Environmentally friendly lubricating grease for steel ropes

Description

The invention relates to an environmentally friendly lubricating grease for steel ropes, in particular zinc-~~plated~~ coated steel ropes. The invention also relates to a method for producing the lubricating grease and its use.

Lubricants for steel ropes are used to separate the individual rope strands from one another by means of a lubricating film, i.e. to lubricate them and thereby reduce wear, as well as to protect the steel rope as a whole against corrosion. Depending on their respective field of application, the lubricants must fulfill various additional tasks. So it is for example in the range of the marine industry and in the oil and gas industry necessary that, the lubricants not only have a good lubricating effect but also are usable in a wide temperature range and also in the presence of water. Furthermore, if zinc-~~plated~~ coated steel ropes are used, the lubricants ~~shall~~ must have no negative influence on the zinc ~~layer~~ coating of the steel rope.

In addition, there is in principle an increasing need for environmentally friendly lubricants, in particular lubricants which meet the ~~preconditions~~ requirements for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit and can therefore also be used for components which may come into contact with seawater. Environmentally friendly lubricants must be biodegradable and shall have only a minimal toxicity and no bioaccumulatability.

A wide variety of lubricants for steel ropes are described in the literature.

CH 540331 A describes a lubricant for steel ropes, which contains, as the main component, a saturated or unsaturated fatty acid with 5-30 C-atoms or an ester of such an acid or a mixture thereof.

EP 0108536 A1 describes a corrosion protection composition, comprising a corrosion inhibitor, a thickening agent and a thixotropic gel. The corrosion protection composition can be used to treat multi-wire electrical conductors, wire ropes or cables.

US 4589990 A describes a lubricant composition, which contains specific synthetic esters, namely polyol esters, trimellitate esters and polymeric fatty acid esters and a mixture of polyisobutylene polymers with different molecular weights. The lubricant composition can among other things also be used to treat wire ropes.

US 4486319 A describes a microporous lubricating composition, which contains an ionomer polymer and a liquid lubricant. The ionomer polymer can be combined with other polymers, and the composition can contain various additives to modify the performance and properties of the formed composition. The formed composition can be used to lubricate mechanical components including wire ropes and bearings, such as sliding bearings.

CA 2364200 describes a lubricating composition for lubricating wire ropes, comprising: (a) between 50 and 95 volume percent of a base fluid; (b) between 1 and 8 volume percent of a lubricant with low acid content; (c) between 0.2 and 5.0 volume percent of a corrosion inhibitor with low acidity; (d) between 0.1 and 10 volume percent of an extreme pressure medium; and (e) between 0.1 and 10 volume percent of an antiwear agent.

US6329073 B1 describes a steel article, treated with a corrosion-inhibiting and adhesion-resistant composition, wherein the composition comprising: A) an oily or waxy carrier as carrier of active components and B) active components, comprising: B1) a corrosion inhibitor in the form of a sulphonate of the Group IIA; B2) a co-corrosion inhibitor, selected from the group consisting of: (a) one or more fatty acids with 6 to 24 carbon atoms, aromatic acids and naphthenic acids, wherein the acids have the free acid form or the salt form; (b) one or more imidazoline derivatives with a C6-24-alkyl unit; and (c) one or more of C6-24-alkyl succinic acid anhydride compounds; and (d) mixtures of one or more of the compounds defined under (a), (b) and (c) or mixtures of multiple forms of the compounds defined under (a), (b) and (c); and C) optionally a compound selected from the group consisting of: C1) a water-repellent agent; C2) a synthetic ester, which is derived from a C1-10-alcohol with 1-12 hydroxyl groups and C6-24-fatty acids; and C3) a C6-18-alcohol; and C4) a mixture from one or more of the compounds defined under C1), C2) and C3) or mixtures of several forms of the compounds defined under C1), C2) and C3); wherein the elongated steel ~~object~~ article is a hard drawn steel wire.

US 6010985 A describes a non-toxic lubricant, fat or gel composition, comprising a combination of: at least one base ~~stock~~ oil from about 45 to about 90 wt.%; at least one

polymer of about 10 to about 20 wt.%, which is at least partially miscible with the at least one base ~~stock~~oil; and about 1 to about 50 wt.% of at least one silicate thickening agent, which comprises at least one compound selected from the group consisting of aluminum silicate, magnesium silicate, sodium silicate, calcium silicate, potassium silicate, lithium silicate, and ammonium silicate.

CN 102102047 A describes a protective grease composition for a high-temperature-resistant steel wire rope and a production method therefor. The lubricating grease composition is made from base ~~stock~~ oil (high viscosity mineral oil or synthetic oil), a thickening agent, an additive and a covering agent. The lubricating grease for the steel wire rope is made by thickening the base ~~stock~~ oil with a solid hydrocarbon thickening agent. The thickening agent is bentonite. A high molecular tackifier and a lubricating grease as a solid filler are used to improve the performance, high temperature resistance and adhesive strength of bentonite-lubricating grease. The protective grease for the steel wire rope is specially used to protect steel wire ropes in an extremely high temperature environment.

CN 102618371 A describes a steel rope grease with a high dropping point and a processing method for the steel rope grease. The steel rope grease consists of the following components (in weight percent): 65 % - 85 % base ~~stock~~oil, 5 % - 20 % thickening agent, 2 % - 15 % adhesive, 1 % - 6% rust protection agent, 0 - 5 % antioxidant, 0 - 5 % polar additive and 0.5 % - 6 % solid lubricant.

CN 102827678 A describes a wire rope lubricating grease composition, which, in addition to lubrication, also offers corrosion protection. The composition consists of the following components: 51.0 % to 72.5 % calcium sulfonate composite grease No. 2, 25.0 to 38.0 % base ~~stock~~oil, 0.2 to 1.0 % diphenylamine, 1.3 to 5.5 % colloidal graphite and 1.0 to 4.5 % ozocerite. The product is suitable for the lubrication and protection of various wire ropes under oceanic climatic conditions such as sea ports, seagoing vessels, offshore drilling platforms, etc.

However, the aforementioned lubricants do not meet all of the above-mentioned preconditions, namely, in addition to having a good lubricating effect, to be usable in a wide temperature range and also in the presence of water, and in addition thereto, to meet the preconditions for environmentally ~~friendly~~ acceptable lubricants (EAL ~~=~~

~~Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

The invention is therefore based on the task of providing a lubricant which meets the aforementioned preconditions.

In one embodiment, the invention provides an~~This task is solved by an~~ environmentally ~~friendly~~ acceptable lubricating grease, comprising:

a) from 50 wt.% to 90 wt.% of a biodegradable base ~~stock~~oil, in particular of a biodegradable ester as base ~~stock~~oil,
b) from 3 wt.% to 25 wt.% and/or 7 wt.% to 20 wt.% of a thickening agent selected from
    b1) from 3 wt.% to 12 wt.% biodegradable calcium soap,
    b2) from 3 wt.% to 25 wt.% and/or 3.5 wt.% to 20 wt.% and/or 4 wt.% to 12 wt.% bentonite,
    b3) and mixtures thereof,
c) from 4 wt.% to 40 wt.%, preferably from 7 wt.% to 40 wt.% additives, comprising
    c1) from 1 wt.% to 12 wt.% and/or 4 wt.% to 12 wt.% pyrogenic silicon dioxide and/or polytetrafluoroethylene and mixtures thereof,
    c2) from 2 wt.% to 45 wt.% and/or 2 wt.% to 25 wt.% of a polymer selected from polyisobutylene, polyisobutylene-/butene copolymer, polymethacrylates, polyesters, preferably complex esters, in particular complex esters from neopentylglycol/dimeric acid/2-ethylhexanol and mixtures thereof,
    c3) from 0.5 wt.% to 20 wt.% and/or 1 wt.% to 10 wt.% of a solid lubricant.

The applicant has found in extensive tests that it is possible to provide an environmentally ~~friendly~~ acceptable lubricant with a lubricating grease of the aforementioned composition, which combines outstanding lubricating properties when used on steel ropes, in particular zinc-~~plated~~ coated steel ropes, with usability even in the presence of water and in a wide temperature range.

Thus, in a preferred embodiment of the invention, the lubricating grease has a dropping point according to standard DIN ISO 2176 of over 150 °C, for example from 150 °C to 300 °C and/or from 170 °C to 300 °C and/or from 200 °C to 290 °C. In a further preferred

embodiment of the invention, the lubricating grease has ~~an upper service~~a maximum operating temperature (~~obere Gebrauchstemperatur, OGT~~MOT) according to standard DIN 58397 part 1 of at least 150 °C, for example from 150 °C to 200 °C and/or 150 °C.

According to the invention, at least 75 wt.%, for example from 75 wt.% to 100 wt.%, more preferably at least 80 wt.%, for example from 80 wt.% to 100 wt.% and/or from 85 wt.% to 100 wt.% and/or from 75 wt.% to 90 wt.% of the lubricating grease consists of biodegradable and non-toxic ingredients. The lubricating grease can also contain up to 25 wt.% of non-biodegradable components, provided that these are not bioaccumulating and/or only minimally toxic. The lubricating grease according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit. Thus the lubricating grease can also be used for applications that may come into contact with seawater.

In addition, it was found that the components a) to c) have no negative influence on the zinc layer of zinc-~~plated~~ coated steel ropes and in particular enter into no reaction with the zinc layer.

~~As component a), the~~The lubricating grease ~~contains~~ comprises the following component a): at least 50 wt.%, for example from 50 wt.% to 90 wt.%, more preferably at least 60 wt.%, for example from 60 wt.% to 80 wt.%, and in particular from 65 wt.% to 75 wt.% of a biodegradable base ~~stock~~oil, in particular of a biodegradable ester as base ~~stock~~oil. ~~In this connection, the~~The proportion of ~~the~~ component (a) is ~~in each case related to~~based on the total quantity of the lubricating grease.

According to the invention, a biodegradable base ~~stock~~ oil or ~~a~~ biodegradable ester is to be understood as meaning a base ~~stock~~ oil and/or an ester, which is biodegradable in accordance with standard OECD 301 A-F or OECD 306.

According to the invention, mixtures of different base ~~stocks~~ oils and/or different esters can also be used. In order for the ~~lubricant~~ lubricating grease to meet the requirements for EAL, the base ~~stock~~ oil or the ester must also have no toxicity.

According to the invention, a large number of biodegradable base ~~stocks~~ oils and in particular of biodegradable esters can be used as component a), provided that these have

a sufficient thermal stability. Preferred biodegradable base ~~stocks~~ oils are base ~~stocks~~ oils and in particular esters, which have a thermal stability, determinable via TGA (DIN 51006; evaporation loss greater than 1 wt.% means thermally unstable) of over 150 °C, for example in the range 150 °C to 200 °C.

The base ~~stock~~ oil and in particular the ester preferably also has ~~a rather~~ low volatility. Therefore, preferred biodegradable base ~~stocks~~ oils are base ~~stocks~~ oils and in particular esters, which have a volatility, measured according to DIN 58397 according to 7d, 150 °C of < 10 wt.%, preferably < 5 wt.%.

The lubricating grease preferably also has ~~a rather~~ low volatility. Therefore, preferred lubricating greases are lubricating greases which have a volatility, measured according to DIN 58397 according to 7d, 150 °C of < 10 wt.%, preferably < 5 wt.%.

In addition, the base ~~stock~~ oil and in particular the ester preferably shows a high hydrolytic stability. For this reason, preferred biodegradable base ~~stocks~~ oils are base ~~stocks~~ oils and/or esters, which have a TAN Delta (change in acid content) from 0.0 to 20 mg KOH/g, more preferably from 0.0 to 15 mg KOH/g, measured according to DIN ASTM D-2619 (with extended running time of 400 h, 93 °C).

Finally, the base ~~stocks~~ oils and in particular the esters preferably have a low acid content (TAN) according to DIN EN 12634, wherein preferred biodegradable base ~~stocks~~ oils and in particular esters have an acid content (TAN) of less than 5 mg KOH/g, for example from 0.01 mg to 5 mg KOH/g, more preferably of less than 1 mg KOH/g, for example from 0.01 mg KOH/g to 1 mg KOH/g.

The viscosity of the biodegradable base ~~stock~~ oil is preferably at least 18 mm^2/s, for example from 18 mm^2/s to 1200 mm^2/s and/or at least 100 mm^2/sec, for example from 100 mm^2/sec to 1200 mm^2/s and/or from 120 to 500 mm^2/sec and/or from 120 to 300 mm^2/sec, each measured according to DIN EN ISO 3104 at 40 °C.

The viscosity of preferred mixtures ~~from~~ of base ~~stocks~~ oils measured according to DIN 51562 part 1 at 40 °C is at least 18 mm^2/s, for example from 18 mm^2/s to 1200 mm^2/s and/or 18 mm^2/s to 500 mm^2/s and/or 18 to 200 mm^2/s.

The viscosity of preferred biodegradable esters is preferably at least 50 mm^2/sec, for example from 50 mm^2/sec to 1000 mm^2/s and/or from 50 mm^2/sec to 1200 mm^2/s, more preferably at least 100 mm^2/sec, for example from 100 mm^2/sec to 1000 mm^2/s and/or from 100 mm^2/sec to 1200 mm^2/s and in particular from 130 to 1000 mm^2/sec and/or from 130 mm^2/sec to 1200 mm^2/s, each measured according to DIN EN ISO 3104 at 40 °C.

In a preferred embodiment of the invention, the biodegradable ester is a synthetic ester. Furthermore, the ester is particularly preferably ~~an~~ a renewable ester ~~on a renewable basis~~. An ester particularly preferred according to the invention is a polyol ester, in particular (trimethylolpropane) ester, pentaerythritol ester, mixtures and/or complex esters thereof.

~~Particularly preferred~~ (~~trimethylolpropane~~Trimethylolpropane) esters ~~are esters~~derived from trimethylolpropane and branched or unbranched ~~and~~ or saturated or unsaturated C_{10}-C_{22}-carboxylic acids are particularly preferable. The acids can be mono- and/or dicarboxylic acids. If dicarboxylic acids are used, complex esters can be obtained. Particularly preferred pentaerythritol esters are esters derived from pentaerythritol and branched or unbranched and saturated or unsaturated C_{10}-C_{22}-carboxylic acids. Most particularly preferred esters are esters derived from trimethylolpropane or pentaerythritol with saturated or unsaturated branched C_{18}-carboxylic acids, in particular with oleic acid, isostearic acid mixtures and/or complex esters thereof. Likewise particularly preferred esters are esters derived from trimethylolpropane with saturated or unsaturated, branched or unbranched, C_8-C_{20}-carboxylic acids, and/or C_{10}-C_{22}-carboxylic acids, in particular with sebacic acid, stearic acid and isostearic acid, mixtures and/or complex esters thereof.

Likewise particularly preferred esters are complex esters derived from trimethylolpropane with saturated, branched or unbranched, C_8-C_{20}-carboxylic acids and/or C_{10}-C_{22}-carboxylic acids, in particular with sebacic acid, stearic acid and isostearic acid, and/or mixtures thereof. Likewise particularly preferred esters are complex esters derived from trimethylolpropane with a mixture from at least two saturated or unsaturated, branched or unbranched, C_8-C_{20}-carboxylic acids and/or C_{10}-C_{22}-carboxylic acids, wherein at least one ~~first~~ carboxylic acid is a saturated or unsaturated, branched or unbranched C_8-C_{20}-dicarboxylic acid and/or C_{10}-C_{22}-dicarboxylic acid and at least one ~~second~~ other acid is a saturated or unsaturated, branched or unbranched C_8-C_{20}-carboxylic acid and/or C_{10}-C_{22}-~~Carboxylic~~ carboxylic acid. Likewise particularly preferred esters are complex esters ~~of~~ derived from trimethylolpropane with a mixture from at least two saturated, branched or unbranched, C_8-C_{20}-carboxylic acids and/or C_{10}-C_{22}-carboxylic acids, wherein at least one

~~first~~ carboxylic acid is a saturated, unbranched C_8-C_{12}-dicarboxylic acid, in particular sebacic acid, and at least one ~~second~~ other acid is a saturated, branched or unbranched C_{15}-C_{20}-carboxylic acid, in particular stearic acid, isostearic acid or a mixture thereof.

In a preferred embodiment of the invention, the component a) is not a triglyceride, since triglycerides ~~have at least for some applications and~~demonstrate unsatisfactory hydrolytic ~~and~~ , oxidative or chemical stability, at least for certain applications.

Likewise suitable biodegradable base ~~stocks~~ oils are polyalphaolefins and / or polyglycols.

Particularly preferred biodegradable polyalphaolefins have a viscosity measured according to DIN 51562 part 1 at 100 °C of at most 6 mm^2/s, for example from 2mm^2/s to 6 mm^2/s and/or 2 mm^2/s to 5 mm^2/s and/or 2 to 4 mm^2/s.

Particularly preferred biodegradable polyglycols are oil-soluble polyglycols. These preferably have a viscosity measured according to DIN 51562 part 1 at 40 °C of at most 150 mm^2/s, for example from 18 mm^2/s to 150 mm^2/s and/or 18 mm^2/s to 68 mm^2/s and/or 18 to 46 mm^2/s.

As component b), the lubricating grease contains a thickening agent selected from biodegradable calcium soaps (b1)) in a quantity of 3 to 12 wt.%, more preferably of 4 wt.% to 10 wt.%, in particular of 4 wt.% to 7 wt.%, bentonites (b2)) in a quantity of 3 wt.% to 25 wt.% and/or 3.5 wt.% to 20 wt.% and/or 4 to 12 wt.%, more preferably of 4 wt.% to 10 wt.% and mixtures thereof. According to the invention, the proportion of the thickening agent is 3 wt.% to 25 wt.% and/or 7 wt.% to 20 wt.%. ~~In this connection, the~~ The proportion of ~~the~~ component b) is ~~in each case related to~~based on the total quantity of the lubricating grease.

The advantage of using calcium soap as a thickening agent is that it increases the resistance to water, ~~in particular~~ in combination with the component c2).

According to the invention, a biodegradable calcium soap is to be understood as meaning a calcium soap which is biodegradable according to standard OECD 301 A-F and/or OECD 306. In order for the ~~lubricant~~ lubricating grease to meet the requirements for EAL, the calcium soap must also have no or only minimal toxicity. Preferred calcium soaps are water-resistant, in particular they have a static water resistance according to DIN 51807 T1.

According to the invention, calcium soaps are preferred over bentonites, since they have a higher thickening effect and better biodegradability. Mixtures of different calcium soaps or bentonites can also be used.

Calcium soaps of fatty acids, in particular C_8-C_{26} fatty acids, in particular ~~calcium-~~C_{12}-hydroxystearate, are particularly preferred.

In principle, mixtures from calcium soaps and bentonites can also be used. However, this embodiment is less preferred, at least when using zinc-~~plated~~ coated steel ropes, since the zinc corrosion is worsened compared with the isolated use of calcium soaps or bentonites.

It is conceivable that the base ~~stock~~ oil contains from 1 wt.% to 40 wt.% additives as component c). According to the invention, the base ~~stock~~ oil contains 4 wt.% to 40 wt.%, more preferably from 5 wt.% to 40 wt.%, more preferably from 7 wt.% to 40 wt.% and in particular from 10 wt.% to 35 wt.% additives. ~~In this connection, the~~ The proportion of ~~the~~ component c) is ~~in each case related to~~based on the total quantity of the lubricating grease.

According to the invention, the additives of the component c) comprise from 1 to 12 wt.% and/or 4 to 12 wt.%, preferably from 4 wt.% to 10 wt.% pyrogenic silicon dioxide and/or polytetrafluoroethylene as component c1). ~~In this connection, the~~ The proportion of ~~the~~ component c1) is ~~in each case related to~~based on the total quantity of the lubricating grease.

In a particularly preferred embodiment of the invention, the pyrogenic silicon dioxide is selected from silicic acid with a specific surface area of 90 to 130 m^2/g. Hydrophobized pyrogenic silica, in particular a silicic acid hydrophobized by means of dichlorodimethylsilane, is likewise preferred.

The component c1) contributes to the improvement of the dropping point of the lubricating grease and thereby to its temperature resistance in the sense of an increase in the ~~upper service~~maximum operating temperature (~~obere Gebrauchstemperatur, OGT~~MOT). In addition, component c1) has the advantage that it can function as co-~~thickener~~ thickening agent and thereby contribute to stabilizing the ~~thickener~~ thickening system.

According to the invention, as component c2), the additives of the component c) comprise a polymer selected from polyisobutylene, polyisobutylene-/butene copolymer, polymethacrylates, polyesters, preferably complex esters, in particular complex esters from neopentyl glycol/dimer acid/2-ethylhexanol and mixtures thereof. According to the invention, a complex ester is understood to mean a polyester which is produced by reaction of polyols with dicarboxylic acids, and if appropriate, monocarboxylic acids. The proportion of the component c2) is 2 wt.% to 45 wt.%, preferably from 2 wt.% to 25 wt.%, more preferably from 5 wt.% to 20 wt.% and in particular from 7 wt.% to 17 wt.%, ~~related in each case to~~based on the total quantity of the lubricating grease.

The polymers of the component c2) preferably have a viscosity, measured according to DIN 51562 part 1 at 100 °C of at least 600 mm^2/s, more preferably of at least 800 mm^2/s and/or at least 1000 mm^2/s and/or at least 1500 mm2/s and/or at least 4000 mm^2/s, for example from 4000 mm^2/s to 10000 mm^2/s and/or from 4000 mm^2/s to 6000 mm^2/s, in particular from 4000 to 4700 mm^2/s. A high viscosity is advantageous because this allows the quantity used to be kept low. According to the invention, polyisobutylene and/or polyisobutylene-/butene copolymer is particularly preferred, since these are inexpensive raw materials and have no hydrolyzable groups, such as ester groups. Polymers that are biodegradable are also preferred.

The use of the component c2) is advantageous since, as a toxicologically harmless ~~adhesion improver~~bonding enhancer, it can improve the ~~adhesion~~bonding, measured according to ASTM D 4049 of < 50 wt.% loss, for example < 30 wt.% loss, more preferably of < 25 wt.% loss between lubricating grease and steel rope.

According to the invention, the lubricating grease therefore preferably has a weight loss in a water spray-off test according to ASTM D 4049 of < 50 wt.% loss, for example of < 30 wt.% loss, more preferably of < 25 wt.%.

According to the invention, as component c3), the additives of the component c) comprise from 0.5 wt.% to 20 wt.% and/or 1 wt.% to 10 wt.%, more preferably from 1 wt.% to 9 wt.% and in particular from 1.5 wt.% to 8 wt.% of a solid lubricant, preferably selected from alkaline earth salts, in particular calcium carbonate, calcium stearate, graphite, melamine cyanurate, zinc sulfide (ZnS), molybdenum sulfide (MoS2) and mixtures thereof. In this connection, the proportion of the component c3) is ~~in each case related to~~based on the total quantity of the lubricating grease.

The use of the aforementioned solid lubricants, in particular calcium carbonate, graphite, melamine cyanurate and calcium stearate as component c3), is particularly advantageous, since these compounds are toxicologically harmless and can significantly improve the friction properties of the steel rope.

According to the invention, less preferred solid lubricants are dithiocarbamates, in particular ashless dithiocarbamates, bis-stearoyl-ethylenediamine and mixtures thereof. It has been found in practical tests that the use of these compounds has a negative effect on the corrosion of the zinc layer. This is also disadvantageous from an environment-technical point of view, since zinc oxide ~~is toxic to aquatic organisms~~, which is produced when zinc corrodes, is toxic to aquatic organisms.

It is also conceivable that the lubricating grease contains from 0.5 wt.% and in particular from 0.5 to 2.8 wt.% succinic acid derivatives as ~~first~~ an anti-corrosion ~~protection~~ agent, in particular amidized succinic acid half-esters as component c4). In this connection, the proportion of the component c4) is ~~in each case related to~~based on the total quantity of the lubricating grease. The component c4) preferably has a neutralization number (NZ) (DIN 53402) of 70 to 100 mg KOH/g.

The use of the succinic acid derivatives is advantageous, since they are biodegradable and have a high corrosion protection effect.

In a preferred embodiment of the invention, the lubricating grease contains, as component c5), a second anti-corrosion ~~protection~~ agent, preferably selected from alkaline earth oxides, in particular calcium oxide and/or magnesium oxide, and calcium-, magnesium- and/or sodium sulfonates or salts of C_8-C_{20} dicarboxylic acids, in particular disodium sebacate. The advantages of the aforementioned components are that they offer good corrosion protection and are non-toxic. Magnesium oxide, disodium sebaccate and/or mixtures thereof are particularly preferred. In a further preferred embodiment of the invention, the component c5) has a particle size distribution d10 from 1 to 10 µm, more preferably from 3 to 8 µm, more preferably from 4 to 6 µm and in particular of 5 µm and/or a particle size distribution d50 from 10 to 30 µm, more preferably from 13 to 22 µm, more preferably from 15 to 20 µm and in particular of 17 µm and/or a particle size distribution d90 from 30 to 50 µm, more preferably from 35 to 45 µm and in particular of 40 µm. In a particularly preferred embodiment of the invention, the component c5) has a particle size

distribution d50 of less than 25 µm, for example from 5 µm to 25 µm and/or from 5 µm to 20 µm.

The advantage of using the component c5) is that it can act as a basic reserve in addition to increasing the corrosion protection of the lubricating grease. In addition, it has been found in practical tests that magnesium oxide acts synergistically as component c5) in combination with c4).

The proportion of the component c5) is preferably in the range from 0.3 to 5 wt.%, more preferably from 0.5 to 2.5 wt.% and in particular from 1 wt.% to 2.3 wt.%. In this connection, the proportion of the component c5) is ~~in each case related to~~based on the total quantity of the lubricating grease.

The lubricating grease can also contain other ~~customary~~ common additives, for example antioxidants, provided that these do not have a negative impact on the environmental acceptability of the lubricating grease. Thus, in a preferred embodiment of the invention, the lubricating grease contains an antioxidant as component c6). It is preferably selected from non-toxic or only minimally toxic antioxidants. The proportion of the antioxidant is preferably in the range from 0.3 to 3 wt.%, more preferably from 0.5 to 2 wt.%, and in particular from 0.8 wt.% to 1.5 wt.%. ~~In this connection, the~~ The proportion of the component c6) is ~~in each case related to~~based on the total quantity of the lubricating grease.

According to the invention, particularly preferred antioxidants are phenolic and/or aminic antioxidants.

In an embodiment of the invention, the lubricating grease comprises:

a) from 50 wt.% to 90 wt.% of a biodegradable ester as base ~~stock~~oil,
b) from 7 wt.% to 20 wt.% of a thickening agent selected from
    b1) from 3 wt.% to 12 wt.% biodegradable calcium soap,
    b2) from 4 wt.% to 12 wt.% bentonite,
c) from 4 wt.% to 40 wt.% additives, comprising
    c1) from 4 wt.% to 12 wt.% pyrogenic silicon dioxide and/or polytetrafluoroethylene and mixtures thereof,

c2) from 2 wt.% to 25 wt.% of a polymer selected from polyisobutylene, polyisobutylene-/butene copolymer, polymethacrylates, complex esters from neopentylglycol/dimeric acid/2-ethylhexanol and mixtures thereof,

c3) from 1 wt.% to 10 wt.% of a solid lubricant.

In a further preferred embodiment of the invention, the lubricating grease comprises:

a) from 50 wt.% to 90 wt.%, more preferably from 60 wt.% to 80 wt.%, more preferably from 65 wt.% to 75 wt.% pentaerythritol ester, in particular pentaerythritol ester from pentaerythritol and isostearic acid, as base ~~stock~~oil,

b) from 3 wt.% to 25 wt.% of a thickening agent selected from

b1) from 3 wt.% to 12 wt.%, more preferably from 4 wt.% to 10 wt.%, more preferably from 4 wt.% to 7 wt.%, Ca-12-hydroxystearate,

c) from 4 wt.% to 40 wt.%, more preferably from 5 wt.% to 40 wt.%, more preferably from 7 wt.% to 40 wt.%, more preferably from 10 wt.% to 35 wt.% additives, comprising

c1) from 1 wt.% to 12 wt.% and/or from 4 wt.% to 12 wt.%, preferably from 4 wt.% to 10 wt.% pyrogenic silicon dioxide,

c2) from 2 wt.% to 45 wt.% and/or from 2 wt.% to 25 wt.%, more preferably from 5 wt.% to 20 wt.% and in particular from 7 wt.% to 17 wt.%, polyisobutylene,

c3) from 0.5 wt.% to 20 wt.% and/or from 1 wt.% to 10 wt.%, more preferably from 1 wt.% to 9 wt.% and in particular from 1.5 wt.% to 8 wt.% calcium carbonate as solid lubricant.

In a further preferred embodiment of the invention, the lubricating grease comprises:

a) from 50 wt.% to 90 wt.%, more preferably from 60 wt.% to 80 wt.%, more preferably from 65 wt.% to 75 wt.% pentaerythritol ester, in particular pentaerythritol ester from pentaerythritol and isostearic acid, as base ~~stock~~oil,

b) from 3 wt.% to 25 wt.% of a thickening agent selected from

b1) from 3 wt.% to 12 wt.%, more preferably from 4 wt.% to 10 wt.%, more preferably from 4 wt.% to 7 wt.%, Ca-12-hydroxystearate,

c) from 4 wt.% to 40 wt.%, more preferably from 5 wt.% to 40 wt.%, more preferably from 7 wt.% to 40 wt.%, more preferably from 10 wt.% to 35 wt.% additives, comprising

c1) from 1 wt.% to 12 wt.% and/or from 4 wt.% to 12 wt.%, preferably from 4 wt.% to 10 wt.% pyrogenic silicon dioxide,

c2) from 2 wt.% to 45 wt.% and/or from 2 wt.% to 25 wt.%, more preferably from 5 wt.% to 20 wt.% and in particular from 7 wt.% to 17 wt.%, polyisobutylene,

c3) from 0.5 wt.% to 20 wt.% and/or from 1 wt.% to 10 wt.%, more preferably from 1 wt.% to 9 wt.% and in particular from 1.5 wt.% to 8 wt.% calcium carbonate as solid lubricant,

c5) from 0.3 to 5 wt.%, more preferably from 0.5 to 2.5 wt.% and in particular from 1 wt.% to 2.3 wt.% magnesium oxide as an anti-corrosion ~~protection~~ agent,

c6) from 0.3 to 3 wt.%, more preferably from 0.5 to 2 wt.%, and in particular from 0.8 wt.% to 1.5 wt.% of a phenolic antioxidant.

In a further preferred embodiment of the invention, the lubricating grease comprises:

a) from 50 wt.% to 90 wt.%, more preferably from 60 wt.% to 80 wt.%, more preferably from 65 wt.% to 75 wt.% complex esters, in particular complex esters of trimethylolpropane with a mixture from at least two saturated or unsaturated, branched or unbranched, C_8-C_{20}-carboxylic acids, wherein at least one ~~first~~ carboxylic acid is a saturated or unsaturated, branched or unbranched C_8-C_{20}-dicarboxylic acid, and at least one ~~second~~ other acid is a saturated or unsaturated, branched or unbranched C_8-C_{20}-carboxylic acid, as base ~~stock~~oil,

b) from 3 wt.% to 25 wt.% of a thickening agent selected from

b1) from 3 wt.% to 12 wt.%, more preferably from 4 wt.% to 10 wt.%, more preferably from 4 wt.% to 7 wt.%, Ca-12-hydroxystearate,

c) from 4 wt.% to 40 wt.%, more preferably from 5 wt.% to 40 wt.%, more preferably from 7 wt.% to 40 wt.%, more preferably from 10 wt.% to 35 wt.% additives, comprising

c1) from 1 wt.% to 12 wt.% and/or from 4 wt.% to 12 wt.%, preferably from 4 wt.% to 10 wt.% pyrogenic silicon dioxide,

c2) from 2 wt.% to 45 wt.% and/or from 2 wt.% to 25 wt.%, more preferably from 5 wt.% to 20 wt.% and in particular from 7 wt.% to 17 wt.%, polyisobutylene,

c3) from 0.5 wt.% to 20 wt.% and/or from 1 wt.% to 10 wt.%, more preferably from 1 wt.% to 9 wt.% and in particular from 1.5 wt.% to 8 wt.% calcium carbonate as solid lubricant.

In a further preferred embodiment of the invention, the lubricating grease comprises:

a) from 50 wt.% to 90 wt.%, more preferably from 60 wt.% to 80 wt.%, more preferably from 65 wt.% to 75 wt.% complex esters, in particular complex esters of trimethylolpropane with a mixture from at least two saturated, or unsaturated, branched or unbranched, C_8-C_{20}-carboxylic acids, wherein at least one ~~first~~ carboxylic acid is a saturated, or unsaturated, branched or unbranched C_8-C_{20}-dicarboxylic acid, and at least one ~~second~~ other acid is a saturated or unsaturated, branched or unbranched C_8-C_{20}-carboxylic acid as base ~~stock~~oil,

b) from 3 wt.% to 25 wt.% of a thickening agent selected from

   b1) from 3 wt.% to 12 wt.%, more preferably from 4 wt.% to 10 wt.%, more preferably from 4 wt.% to 7 wt.%, Ca-12-hydroxystearate,

c) from 4 wt.% to 40 wt.%, more preferably from 5 wt.% to 40 wt.%, more preferably from 7 wt.% to 40 wt.%, more preferably from 10 wt.% to 35 wt.% additives, comprising

   c1) from 1 wt.% to 12 wt.% and/or from 4 wt.% to 12 wt.%, preferably from 4 wt.% to 10 wt.% pyrogenic silicon dioxide,

   c2) from 2 wt.% to 45 wt.% and/or from 2 wt.% to 25 wt.%, more preferably from 5 wt.% to 20 wt.% and in particular from 7 wt.% to 17 wt.%, polyisobutylene,

   c3) from 0.5 wt.% to 20 wt.% and/or from 1 wt.% to 10 wt.%, more preferably from 1 wt.% to 9 wt.% and in particular from 1.5 wt.% to 8 wt.% calcium carbonate as solid lubricant,

   c5) from 0.3 to 5 wt.%, more preferably from 0.5 to 2.5 wt.% and in particular from 1 wt.% to 2.3 wt.% magnesium oxide as an anti-corrosion protection agent,

   c6) from 0.3 to 3 wt.%, more preferably from 0.5 to 2 wt.%, and in particular from 0.8 wt.% to 1.5 wt.% of a phenolic antioxidant.

A further subject of the present invention is the use of lubricating grease for coating steel ropes, in particular zinc-~~plated~~ coated steel ropes. Steel ropes provided with the lubricating grease according to the invention are because of their high resistance outstandingly suitable for a wide variety of applications in which high-performance ropes are required, for example in the marine industry and in the oil and gas industry.

The invention is explained in more detail below with the aid of several examples. All examples show excellent lubricating properties when used on steel ropes. Furthermore, they have a usability also in the presence of water and in a wide temperature range.

Example 1: Production of a lubricating grease according to the invention (lubricating grease 1)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2) and c3).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	75.0
b1)	Calcium-12-hydroxystearate	~~Thickener~~Thickening agent	6.0
c1)	Pyrogenic silicon dioxide	Additive	5.0
c2)	Isobutylene-/butene copolymer	~~Adhesion improver~~improves bonding	11.0
c3)	Calcium carbonate	Solid lubricant	3.0

All components of the lubricating grease 1 according to the invention are biodegradable, if not biodegradable, then not bioaccumulating and have no or only minimal toxicity. The lubricating grease 1 according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 1 are shown in Table 1:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 20 %
KL-PN 010	Zinc corrosion	< 0.01 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 2: Production of a lubricating grease according to the invention (lubricating grease 2)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	70.0
b1)	Calcium-12-hydroxystearate	~~Thickener~~Thickening agent	5.5
c1)	Pyrogenic silicon dioxide	Additive	4.0
c2)	Isobutylene-/butene copolymer	~~Adhesion improver~~Improves bonding	15.0
c3)	Calcium carbonate	Solid lubricant	2.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.5
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 2 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. The lubricating grease 2 according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 2 are shown in Table 2:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 20 %
KL-PN 010	Zinc corrosion	< 0.01 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 3: Production of a lubricating grease according to the invention (lubricating grease 3)

A lubricating grease according to the invention is obtained by mixing the components a), b1), b2), c1), c2) and c3).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	68.0
b1) (b3)	Calcium-12-hydroxystearate	~~Thickener~~Thickening agent	5.0
b2) (b3)	Bentonite	~~Thickener~~Thickening agent	4.0

c1)	Pyrogenic silicon dioxide	Additive	4.0
c2)	Isobutylene-/butene copolymer	~~Adhesion improver~~Improves bonding	6.0
c2)	Complex ester	~~Adhesion improver~~Improves bonding	10.0
c3)	Zinc sulfide	Solid lubricant	3.0

The components of the lubricating grease 3 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. The lubricating grease 3 according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 3 are shown in Table 3:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 10 %
KL-PN 010	Zinc corrosion	< 0.05 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 4: Production of a lubricating grease according to the invention (lubricating grease 4)

A lubricating grease according to the invention is obtained by mixing the components a), b1), b2), c1), c2) and c3).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	71.0
b1) (b3)	Calcium-12-hydroxystearate	~~Thickener~~Thickening agent	5.0
b2) (b3)	Bentonite	~~Thickener~~Thickening agent	3.0
c1)	Pyrogenic silicon dioxide	Additive	4.0
c2)	Isobutylene-/butene copolymer	~~Adhesion improver~~Improves bonding	9.0
c2)	Polymethacrylate	~~Adhesion improver~~Improves bonding	4.0
c3)	Zinc sulfide	Solid lubricant	4.0

The components of the lubricating grease 4 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. The lubricating grease 4 according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 4 are shown in Table 4:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 10 % (7 %)
KL-PN 010	Zinc corrosion	< 0.1 % (0.06 %)
DIN 58397 T1	Evaporation loss	< 5 %

Example 5: Production of a lubricating grease according to the invention (lubricating grease 5)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2) and c3).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	75
b1)	Calcium-12-hydroxystearate	~~Thickener~~Thickening agent	4
c1)	Pyrogenic silicon dioxide	Additive	6.0
c2)	Isobutylene-/butene copolymer	~~Adhesion improver~~Improves bonding	8.0
c2)	Polymethacrylate	~~Adhesion improver~~Improves bonding	2.0
c2)	Complex ester	~~Adhesion improver~~Improves bonding	3.0
c3)	Zinc sulfide	Solid lubricant	2.0

The components of the lubricating grease 5 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. The lubricating grease 5 according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 5 are shown in Table 5:

Standard	Test name	Result
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	1
ASTM D 4049	Water Spray-off	< 30 %
KL-PN 010	Zinc corrosion	< 0.02 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 6: Production of a lubricating grease according to the invention (lubricating grease 6)

A lubricating grease according to the invention is obtained by mixing the components a), b1), b2), c1), c2), c3), c4), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	64.0
b1) (b3)	Calcium-12-hydroxystearate	~~Thickener~~Thickening agent	4.0
b2) (b3)	Bentonite	~~Thickener~~Thickening agent	7.0
c1)	Pyrogenic silicon dioxide	Additive	4.0
c2)	Isobutylene-/butene copolymer	~~Adhesion improver~~Improves bonding	10.0
c3)	Calcium stearate	Solid lubricant	7.0
c4)	Succinic acid derivative	~~Corrosion protection~~Anti-corrosive	2.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	1.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 6 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. The lubricating grease 6 according to the invention therefore meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 6 are shown in Table 6:

Standard	Test name	Result
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 10 %
KL-PN 010	Zinc corrosion	< 0.1 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 7: Production of a lubricating grease according to the invention (lubricating grease 7)

A lubricating grease according to the invention is obtained by mixing the components a), b2), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Pentaerythritol ester	Base ~~stock~~oil	71.0
b2)	Bentonite	~~Thickener~~Thickening agent	12.0
c1)	Pyrogenic silicon dioxide	Additive	2.0
c2)	Complex ester	~~Adhesion improver~~Improves bonding	4.0
c2)	Polymethacrylate	~~Adhesion improver~~Improves bonding	3.0
c3)	Calcium stearate	Solid lubricant	5.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 7 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 7 according to the invention meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 7 are shown in Table 7:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	1
ASTM D 4049	Water Spray-off	< 20 %
KL-PN 010	Zinc corrosion	< 0.05 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 8: Production of a lubricating grease according to the invention (lubricating grease 8)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Pentaerythritol ester from pentaerythritol and isostearic acid	Base ~~stock~~oil	70.0
b1)	Ca-12-hydroxystearate	~~Thickener~~Thickening agent	6.0
c1)	Pyrogenic silicon dioxide	Additive	6.0
c2)	Polyisobutylene	~~Adhesion improver~~Improves bonding	13.0
c3)	Calcium carbonate	Solid lubricant	2.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 8 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 8 according to the invention meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 8 are shown in Table 8:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 10 %
KL-PN 010	Zinc corrosion	< 0.01 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 9: Production of a lubricating grease according to the invention (lubricating grease 9)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Complex esters based on trimethylolpropane, sebacic acid, stearic acid and isostearic acid	Base ~~stock~~oil	70.0
b1)	Ca-12-hydroxystearate	~~Thickener~~Thickening agent	7.0
c1)	Pyrogenic silicon dioxide	Additive	5.0
c2)	Polyisobutylene	~~Adhesion improver~~Improves bonding	11.0
c3)	Calcium carbonate	Solid lubricant	4.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 9 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 9 according to the invention meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 9 are shown in Table 9:

Standard	Test name	Result
DIN ISO 2176	Dropping point	> 200 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 5 %
KL-PN 010	Zinc corrosion	< 0.01 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 10: Production of a lubricating grease according to the invention (lubricating grease 10)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Oil soluble polyglycol	Base ~~stock~~oil	68.0
b1)	Ca-12-hydroxystearate	~~Thickener~~Thickening agent	8.0
c1)	Pyrogenic silicon dioxide	Additive	5.0
c2)	Complex ester	~~Adhesion improver~~Improves bonding	4.0
c2)	Polyisobutylene	~~Adhesion improver~~Improves bonding	14.0
c3)	Calcium carbonate	Solid lubricant	2.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 10 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 10 according to the invention meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 10 are shown in Table 10:

Standard	Test name	Result
DIN ISO 2176	Dropping point	≥ 150 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 65 %
KL-PN 010	Zinc corrosion	< 0.0005 %

Example 11: Production of a lubricating grease according to the invention (lubricating grease 11)

A lubricating grease according to the invention is obtained by mixing the components a), b2), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	70.0
b2)	Bentonite	~~Thickener~~Thickening agent	18.0
c1)	Polytetrafluoroethylene	Additive	1.0
c2)	Polyisobutylene	~~Adhesion improver~~Improves bonding	2.0
c3)	Calcium stearate	Solid lubricant	6.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 11 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 11 according to the invention meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 11 are shown in Table 11:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	≥ 200 °C
DIN 51807	Static water resistance	1
ASTM D 4049	Water Spray-off	< 15 %
KL-PN 010	Zinc corrosion	< 0.05 %
DIN 58397 T1	Evaporation loss	< 10 %

Example 12: Production of a lubricating grease according to the invention (lubricating grease 12)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	70.0
b1)	Ca-12-hydroxystearate	~~Thickener~~Thickening agent	7.0
c1)	Pyrogenic silicon dioxide	Additive	1.0
c2)	Polyisobutylene	~~Adhesion improver~~Improves bonding	17.0
c3)	Calcium stearate	Solid lubricant	2.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 12 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 12 according to the invention meets the

criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 12 are shown in Table 12:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	≥ 150 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 20 %
KL-PN 010	Zinc corrosion	< 0.005 %
DIN 58397 T1	Evaporation loss	< 5 %

Example 13: Production of a lubricating grease according to the invention (lubricating grease 13)

A lubricating grease according to the invention is obtained by mixing the components a), b1), c1), c2), c3), c5) and c6).

Components	Composition	Function	Quantity (wt.%)
a)	Polyol ester	Base ~~stock~~oil	60.0
b1)	Ca-12-hydroxystearate	~~Thickener~~Thickening agent	3.0
c1)	Pyrogenic silicon dioxide	Additive	8.0
c1)	Polytetrafluoroethylene	Additive	4.0
c2)	Polyisobutylene	~~Adhesion improver~~Improves bonding	5.0
c3)	Calcium stearate	Solid lubricant	17.0
c5)	Magnesium oxide	~~Corrosion protection~~Anti-corrosive	2.0
c6)	Phenolic antioxidant	Antioxidant	1.0

The components of the lubricating grease 13 according to the invention are also biodegradable, if not biodegradable, then not bioaccumulating, and have no or only minimal toxicity. In addition, the lubricating grease 13 according to the invention meets the criteria for environmentally ~~friendly~~ acceptable lubricants (EAL ~~= Environmentally Friendly Lubricants~~) according to Appendix A of the 2013 Vessel General Permit.

Physicochemical properties of the example 13 are shown in Table 13:

Standard	**Test name**	**Result**
DIN ISO 2176	Dropping point	≥ 150 °C
DIN 51807	Static water resistance	0
ASTM D 4049	Water Spray-off	< 20 %
KL-PN 010	Zinc corrosion	< 0.02 %
DIN 58397 T1	Evaporation loss	< 5 %

Claims

1. ~~An environmentally friendly~~ Environmentally acceptable lubricating grease, comprising:

a) ~~from~~ 50 ~~wt.%~~ to 90 wt.% of a biodegradable base ~~stock, in particular of a biodegradable ester as base stock~~oil,

b) ~~from~~ 3 ~~wt.%~~ to 25 wt.% and/or 7 ~~wt.%~~ to 20 wt.% of a thickening agent, selected from

b1) ~~from~~ 3 ~~wt.%~~ to 12 wt.% biodegradable calcium ~~soap~~soaps,

b2) ~~from~~ 3 ~~wt.%~~ to 25 wt.% and/or 3.5 ~~wt.%~~ to 20 wt.% and/or 4 ~~wt.%~~ to 12 wt.% bentonite,

~~b3) and~~

b3) mixtures thereof,

c) ~~from 4 wt.% to 40 wt.%, preferably from 7 wt.%~~ 4 to 40 wt.% additives, comprising:

c1) ~~from~~ 1 ~~wt.%~~ to 12 wt.% and/or 4 ~~wt.%~~ to 12 wt.% pyrogenic silicon dioxide and/or ~~polytetrafluoroethylene~~polytetrafluorethylene and/or mixtures thereof,

c2) ~~from~~ 2 ~~wt.% to 45 wt.% and/or 2 wt.%~~ to 25 wt.% of a polymer, selected from polyisobutylene, polyisobutylene-/butene copolymer, polymethacrylates, polyesters, ~~preferably~~and mixtures thereof, and

c3) 0.5 to 20 wt.% and/or 1 to 10 wt.% of a solid lubricant.

2. Lubricating grease as claimed in claim 1, wherein the biodegradable base oil is a biodegradable ester.

3. Lubricating grease as claimed in claim 1 or claim 2, wherein c) comprises 7 to 40 wt.% additives.

4. Lubricating grease as claimed in any one of claims 1 to 3, wherein the polyesters of c2) are complex esters~~, in particular~~ .

5. Lubricating grease as claimed in claim 4, wherein the complex esters are derived from ~~neopentylglycol/~~neopentyl glycol, dimeric ~~acid/~~acids, 2-ethylhexanol and mixtures thereof~~,~~.

~~c3) from 0.5 wt.% to 20 wt.% and/or 1 wt.% to 10 wt.% of a solid lubricant.~~

2. The 6. Lubricating grease as claimed in any one of claims 1 to 5, wherein the lubricating grease according to claim 1, **characterized by** a has a dropping point according to of greater than 150°C in accordance with standard DIN ISO 2176 of over 150 °C.

3. The 7. Lubricating grease as claimed in any one of claims 1 to 6, wherein the lubricating grease according to claim 1 or 2, characterized by an upper servicehas a maximum operating temperature (obere Gebrauchstemperatur, OGT) according to MOT) of at least 150°C in accordance with standard DIN 58397, Part 1 of at least 150 °C.

4. The 8. Lubricating grease according to as claimed in any one or more of the preceding claims, **characterized in that** 2 to 7, wherein the lubricating grease and/or the biodegradable ester of a) has a thermalthermic stability, determinable of 150 to 200°C as measured via TGA (DIN 51006) of 150 °C to 200 °C and/or a volatility, of <10 wt.% as measured according toin accordance with DIN 58397 of <10 wt.%, preferably <5 wt.% and/or a TAN delta, of 0.0 mg KOH/g to 20 mg KOH/g as measured according toin accordance with DIN ASTM D-2619 (with extended runningan increased run time of 400 h) from 0.0 mg KOH/g to 20 mg KOH/g and/or an acid content (TAN) of less than 5 mg KOH/g.

5. The 9. Lubricating grease as claimed in claim 8, wherein the lubricating grease according to one and/or morethe biodegradable ester has a volatility of the preceding< 5 wt.% as measured in accordance with DIN 58397.

10. Lubricating grease as claimed in any one of claims, **characterized in that** 2 to 9, wherein the viscosity of the biodegradable ester of a) is at least 50 mm^2/sec.

6. The 11. Lubricating grease according to as claimed in any one or more of the preceding claims, **characterized in that** the degradable 1 to 10, wherein the biodegradable calcium soap of b1) is selected from at least one calcium soaps of soap derived from a fatty acids, in particular calcium acid.12-hydroxystearate.

7. The 12. Lubricating grease according to one or moreas claimed in claim 11, wherein the at least one calcium soap derived from a fatty acid is calcium-12-hydroxy stearate.

13. Lubricating grease as claimed in any one of ~~the preceding~~ claims~~,~~ ~~**characterized in that**~~ 1 to 12, wherein the pyrogenic silicon dioxide ~~(~~of c1) is ~~selected from~~at least one silicic acid with a specific surface area ~~from~~of 90 to 130 m^2/g.

~~8. The~~ 14. Lubricating grease ~~according to~~as claimed in any one ~~or more~~ of claims 1 to 13, wherein the ~~preceding claims, **characterized in that** the polymers~~polymer of ~~the component~~ c2) ~~have~~has a viscosity~~, measured according to DIN 51562 part 1 at 100 °C~~ of at least 600 mm^2/s and/or ~~of~~ at least 4000 mm^2/s at 100°C, as measured in accordance with DIN 51562, Part 1.

~~9. The~~ 15. Lubricating grease ~~according to~~ as claimed in any one ~~or more~~ of ~~the preceding~~ claims~~, **characterized in that** it contains, as component c5), a corrosion protection~~ 1 to 14, further comprising an anticorrosion agent~~, preferably~~ c5) selected from at least one earth alkaline ~~earth oxides, in particular~~oxide, or at least one calcium ~~oxide and/or~~ , magnesium, and/or sodium sulfonate or salt of a C_8-C_{20} dicarboxylic acid.

16. Lubricating grease as claimed in claim 15, wherein the earth alkaline oxide~~, and~~ is calcium~~-~~, oxide and/or magnesium~~-~~ oxide.

17. Lubricating grease as claimed in claim 15, wherein the at least one calcium, magnesium, and/or sodium ~~sulfonates~~sulfonate or ~~salts~~salt of C_8-C_{20} dicarboxylic ~~acids, in particular~~acid is disodium ~~sebaccate~~sebacate.

~~10~~18. Use of ~~a~~an environmentally acceptable lubricating grease ~~according to~~ as claimed in any one ~~or more~~ of ~~the preceding~~ claims 1 to 17 for coating steel ropes~~, in particular zinc-plated~~.

19. Use as claimed in claim 18, wherein the steel ropes~~.~~ are zinc-coated steel ropes.