

The molecular weight is determined by means of GPC (gel permeation chromatography) against a polystyrene standard.

Oil-soluble polyalkylene glycols having a molecular weight M_n of 500 g/mol or up to 1400 g/mol or less are advantageous in terms of their biodegradability. In addition, it was found that the use of such oil-soluble polyalkylene glycol copolymers has an advantageous effect on the compatibility of the lubricant composition with elastomer materials.

In a further preferred embodiment of the invention, the oil-soluble polyalkylene glycol is biodegradable according to standard OECD 301 A-F or OECD 306 in order to achieve improved biodegradability and ecological compatibility of the lubricant composition according to the invention.

Furthermore, the oil-soluble polyalkylene glycol preferably has a kinematic viscosity at 40° C of 15 mm²/s or higher, more preferably 18 mm²/s or higher, particularly preferably 32 mm²/s or higher, for example 68 mm²/s cSt or higher, and 130 mm²/s or less, more preferably 100 mm²/s or less. The viscosity is determined according to ASTM D 7042.

According to the invention, suitable oil-soluble polyalkylene glycols are commercially

available, for example under the brand names UCON™ OSP-18, UCON™ OSP-32, UCON™ OSP-68 and UCON™ OSP-680.

The amount of the oil-soluble polyalkylene glycol in the lubricant composition is generally determined based on the amounts of the further constituents/components contained in the composition, that is, the lubricant composition is filled up to 100 wt.% with the oil-soluble polyalkylene glycol. However, the amount of the oil-soluble polyalkylene glycol is preferably 0.1-70 wt.%, particularly preferably 5-70 wt.%, and very particularly preferably 10-70 wt.%, based on the total weight of the lubricant composition.

The lubricant composition according to the invention also contains, as a further base oil component, an ester compound selected from the group consisting of natural esters and synthetic esters, and combinations thereof, wherein according to the invention mixtures of two or more different natural esters or mixtures of two or more different synthetic esters are also included.

In a preferred embodiment of the present invention, the ester compound is selected from: natural glyceride esters, in particular from the group consisting of sunflower oil, rape oil or rapeseed oil, linseed oil, corn oil, safflower oil, soybean oil, linseed oil, peanut oil, “Lesqueralle” oil, palm oil and olive oil, each of which can be present in its monomeric, oligomeric and/or polymerized form; and synthetic esters from the group consisting of polyol esters, polyol complex esters, complex esters of dimer acids, dimer acid esters, aliphatic carboxylic and dicarboxylic acid esters, phosphate esters, and trimellitic and pyromellitic acid esters and estolides; as well as combinations thereof.

Particularly preferably, the ester compound is selected from: polyol esters, in particular those obtained by reaction of polyvalent alcohols (i.e. polyols or alcohols with more than one hydroxy group) with monocarboxylic acids (i.e. monovalent carboxylic acids); and polyol complex esters, in particular those obtained by reaction of polyvalent alcohols with monocarboxylic acids and dicarboxylic acids (i.e., bivalent carboxylic acids) in any mixture; and combinations thereof.

Particularly preferably, the polyol esters used according to the invention are produced by reaction/esterification of one or more polyvalent alcohols, selected from neopentyl glycol (NPG), trimethylolpropane (TMP) and pentaerythritol (PE), or dimers or trimers thereof, with one or more linear and/or branched monocarboxylic acids of chain length C4-C36 (i.e. 4 to 36 carbon atoms), preferably C10-36, particularly preferably C14-C36, and very particularly preferably C18-C36, the monocarboxylic acids being capable of being saturated and/or mono- or polyunsaturated, and being preferably saturated.

Also particularly preferably, the polyol complex esters used according to the invention are produced by reaction/esterification of one or more polyvalent alcohols, selected from neopentyl glycol (NPG), trimethylolpropane (TMP) and pentaerythritol (PE), or dimers or trimers thereof, in any mixture with one or more linear and/or branched monocarboxylic acids of chain length C4-C36 preferably C10-36, particularly preferably C14-C36, and very particularly preferably C18-C36, the monocarboxylic acids being capable of being saturated and/or mono- or polyunsaturated, and being preferably saturated, and with one or more linear and/or branched dicarboxylic acids of chain length C4-C36, preferably C4-C18, particularly preferably C4-C12, the dicarboxylic acids being capable of being saturated and/or mono- or polyunsaturated, and being preferably saturated.

The polyol complex esters obtained here can be present in a fully esterified or partially esterified manner (i.e. free, non-esterified hydroxyl groups are still present).

In a very particularly preferred embodiment of the invention, the ester compound is therefore selected from: neopentyl glycol esters, trimethylolpropane esters and pentaerythritol esters, which are fully esterified or partially esterified in particular with saturated and/or mono- or polyunsaturated, linear and/or branched monocarboxylic acids of chain length C4-C36, preferably C10-36, particularly preferably C14-C36, and very particularly preferably C18-C36; and neopentyl glycol complex esters, trimethylolpropane complex esters, and pentaerythritol complex esters, which are fully esterified or partially esterified in particular with saturated and/or mono- or polyunsaturated, linear and/or branched monocarboxylic acids of chain length C4-C36, preferably C10-36, particularly preferably C14-C36, and very particularly preferably

C18-C36, and with saturated and/or mono- or polyunsaturated, linear and/or branched dicarboxylic acids of chain length C4-C36, preferably C4-C18, particularly preferably C4-C12, in any mixture; as well as combinations thereof.

Examples of particularly preferred ester compounds are pentaerythritol tetraisostearate, pentaerythritol tetraoleate, pentaerythritol isostearate sebacate complex ester, trimethylolpropane triisostearate, trimethylolpropane trioleate, trimethylolpropane tricaprylate, trimethylolpropane isostearate stearate sebacate complex ester, neopentyl glycol diisostearate, without being limited thereto.

Suitable ester compounds are also commercially available, for example under the brand names Priolube 3987, Radialube 7257, Synative ES 1200, Priolube 1973, Synative ES TMP 05/140, Palub 8433, Nycobase 8397, Estilube P 688, Rümanox 804.

It has been shown that the presence/addition of such ester compounds, and in particular those containing the residue of a monocarboxylic acid of chain length C18-C36, has an advantageous effect on the compatibility with elastomer materials. The ester compounds defined above are also generally characterized by good biodegradability.

In a further preferred embodiment of the invention, ester compounds that are biodegradable according to standard OECD 301 A - F or OECD 306 are used in order to achieve improved biodegradability and eco-compatibility of the lubricant composition according to the invention.

The lubricant composition according to the invention preferably contains the ester compound in an amount of 0.1-85 wt.%, more preferably of 5-85 wt.%, particularly preferably of 10-85 wt.%, and very particularly preferably of 15-85 wt.%, based on the total lubricant composition.

According to a particularly preferred embodiment of the invention, the oil-soluble polyalkylene glycol and the ester compound are the only base oil components in the lubricant composition, that is, the lubricant composition according to the invention contains as base oil components only oil-soluble polyalkylene glycol (an individual compound or a mixture of different OSP) and ester compound (an individual compound or a mixture of different ester compounds), but

no other base oil components, in particular no mineral oil.

The weight ratio of “oil-soluble polyalkylene glycol” to “ester compound” based on the total weight of these two components in the lubricant composition is preferably in the range of 5:95 to 95:5, more preferably of 10:90 to 80:20, and particularly preferably of 15:85 to 70:30.

The lubricant composition according to the invention further contains a mixture of additives which comprises an antioxidant and a corrosion inhibitor. The antioxidant and the corrosion inhibitor can in each case be present as an individual substance or as a mixture of different antioxidants or corrosion inhibitors in the lubricant composition. The same also applies to any other additive that may be present in the lubricant composition.

Through the targeted addition of additives, it can be achieved certain properties of the lubricant can be improved and/or can be imparted to the lubricant.

The addition of corrosion inhibitors gives the lubricant composition an anti-corrosion and rust-inhibiting effect.

According to the invention, the corrosion inhibitor is selected from neutral alkali and alkaline earth salts of sulfonic acids, carboxylic acids, naphthoic acids, naphthenic acids, benzoic acids and phosphoric acids, as well as combinations thereof. Within the scope of the present invention, this also includes derivatives of the acids/acid salts mentioned, including linear and branched aliphatic and aromatic derivatives of these acids/acid salts, which can also be substituted with one or more radicals selected from linear and/or branched alkyl radicals and aryl radicals. Among the neutral alkali and alkaline earth salts of these acids, the Na salts, Ca salts, K salts and Mg salts are preferred, and Ca salts are particularly preferred, especially for reasons of environmental compatibility.

In the sense of the present invention, “neutral” acid salts are understood as acid salts that have an acid value (TAN) of 30 mg KOH/g or less.

It is therefore preferred within the scope of the present invention that the corrosion inhibitor, or the neutral sulfonic acid, carboxylic acid, naphthenic acid, naphthoic acid, benzoic acid or

phosphoric acid salt used, or mixtures thereof, has a TAN of 30 mg KOH/g or less, more preferably 20 mg KOH/g or less, particularly preferably 15 mg KOH/g or less, and very particularly preferably 10 mg KOH/g or less.

In a particularly preferred embodiment, the corrosion inhibitor is selected from neutral calcium sulfonates. These have turned out to be particularly advantageous in terms of the compatibility of the lubricant composition with elastomer materials. An example of a corrosion inhibitor that is particularly suitable according to the invention is represented by neutral alkyl naphthalene sulfonic acid calcium salts, without being limited thereto.

Suitable neutral corrosion inhibitors are commercially available, e.g. under the brand names NA-SUL® CA-770 FG or NA SUL® CA 1089.

It was surprisingly found that the through the targeted addition of the neutral acid salts as defined above to the lubricant composition, in addition to the anti-corrosion and rust-inhibiting effect, an improvement in the compatibility of the lubricant composition with respect to sealing materials, in particular elastomer materials, is achieved, which results in particular from a synergistic interaction with the remaining components of the lubricant composition.

The oxidation stability of the lubricant composition can be increased by adding antioxidants.

In a preferred embodiment of the present invention, the antioxidant is selected from phenolic antioxidants (phenolic compounds), aminic antioxidants (amine compounds), phosphites and sulfur-containing compounds, in particular alkyl sulfides and aryl sulfides, sulfur-containing phenolic compounds and sulfur-containing carboxylic acids, phosphothionates, thiocarbamates and dithiocarbamates, thiophosphates and thiopropionates, as well as combinations thereof, with phenolic antioxidants, aminic antioxidants, thiocarbamates and dithiocarbamates being particularly preferred. Particularly preferably, the antioxidant is selected from amine antioxidants, and in particular from linear or branched aliphatic amine compounds and aromatic amine compounds as well as their salts, wherein the aliphatic and aromatic amine compounds can be substituted with one or more radicals selected from linear and/or branched alkyl radicals and aryl radicals.

Preferred antioxidants are selected from aromatic diamines and secondary aromatic amines, phenolic resins, thiophenolic resins, zinc thiocarbamate, zinc thiophosphate, organic thiocarbamates and dithiocarbamates, butylated hydroxytoluene, butylated hydroxyanisole, phenyl-alpha-naphthylamines, phenyl-beta-naphthylamines, diphenylamine and diphenylamine derivatives, in particular, octylated diphenylamines, butylated diphenylamines and styrenated diphenylamines, quinoline and quinoline derivatives, naphthylamine and naphthylamine derivatives, di-alpha-tocopherol, di-tert-butyl-phenylpropanoic acid and their esters, as well as mixtures thereof, without being limited thereto.

Examples of antioxidants which are particularly preferred according to the invention are benzeneamine products, N-phenyl products, reaction products having 2,4,4-trimethylpentene, octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate, bis(4-(1,1,3,3-tetramethylbutyl)phenyl)amine, N-[(1,1,3,3-tetramethylbutyl)phenyl]naphthalene-1-amine 4,4'-methylenebis(dibutylthiocarbamate), without being limited thereto.

Suitable antioxidants are commercially available, e.g. under the brand names Vanlube® 81, Irganox® L 57, Vanlube® 1202 or Irganox® L 107 ADDITIN RC 6340.

It was surprisingly found that through the targeted selection of the antioxidant, in particular the targeted use of amine compounds, phenol compounds and/or thiocarbamates and dithiocarbamates as antioxidants, in addition to increasing the oxidation stability, the compatibility of the lubricant composition with sealing materials, in particular elastomeric materials, can be improved, which results in particular from a synergistic interaction with the remaining components of the lubricant composition.

The amount of the mixture of additives in the lubricant composition, that is, the total amount of all additives in the lubricant composition, is preferably 0.1-20 wt.%, more preferably 0.1-10 wt.%, and particularly preferably 0.1-5 wt.%, based on the total lubricant composition. Here, the amount of the antioxidant is preferably in the range of 0.05-3.5 wt.%, and the amount of the corrosion inhibitor is preferably in the range of 0.05-3.5 wt.%, based in each case on the

entire lubricant composition, wherein the above-defined total amount of all additives is not exceeded.

In a preferred embodiment, the present invention therefore relates to a lubricant composition comprising:

- an oil-soluble polyalkylene glycol;
- an ester compound, in an amount of 0.1-85 wt.% based on the total lubricant composition, selected from the group consisting of natural esters and synthetic esters, as well as combinations thereof; and
- a mixture of additives, in an amount of 0.1-20 wt.% based on the total lubricant composition, comprising an antioxidant and a corrosion inhibitor,

wherein the corrosion inhibitor is selected from neutral alkali and alkaline earth salts of sulfonic acids, carboxylic acids, naphthenic acids, naphthoic acids, benzoic acids and phosphoric acids, and their derivatives and combinations thereof, and wherein the components contained add up to a total of 100 wt.% and are defined as above.

In a further preferred embodiment of the invention, the mixture of additives comprises a non-ferrous metal deactivator in addition to antioxidant(s) and corrosion inhibitor(s), wherein both individual compounds and mixtures of two or more different non-ferrous metal deactivators are included within the scope of the invention.

By adding non-ferrous metal deactivators, non-ferrous metals such as cadmium (Cd), cobalt (Co), copper (Cu), nickel (Ni), lead (Pb), tin (Sn), and zinc (Zn), which belong to the so-called non-ferrous metals, and their alloys can be protected from corrosion by active sulfur.

The non-ferrous metal deactivator is preferably selected from triazoles, mercaptothiadiazoles and salicylates, and combinations thereof, with triazoles and in particular benzotriazoles being particularly preferred. With the scope of the present invention, the terms “triazoles” and “benzotriazoles” also include triazole derivatives or benzotriazole derivatives and reaction

mixtures and reaction masses in which “triazoles” and “benzotriazoles” are contained as an individual compound or in a variety.

Examples of non-ferrous metal deactivators that are particularly suitable according to the invention are benzotriazole and tolyltriazole and derivatives thereof, N,N-bis(2-ethylhexyl)-ar-methyl-1H-benzotriazole-1-methanamine, and a reaction mass consisting of N,N-bis(2-ethylhexyl)-6-methyl-1H-benzotriazole-1-methanamine, N,N-bis(2-ethylhexyl)-4-methyl-2H-benzotriazole-2-methanamine, N,N-bis(2-ethylhexyl)-5-methyl-2H-benzotriazole-2-methanamine, N,N-bis(2-ethylhexyl)-4-methyl-1H-benzotriazole-1-methylamine and N,N-bis(2-ethylhexyl)-5-methyl-1H-benzotriazole-1-methylamine, without being limited thereto.

Suitable non-ferrous metal deactivators are commercially available, e.g. under the brand names Irgamet® 39 or Irgamet® BTZ.

Through the targeted selection of the non-ferrous metal deactivator, in particular the targeted use of triazoles or benzotriazoles, in addition to the protection against corrosion by active sulfur, an improvement in the compatibility of the lubricant composition with respect to sealing materials, in particular elastomer materials, can be achieved, which results in particular from a synergistic interaction with the remaining components of the lubricant composition.

In a further preferred embodiment, the present invention therefore relates to a lubricant composition comprising:

- an oil-soluble polyalkylene glycol;
- an ester compound, in an amount of 0.1-85 wt.% based on the total lubricant composition, selected from the group consisting of natural esters and synthetic esters, and combinations thereof; and
- a mixture of additives, in an amount of 0.1-20 wt.% based on the total lubricant composition, comprising an antioxidant, a corrosion inhibitor and a non-ferrous metal deactivator,

wherein the corrosion inhibitor is selected from neutral alkali and alkaline earth salts of sulfonic acids, carboxylic acids, naphthenic acids, naphthoic acids, benzoic acids and phosphoric acids, and combinations thereof, and wherein the components contained add up to a total of 100 wt.% and are defined as above.

The lubricant composition according to the invention or the used mixture of additives can comprise one or more further additives in addition to antioxidant(s), corrosion inhibitor(s) and optionally non-ferrous metal deactivator(s), the further additives being selected in particular from anti-wear agents, friction reducers, high-pressure additives, ion complexing agents, solid lubricants, dispersants, pour point and viscosity improvers, UV stabilizers, emulsifiers, color indicators, sliding improvers and defoamers, without being limited thereto.

Anti-wear agents, friction reducers, high-pressure additives suitable according to the invention are preferably selected from amines, amine phosphates, branched and/or linear alkylated phosphates, phosphites, thiophosphates, and phosphothionates, aryl phosphates, aryl thiophosphates, alkylated polysulfides, sulphurised amine compounds, sulphurised fatty acid methyl esters, naphthenic acids, nanoparticles (selected from Al_2O_3 , SiO_2 , TiO_2 , ZrO_2 , WO_3 , Ta_2O_5 , V_2O_5 , CeO_2 , aluminum titanate, BN, MoSi_2 , SiC, Si_3N_4 , TiC, TiN, ZrB_2 , clay minerals and their mixtures), sulfonic acid salts, and thermally stable carbonates and sulfates, as well as mixtures of two or more thereof, without being limited thereto. Suitable commercially available additives are, for example, the products listed below: IRGALUBE® TPPT, IRGALUBE® 232, IRGALUBE® 349, IRGALUBE® 353, IRGALUBE® 211 and ADDITIN® RC3760 Liq 3960, FIRC-SHUN® FG 1505 and FG 1506, NA-LUBE® KR-015FG, LUBEBOND®, FLUORO® FG, SYNALOX® 40-D, ACHESON® FGA 1820 and ACHESON® FGA 1810.

Suitable viscosity improvers are preferably selected from linear and branched alkylated, acrylated and aliphatic polymers and copolymers as well as polymerized fatty acid esters, and mixtures of two or more thereof. Examples of suitable viscosity improvers are, but not limited to, polymethacrylate, ethylene-propylene copolymer, polyisobutylene, polyalkylstyrene, hydrogenated styrene-isoprene copolymer. Suitable viscosity improvers can be purchased.

Suitable UV stabilizers are preferably selected from, but not limited to, nitrogen heterocycles and substituted nitrogen heterocycles, as well as mixtures of two or more thereof. Suitable UV stabilizers can be purchased.

Suitable solid lubricants are preferably selected from, but not limited to, PTFE, boron nitride, zinc oxide, magnesium oxide, pyrophosphates, thiosulfates, magnesium carbonate, calcium carbonate, calcium stearate, zinc sulfide, molybdenum sulfide, Tungsten sulfide, tin sulfide, graphite, graphene, nanotubes, SiO₂ modifications, as well as mixtures of two or more thereof. Suitable solid lubricants can be purchased.

Suitable emulsifiers are preferably selected from, but not limited to, branched and/or linear ethoxylated and/or propoxylated alcohols and salts thereof, in particular alcohols with chain lengths of 14-18 carbon atoms, ethoxylated and/or propoxylated alkyl ethers, fatty acid esters, and ionic surfactants such as B. sodium salts of alkyl sulfonic acids, as well as mixtures of two or more thereof. Suitable emulsifiers can be purchased.

The addition of defoamers prevents the formation of foam. Suitable defoamers are preferably selected from, but not limited to, ethoxylated and/or propoxylated alcohols with chain lengths of 10-18 carbon atoms, mono- and diglycerides of edible fats, acrylates, propoxylated and/or ethoxylated alkyl ethers, polyols including diols, and polysiloxanes such as silicone oils or polydimethylsiloxanes, as well as mixtures of two or more thereof. Suitable defoamers can be purchased.

An example of a suitable color indicator is, but is not limited to, 2,5-thiophenediylbis(5-terbutyl-1,3-benzoxazole). Suitable color indicators can be purchased.

A sliding improver in the sense of the present invention is an organic compound that includes both a polar part and a non-polar part. The term “organic compound” includes both individual compounds (that is, molecules) and mixtures of individual compounds as well as oligomers and polymers including homopolymers, copolymers and polymer blends, and mixtures thereof.

By adding the sliding improver to the lubricant composition, an improvement in the sliding properties of the lubricant composition can be achieved, especially in the case of low gear and bearing speeds as well as high loads.

Preferred examples of organic compounds that can be used advantageously as sliding improvers in the lubricant composition according to the invention are the following compounds, without being limited thereto: maleic acid-olefin copolymers (commercially available, e.g., as Ketjenlube® 135, Ketjenlube® 2700, Ketjenlube® 23000); modified polyesters (commercially available e.g. as Perfad™ 3000, Perfad™ 3050); polymethyl methacrylate (PMMA), linear polymers as well as star polymers (commercially available e.g. as Lubrizol 87725); oleic acid, in particular mixtures of C16-C18 fatty acids and C18 unsaturated fatty acids (commercially available e.g. as Herwemag OA); glycerol monooleates (GMO), in particular those with a minimum mono content of 40% and a maximum free glycerol of 6% (commercially available e.g. as Ilco Lube 2316); polymethacrylate (PMA), linear polymers and comb polymers (commercially available, e.g. as Viscoplex® 3-200); comb polymers consisting of 1-decene and 9-dodecyl acid methyl ester (commercially available e.g. as Elevance Aria® WTP 40); pentaerythritol tetraisostearate (commercially available e.g. as Priolube™ 3987-LQ).

Since the additives serve to improve certain properties of the lubricant and/or to impart certain properties to it, they can be added to the lubricant as an individual substance or as a mixture of two or more additives, depending on the need or requirement, wherein the amount of the additives in the mixture of additives is not limited as long as the total amount of all additives defined above, based on the total lubricant composition, is not exceeded or fallen below.

In a further preferred embodiment of the invention, the acid value of the total lubricant composition is 30 mg KOH/g or less, more preferably 20 mg KOH/g or less, particularly preferably 15 mg KOH/g or less, and very particularly preferably 10 mg KOH/g or less.

In a further preferred embodiment, the lubricant composition has a kinematic viscosity at 40° C of from 20 mm²/s to 680 mm²/s, particularly preferably from 30 mm²/s to 480 mm²/s and

very particularly preferably from 60 mm²/s to 150 mm²/s. Viscosity measurements are carried out according to ASTM D 7042.

In a further preferred embodiment, the lubricant composition is biodegradable according to the OECD 301 A-F or OECD 306 standard and/or has low aquatic toxicity according to the OECD 201, 202, 203 or 236 standards.

It has surprisingly been found that the lubricant composition according to the present invention described herein, which as defined above contains an oil-soluble polyalkylene glycol, an ester compound and a mixture of additives comprising an antioxidant and a neutral corrosion inhibitor as components, shows the advantage of improved compatibility with sealing materials, in particular elastomers, which results in particular from a synergistic interaction of the components. The lubricant composition according to the invention also has good lubricating or sliding properties and good biodegradability or ecological compatibility.

The lubricant composition according to the invention is therefore outstandingly suitable for use as gear oil, rolling bearing oil, hydraulic oil or sliding bearing oil in the marine field and in the field of inland waters, as well as in on-shore machines and machine elements that can come into contact with water and/or aqueous media.

A further object of the present invention therefore relates to the use of the lubricant composition according to the invention described herein as gear oil, rolling bearing oil, hydraulic oil or sliding bearing oil in the marine field and in the field of inland waters, as well as in on-shore machines and machine elements that can come into contact with water and/or aqueous media.

Application in the marine field and in the field of inland waters include, in particular, the lubrication of gears, hydraulic systems, bearings, such as sliding bearing, rolling bearing or stern tube bearing, propeller rudders, propeller shafts, pneumatic components, linear guides, chains and ropes in machines, machine elements and facilities that come into contact with salt water in the marine area, for example offshore facilities, or with (fresh) water and/or aqueous media in inland waters, without being limited thereto.

In the marine field, gears are used in thrusters and azipods, for example. This application is used for power transmission and power conversion, which takes place between the drive and the propeller. Here, both the entry of water into the interior and the escape of lubricant into the marine environment are to be expected.

A further application in the marine field relates to jack-up systems that lift platforms, installation ships for wind power plants or oil rigs. This movement is accomplished by open gears.

Hydraulic systems in the marine field are used to drive adjustable propeller rudders, as well as in fin stabilizers and rudder bearings. In the latter, linear guides are also used, which are usually lubricated with the same lubricant. Here, the lubrication also takes place below the waterline. Correspondingly, in this case, water entry into the machine parts as well as leakage of the lubricant into the marine environment is also to be expected.

The sliding bearing application in the marine field is primarily a propeller shaft bearing, which is located in the stern tube, the so-called stern tube bearing. The primary task of the propeller shaft is to transmit the drive movement through the ship's hull to the screw. Here, the bearing ensures low-friction movement.

Furthermore, machines and machine structural elements in offshore wind power plants, oil and gas conveyor platforms, in port facilities, shipyards and the like that come into contact with seawater, water and aqueous media are lubricated.

This also includes chains, which are used for example in lock gates, ropes, such as ship's ropes or ropes used in networks, and fittings for controlling flows of solids, liquids and gases. Screws, springs and valves in a wide variety of apparatus and machines also have to be lubricated.

In a preferred embodiment, the present invention therefore relates to the use of the lubricant composition according to the invention described herein as gear oil, rolling bearing oil, hydraulic oil or sliding bearing oil in the marine field and in the field of inland waters, in particular for the lubrication of gears, hydraulic systems, propeller rudders, propeller shafts,

linear guides, pneumatic components, fittings, bearings, such as sliding bearing, rolling bearing or stern tube bearing, chains, ropes, springs, valves and screws in machines, machine structural elements and facilities that come into contact with water (salt and/or fresh water) as well as in on-shore machines and machine elements that come into contact with water and/or aqueous media, wherein the lubricant composition preferably contains:

- an oil-soluble polyalkylene glycol;
- an ester compound, in an amount of 0.1-85 wt.% based on the total lubricant composition, selected from the group consisting of natural esters and synthetic esters, as well as combinations thereof; and
- a mixture of additives, in an amount of 0.1-20 wt.% based on the total lubricant composition, comprising an antioxidant, a corrosion inhibitor and optionally a non-ferrous metal deactivator, wherein the corrosion inhibitor is selected from neutral alkali and alkaline earth salts of sulfonic acids, carboxylic acids, naphthenic acids, naphthoic acids, benzoic acids and phosphoric acids, as well as derivatives and combinations thereof, and wherein the components contained add up to a total of 100 wt.% and are defined as above.

The lubricant compositions are produced using a procedure known to the skilled person in the art, by mixing the base oil components (oil-soluble polyalkylene glycol(s), ester compound(s)) and the additives in a suitable vessel, e.g. a mixing vessel, using a suitable stirrer. Solid additives or components are dissolved and stirred in by increasing the temperature. The production can also be carried out by means of continuous processes.

DETAILED DESCRIPTION

The present invention is described in more detail by the following non-limiting examples.

Examples

General test methods used:

The properties of the lubricant composition and the components contained therein are determined using the following methods, unless known from the manufacturer:

- Determination of the viscosity: Viscosity measurements are carried out in accordance with ASTM D 7042 using a Stabinger viscometer SVM 3000 (Anton Paar).
- Determination of acid value (TAN, total acid number [mg KOH/g]):

To determine the acid value, the sample is dissolved in a solvent mixture and then titrated with an alcoholic potassium hydroxide solution in accordance with ASTM D664-18E02. The titration is carried out potentiometrically using a Solvotrode on a Metrohm 905 Titrand titration unit.

- Determination of molecular weight (M_n):

The molecular weight is determined by means of GPC (gel permeation chromatography) against a polystyrene standard in accordance with DIN 55672-1:2016-03 "Gel Permeation Chromatography (GPC) - Part 1: Tetrahydrofuran (THF) as eluent" by means of a SECcure GPC system.

Preparation of the lubricant compositions:

The lubricant compositions are produced using a procedure known to the skilled person in the art, by mixing the base oil components (oil-soluble polyalkylene glycol(s), ester compound(s)) and the additives in a suitable vessel, e.g. a mixing vessel, using a suitable stirrer. Solid additives or components are dissolved by increasing the temperature and stirred. The production can also be carried out by means of continuous processes.

The following formulations according to the invention (Examples 1-5) and not according to the invention (Comparative Examples 1-11) are produced as described above:

Example 1

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble polyalkylene glycol	polyisobutylene oxide (iBO)- polyisopropylene oxide (iPO)- copolymer; iBO:iPO 50:50,	19.0
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.305
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹	4.695
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal deactivator	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Example 2

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	19.5
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.305
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹	4.195
	antioxidant	amine antioxidant ³	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Example 3

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	19.9
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.305
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹ (TAN < 10 mg KOH/g)	3.795
	antioxidant	amine antioxidant ⁴	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Example 4

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	60.0
Base oil 2	pentaerythritol complex ester	pentaerythritol isostearate sebacate complex ester	35.305
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹	4.695
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Example 5

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	19.0
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	75.805
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹ (TAN < 10 mg KOH/g)	5.195
	antioxidant	thiocarbamate ¹⁰	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 1

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	19.5
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.805
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹ (TAN < 10 mg KOH/g)	3.695
	antioxidant	--	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 2

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	21
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	74.705
Mixture of additives	corrosion inhibitor	amine neutralized phosphate ⁵ ; sarcosine derivative ⁶ (TAN > 100 mg KOH/g)	4.295
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 3

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50, dodecanoline-initiated	19.0
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.705
Mixture of additives	corrosion inhibitor	carboxylic acid half ester ⁷ ; sarcosine derivative ⁶	4.295
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 4

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50 dodecanoline-initiated	19.0
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.71
Mixture of additives	corrosion inhibitor	carboxylic acid half ester ⁷ (TAN > 100 mg KOH/g)	4.29
	antioxidant	phenolic antioxidant	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 5

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50 dodecanoline-initiated	19.71
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.0
Mixture of additives	corrosion inhibitor	carboxylic acid diester ⁸ , carboxylic acid half ester ⁷	4.29
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 6

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	oil-soluble	iBO-iPO-copolymer; iBO:iPO 50:50 dodecanoline-initiated	19.71
Base oil 2	pentaerythritol ester	pentaerythritol tetraisostearate	76.0
Mixture of additives	corrosion inhibitor	carboxylic acid half ester ⁹ (TAN > 100 mg KOH/g)	4.29
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 7

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	pentaerythritol ester	pentaerythritol tetraisostearate	51.764
Base oil 2	pentaerythritol ester	pentaerythritol tetraoleate	43.041
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹ (TAN < 10 mg KOH/g)	5.195
	antioxidant	thiocarbamate ¹⁰	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 8

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	pentaerythritol ester	pentaerythritol tetraisostearate	43.041
Base oil 2	pentaerythritol ester	pentaerythritol tetraoleate	52.264
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹ (TAN < 10 mg KOH/g)	4.695
	antioxidant	phenolic antioxidant ²	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 9

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	pentaerythritol ester	pentaerythritol tetraisostearate	44.541
Base oil 2	pentaerythritol ester	pentaerythritol tetraoleate	51.664
Mixture of additives	corrosion inhibitor	neutral calcium sulfonate ¹ (TAN < 10 mg KOH/g)	3.795
	antioxidant	aminic antioxidant ⁴	
	non-ferrous metal	benzotriazole derivative	
	sliding improver	maleic acid-olefin copolymer	
	defoamer	defoamer containing silicone	

Comparative Example 10

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	polyalkylene glycol	polypropylene glycol ¹¹	68.48
Base oil 2	pentaerythritol ester	pentaerythritol tetraoleate	29.32
Mixture of additives	corrosion inhibitor	basic barium sulfate ¹²	2.20
	antioxidant	aminic antioxidant ⁴	
	non-ferrous metal	benzotriazole (CAS No. 95-14-7)	

Comparative Example 11

	Chemical 1	Chemical 2	Proportion (wt %)
Base oil 1	polyalkylene glycol	polypropylene glycol ¹¹	68.48
Base oil 2	trimethylolpropane ester	trimethylolpropane fatty acid ester	29.32
Mixture of additives	corrosion inhibitor	basic barium sulfate ¹²	2.20
	antioxidant	aminic antioxidant ⁴	
	non-ferrous metal	benzotriazole (CAS No. 95-14-7)	

¹¹Neutral alkyl naphthalene sulfonic acid calcium salt (NA-SUL® CA-770 FG);

¹²Octadecyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate (CAS No. 2082-79-3);

³Benzeneamine, N-phenyl, reaction products with 2,4,4-trimethylpentene, (CAS No. 68411-46-1);

⁴Bis(4-(1,1,3,3-tetramethylbutyl)phenyl)amine (CAS No. 15721-78-5);

⁵Amines, C11-14 branched alkyl, monohexyl and dihexyl phosphates (CAS No. 80939-62-4);

⁶N-oleoyl sarcosine;

⁷2-(Tetrapropenyl)succinic acid, monoester with propane-1,2-diol (CAS No. 52305-09-6);

⁸(tetrapropenyl)succinic acid (CAS No. 27859-58-1);

⁹Reaction products of dihydro-3-(tetrapropenyl) furan-2,5-dione with propane-1,2-diol (EC No. 947-696-0);

¹⁰4,4'-methylenebis(dibutyldithiocarbamate) (CAS No. 10254-57-6)

¹¹Polypropylene glycol monobutyl ether, n-butanol initiated (Synalox™ 100-40B DOW, M_n 1100 g/mol);

¹²Barium bis (dinonylnaphthalene sulfonate) in mineral oil (CAS No. 25619-56-1; King Industries Na-Sul ® BSN, pH 10)

Example 6 - Determination of elastomer compatibility:

When selecting a suitable elastomer material, the chemical and physical resistance of the elastomer is often decisive in addition to the temperature application range. The elastomers are subject to effects of aging and wear, which in turn are decisive for the service life in the application.

To determine the elastomer compatibility with lubricants, elastomer test specimens (NBR and FKM test specimens) are embedded in formulations from Examples 1-5 and Comparative Examples 1-7, and the effect of the respective formulation on the elastomer material is examined. The change in material properties such as hardness, weight, volume, tensile strength or elongation at break after storage in the lubricant is determined as a measure of elastomer compatibility in comparison with the condition as supplied.

Storage experiments are carried out both in pure lubricating oil and in an oil-water emulsion using commercially available appliances.

The storage experiments in pure lubricating oil are carried out in accordance with the DIN ISO 1817 standard (DIN ISO 1817:2016-11). The following elastomer test specimens are exposed to the pure lubricating oil under the following measurement conditions:

FKM: 80 FKM 10061: 168 h / 150 °C;

85 FKM 245601: 168 h / 150 °C

NBR: ISO 6072 NBR 1: 1000 h / 100 °C

The storage experiments in oil-water emulsions are carried out based on DIN ISO 1817 (DIN ISO 1817:2016-11). The test oil is mixed (for 1600 ml oil: 85 ml water, for 1800 ml oil: 95 ml water) with 5% distilled water in a suitable test vessel (for example, flat flange beaker with groove of 2000 ml DN 120, with flat ground lid DN 120) and stirred until a homogeneous state is reached. The test specimens are completely immersed in the test oil and arranged in such a way that the distance to the side walls of the test vessel is at least 5 mm, the distance to the bottom of the vessel and to the surface of the test oil is at least 10 mm. After attaching a contact thermometer and a reflux condenser, the test vessel is closed to prevent water loss and the medium is heated with constant stirring. The following elastomer test specimens are exposed to an oil-water emulsion under the following measurement conditions:

FKM: 80 FKM 10061: 336 h / 80 °C

After the acting time in the pure lubricating oil or the oil-water emulsion has expired, the specimens are left to cool and cleaned. Subsequently, changes in the hardness, weight, volume, tensile strength and/or elongation at break of the elastomers after being stored in the lubricant compared to the delivered condition are determined according to the applicable standards:

- Change in volume, change in weight: Determination is carried out in each case according to DIN ISO 1817 (DIN ISO 1817:2016-11) Elastomers - Determination of the behavior towards liquids

The change in the volume or weight of the test specimen provides information about the migration of the test liquid into the interior of the material or the leaching or possibly dissolving of the material.

- Change in Shore A hardness: Determination is carried out according to DIN ISO 7619-1 (DIN ISO 7619-1:2012-02) Elastomers or thermoplastic elastomers - Determination of the penetration depth

- Part 1: Durometer method (Shore hardness)

Hardness is generally referred to as the mechanical resistance of the material when a harder test specimen penetrates it.

- Change in tensile strength and elongation at break: Determination is carried out according to DIN 53504 (DIN 53504:2017-03) - Testing of rubber and elastomers - Determination of tensile strength, elongation at break and stress values in the tensile experiment

The measurement results of the static elastomer storage in pure lubricating oil are given in Tables 1 to 3 below:

Table 1a (80 FKM 10061/150 °C/168 h):

Parameter	Example 1	Example 2	Example 3	Comparative
Change in weight, %	0.3	0.4	0.4	Not measurable
Change in volume, %	0.9	0.5	0.5	Not measurable
Change in Shore A	0	0	0	Not measurable
Change in Tensile	-2	6	9	Not measurable
Change in elongation at	-16	17	21	Not measurable

Table 1b (85 FKM 245601/150 °C/168 h):

Parameter	Example 1	Example 2	Example 3	Comparative
Change in weight, %	0.1	0.1	0.1	Not measurable
Change in volume, %	0.2	0.3	0.2	Not measurable
Change in Shore A	0	-1	-1	Not measurable
Change in Tensile	-8	-8	-11	Not measurable
Change in elongation at	-6	-5	-9	Not measurable

As can be seen from Tables 1a and 1b, after storage in the lubricant compositions of Examples 1, 2 and 3 according to the invention, each of which contains an OSP, an antioxidant and a neutral corrosion inhibitor, the test specimens show only slight changes in volume, weight, Shore A hardness, tensile strength and elongation at break, which means that the lubricant compositions have good compatibility with elastomers. In contrast, the lubricant composition according to Comparative Example 1, which contains an OSP and a neutral corrosion inhibitor, but no antioxidants, does not lead to any measurable results, since the lubricant composition begins to decompose under the selected conditions before the end of the experiment. The results show a synergistic effect between the components of the lubricants according to the invention.

Table 2 (80 FKM 10061/150 °C/168 h):

Parameter	Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5	Comparative Example 6
Change in Tensile Strength, %	-2	-25	-21	-24	-9	-12
Change in elongation at break, %	-16	-46	-40	-52	-42	-44

As can be seen from Table 2, after storage in the lubricant composition of Example 1 according to the invention, which contains an OSP, an antioxidant and a neutral corrosion inhibitor (TAN <10 mg KOH/g), the test specimen shows significantly smaller changes in the tensile strength and the elongation at break compared to storage in the lubricant compositions of the Comparative Examples, which contain acidic corrosion inhibitors in addition to OSP and antioxidants (TAN>100 mg KOH/g). The results show a synergistic effect between the components of the lubricants according to the invention to the effect that elastomer compatibility can be improved when a suitable corrosion inhibitor is selected.

Table 3 (ISO 6072 NBR 1 / 100 °C/1000 h):

Parameter	Example 1	Example 4
Change in weight, %	4.8	5.8
Change in volume, %	5.6	6.5
Change in Shore A hardness	1	-2
Change in Tensile Strength, %	-28	-18
Change in elongation at break, %	-54	-40

As can be seen from Table 3, after storage in the lubricant compositions of Examples 1 and 4 according to the invention, the test specimens show comparable changes in terms of weight, volume and Shore A hardness, whereas the storage in the lubricant compositions of Example 4 leads to a smaller change in the tensile strength and elongation at break on the test specimen. The results show that the increase in the proportion of OSP in the lubricant composition according to Example 4 leads to a further increase in the compatibility of the lubricant composition with respect to NBR.

The measurement results of the static elastomer storage in oil-water emulsions are given in Table 4 below:

Table 4 (80 FKM 10061 / oil+5% water; 80 °C; 336 h)

Parameter	Example 1	Example 3	Example 5	Comparative Example 7	Comparative Example 8	Comparative Example 9	Comparative Example 10	Comparative Example 11
Change in weight, %	2.2	2.3	2.7	7.9	6.1	11.6	4.3	8.2
Change in volume, %	3.1	2.8	3.8	13.9	10.6	20.5	6.6	14.2

As can be seen from Table 4, compared to Comparative Examples 7-11, only slight changes in the weight and volume of the test specimen are observed in the lubricant compositions according to the invention of Examples 1, 3 and 5, which contain both an ester and an OSP as base oil components, which means increased elastomer compatibility. In particular, comparison of the measurement results with the formulations from Comparative Examples 7, 8 and 9, which contain esters as the base oil component, with otherwise the same additives (in particular see Example 1/Comparative Example 8, Example 3/Comparative Example 9, Example 5/Comparative Example 7), shows that the absence of an OSP leads to worse values with regard to the change in weight and in particular the change in volume of the test specimen, and thus leads to reduced elastomer compatibility. The formulations of Comparative Examples 10 and 11 contain a basic corrosion inhibitor.

CLAIMS

1. A lubricant composition, comprising:

- an oil-soluble polyalkylene glycol;
- an ester compound selected from the group consisting of natural esters and synthetic esters, as well as combinations thereof; and
- a mixture of additives comprising an antioxidant and a corrosion inhibitor,

wherein the corrosion inhibitor is selected from neutral alkali and alkaline earth salts of sulfonic acids, carboxylic acids, naphthoic acids, naphthenic acids, benzoic acids and phosphoric acids, and derivatives and combinations thereof.

2. The lubricant composition according to claim 1, wherein the neutral alkali and alkaline earth salts are Na salts, Ca salts, K salts and Mg salts.

3. The lubricant composition according to claim 1 or 2, wherein the corrosion inhibitor is selected from neutral calcium sulfonates and derivatives thereof.

4. The lubricant composition according to any one of claims 1 to 3, wherein the antioxidant is selected from phenolic antioxidants, aminic antioxidants, phosphites and sulfur-containing compounds, and combinations thereof.

5. The lubricant composition according to any one of claims 1 to 4, wherein the antioxidant is selected from phenolic antioxidants, aminic antioxidants, thiocarbamates and dithiocarbamates, and combinations thereof.

6. The lubricant composition according to any one of claims 1 to 5, wherein the antioxidant is selected from aminic antioxidants.

7. The lubricant composition according to any one of claims 1 to 6, wherein the mixture of

additives further comprises a non-ferrous metal deactivator selected from triazoles, mercapthiadiazoles and salicylates and combinations thereof.

8. The lubricant composition according to claim 7, wherein the non-ferrous metal deactivator is selected from triazoles.

9. The lubricant composition according to any one of claims 1 to 8, wherein the ester compound is selected from natural glyceride esters in the monomeric, oligomeric and/or polymerized form, in particular from the group consisting of sunflower oil, rape oil or rapeseed oil, linseed oil, corn oil, safflower oil, soybean oil, linseed oil, peanut oil, "Lesqueralle" oil, palm oil, olive oil; and synthetic esters from the group consisting of polyol esters, polyol complex esters, complex esters of dimer acids, dimer acid esters, aliphatic carboxylic acid and dicarboxylic acid esters, phosphate esters, and trimellitic and pyromellitic acid esters and estolides; as well as combinations thereof.

10. The lubricant composition according to any one of claims 1 to 9, wherein the ester compound is selected from polyol esters and polyol complex esters, and combinations thereof.

11. The lubricant composition according to any one of claims 1 to 10, wherein the ester compound is selected from neopentyl glycol esters, trimethylolpropane esters and pentaerythritol esters, which are esterified with saturated and/or mono- or polyunsaturated, linear and/or branched monocarboxylic acids of chain length C4-C36; and neopentyl glycol complex esters, trimethylolpropane complex esters and pentaerythritol complex esters, which are fully esterified or partially esterified with saturated and/or mono- or polyunsaturated, linear and/or branched monocarboxylic acids of chain length C4-C36 and saturated and/or mono- or polyunsaturated, linear and/or branched dicarboxylic acids of chain length C4-C36 in any mixture; as well as combinations thereof.

12. The lubricant composition according to claim 11, wherein the neopentyl glycol esters, the trimethylolpropane esters and the pentaerythritol esters are esterified with saturated and/or mono- or polyunsaturated, linear and/or branched monocarboxylic acids of chain length C18-C36, respectively; and the neopentyl glycol complex esters, the trimethylolpropane complex

esters and the pentaerythritol complex esters are fully esterified or partially esterified with saturated and/or mono- or polyunsaturated, linear and/or branched monocarboxylic acids of chain length C18-C36 and saturated and/or mono- or polyunsaturated, linear and/or branched dicarboxylic acids of chain length C4-C36 in any mixture, respectively; as well as combinations thereof.

13. The lubricant composition according to any one of claims 1 to 12, wherein the oil-soluble polyalkylene glycol is a copolymer selected from polybutylene oxide-polypropylene oxide-copolymers, polybutylene oxide-polyethylene oxide-copolymers, and polybutylene oxide-polypropylene oxide-polyethylene oxide-copolymers, as well as combinations thereof.

14. The lubricant composition according to any one of claims 1 to 13, wherein the oil-soluble polyalkylene glycol is a copolymer selected from polyisobutylene oxide-polyisopropylene oxide-copolymers, polyisobutylene oxide-polyethylene oxide-copolymers, and polyisobutylene oxide-polyisopropylene oxide-polyethylene oxide-copolymers, as well as combinations thereof.

15. The lubricant composition according to claim 13 or 14, wherein the oil-soluble polyalkylene glycol-copolymer is an alcohol-initiated copolymer, and in particular a copolymer having a C10-C20 alkyl group attached to at least one terminal end thereof.

16. The lubricant composition according to any one of claims 1 to 15, wherein the oil-soluble polyalkylene glycol has a molecular weight M_n of 500 g/mol or up to 1400 g/mol or less.

17. The lubricant composition according to any one of claims 1 to 16, wherein the ester compound is contained in an amount of 0.1 - 85% by weight based on the total lubricant composition.

18. The lubricant composition according to any one of claims 1 to 17, wherein the mixture of additives is contained in an amount of 0.1 - 20% by weight based on the total lubricant composition.

19. The lubricant composition according to any one of claims 1 to 18, wherein the mixture of

additives further comprises one or more additives selected from anti-wear agents, friction reducers, high-pressure additives, ion complexing agents, solid lubricants, dispersants, pour point and viscosity improvers, UV stabilizers, emulsifiers, color indicators, sliding improvers and defoamers.

20. A use of a lubricant composition according to any one of claims 1 to 19 as gear oil, rolling bearing oil, hydraulic oil or sliding bearing oil in the marine field and in the field of inland waters, in particular for the lubrication of gears, hydraulic systems, propeller rudders, propeller shafts, linear guides, pneumatic components, fittings, bearings, such as sliding bearing, rolling bearing or stern tube bearing, chains, ropes, springs, valves and screws in machines, machine structural elements and facilities that come into contact with water, as well as in on-shore machines and machine elements that come into contact with water and/or aqueous media.