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(54) ENERGY EFFICIENT LUBRICANT COMPOSITIONS

(57) The present invention relates to an energy efficient lubricant concentrate comprising at least one alkoxylated polytetrahydrofuran and at least one ester of a dicarboxylic acid. The present invention further relates to the use of the lubricant concentrate in the lubricant compositions for reducing friction.

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Description

[0001] The present invention relates to an energy efficient lubricant concentrate comprising at least one alkoxylated polytetrahydrofuran and at least one ester of a dicarboxylic acid. The present invention further relates to the use of the lubricant concentrate in the lubricant compositions for reducing friction.

Background of the Invention

[0002] Lubricating oil compositions are used in a variety of applications, such as industrial applications, transportation, manufacturing equipment and engines. Industrial applications comprise of applications such as hydraulic oil, air compressor oil, gas compressor oil, gear oil, bearing and circulating system oil, refrigerator compressor oil and steam and gas turbine oils.

[0003] Energy consumption is a major concern today. As the energy costs continue to rise, the amount of energy used becomes a greater and more immediate concern. More energy is lost to friction than is delivered to the wheels - approximately 10% in engine and 5% in the drivetrain. Reducing friction lowers the amount of energy wasted on generated heat and vibration, which contributes nothing to machine efficiency and potential output. An increase in energy efficiency works hand in hand with reduced energy consumption. With heightened awareness of this key principle, industries around the world are setting up sustainable business practices as they look for energy efficient solutions that minimize energy consumption and maximize productivity.

[0004] An often overlooked aspect for achieving such efficiencies is the usage of energy efficient lubricating oil compositions. Lubricants reduce friction as their primary role in the base case. Using energy efficient lubricants will enable engines and machines to operate at maximum efficiency and with optimal cost. With proper lubrication, energy savings are possible with all types of industrial equipment. For example, selection of an energy efficient turbine lubricant helps the equipment perform under the most demanding conditions and has a direct impact on the reliability and profitability of a power generation operation. Issues such as higher temperatures in bearings can be resolved effectively by using energy efficient lubricants. In hydraulics/circulating applications, advanced high viscosity index (VI) fluids manage balance of mechanical and volumetric efficiency in pressurized pumps for instance, that lead to reduced energy at start up and improved lubrication at high temperature of operation.

[0005] Proper lubrication can reduce frictional losses, increase energy efficiency and help extend the life of the machine. Optimized friction control results in less equipment wear and more productivity, along with reduced maintenance downtime and expense. Reduced energy consumption also results in fewer carbon emissions, which is key for environmental protection and business sustainability goals.

[0006] The efficiency of a machine or an equipment can be increased if losses are minimized. The losses can be categorized in losses without and with load, their sum being the total losses.

[0007] Within many parameters which can be influenced by geometry, material etc. lubricant viscosity has a major effect on losses without load, i.e. spilling: Losses with load can be influenced by a low friction coefficient. Thus, at a given viscosity, energy efficiency strongly depends on the friction coefficient measured for a lubricant.

[0008] The friction coefficient can be measured with several methods like Mini-Traction-Machine (MTM), SRV, 2 disc test rig etc. The benefit of a MTM is that one can see the coefficient of friction as an influence of the slide roll ratio. Slide roll ratio describes the difference of the speeds of ball and disc used in the MTM.

[0009] DE 32 10 28 3 A1 describes polyethers that are obtained by reacting C_8-C_{28}-epoxy alkane and tetrahydrofuran in the presence of a starter compound having Zerewitinoff-active hydrogen atoms. These compounds show lubricating properties.

[0010] EP 1 076 072 A1 discloses polyethers derived from polytetrahydrofuran and mixtures of 1,2-epoxybutane and 1,2-epoxydodecane. These compounds are formulated into gasoline fuels to reduce the deposits in an injector.

[0011] US 2012/0295827 discloses a lubricant composition with enhanced energy efficiency containing a base oil selected from a complex ester having a kinematic viscosity at 40°C of greater than 400 and up to 50000 mm^2/s, in an amount of 1% - 99.9 % by weight of the total weight of the lubricant. The said lubricant is used for the lubrication of gears of wind turbines. However, the lubricant composition works only in a particular range of highly viscous oils.

[0012] WO 2014/139935 A1 describes polyethers that are prepared by alkoxylating polytetrahydrofuran with butylene oxide for use in lubricant compositions and/or for reducing friction in a driveline.

[0013] WO 2014/184062 A1 relates to lubricating oil compositions comprising one or more polytetrahydrofurans that are prepared by alkoxylating polytetrahydrofuran with at least one C_8-C_{30} epoxy alkane.

[0014] WO 2014/005932 A1 is directed to the use of carboxylic acid esters which are obtained by reacting aliphatic dicarboxylic acids and a mixture of structurally different monoalcohols having 10 carbon atoms as lubricants and a process for their preparation.

[0015] WO 2014/184068 A1 relates to a method for reducing the friction coefficient of a lubricating oil composition in the lubrication of a mechanical device comprises formulating said lubricating oil composition with a carboxylic acid ester obtainable by reacting a mixture comprising at least on dicarboxylic acid and at least one branched C_{10} alcohol.

[0016] EP 2 721 129 A1 relates to an ester-based lubricant composition which exhibits enhanced hydrolytic stability, comprising polyalkylene glycols, ester base oils and additives.

However, all of these patent applications are totally silent about combining polyethers and esters in a specific weight ration to arrive at a superior friction reducing effect.

[0017] Thus, there is still a need for a lubricant composition which lowers the friction coefficient without detrimentally affecting the viscosity of the base oil.

[0018] Accordingly, it was an object of the presently claimed invention to provide lubricant compositions which are efficient in minimizing the losses by lowering the friction coefficient, without affecting the viscosity.

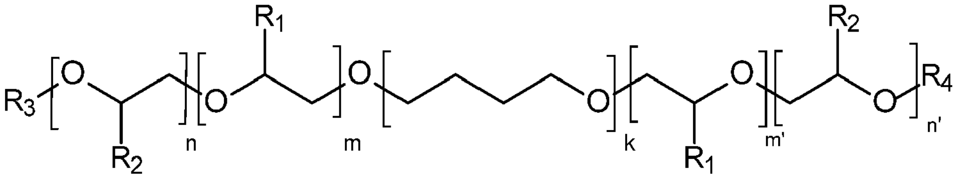
Summary of the Invention

[0019] Surprisingly it was found that a combination of alkoxylated polytetrahydrofuran and certain carboxylic acid esters, when included in a lubricating oil composition, are characterized in their specific behaviour under load, in lowering the friction coefficient of a lubricating oil composition.

[0020] The compositions comprising the alkoxylated polytetrahydrofuran and carboxylic acid ester exhibit super-additive or synergistic effect when the components are combined in certain ratios. Further, the addition of alkoxylated polytetrahydrofuran and certain carboxylic acid esters to the lubricant composition has no adverse effect on the viscosity of the lubricant oil.

[0021] Thus, in one embodiment the presently claimed invention is directed to a lubricant concentrate (LC) comprising

(a) at least one alkoxylated polytetrahydrofuran of general formula (I)



(I)

wherein

m	is in the range of ≥ 1 to ≤ 50,
m'	is in the range of ≥ 1 to ≤ 50,
(m+m')	is in the range of ≥ 1 to ≤ 90
n	is in the range of ≥ 0 to ≤ 75,
n'	is in the range of ≥ 0 to ≤ 75,
(n+n')	is in the range of ≥ 0 to ≤ 90,
k	is in the range of ≥ 2 to ≤ 30,
R_1	denotes an unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl,
R_2	denotes CH_2-CH_3, CH_3 or H, and
R_3 and R_4	denote, identical or different, substituted or unsubstituted, linear or branched C_1-C_5 alkyl or hydrogen;

wherein the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure;

(b) at least one carboxylic acid ester obtainable by reacting

(i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol or;

(ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol or;

(iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group or;

(iv) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group or;

(v) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one linear or branched C_1-C_{20} monoalcohol or;

(vi) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group;

(vii) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group and at least one C_1-C_{20} monoalcohol.

[0022] In a preferred embodiment the weight ratio of (a) : (b) is in the range of 99.9 : 0.1, 99 : 1 to 1 : 99, more preferably in the range of 95:5 to 5:95, even more preferably in the range of 90:10 to 10:90, still more preferably in the range of 80:20 to 20:80, yet more preferably in the range of 60:40 to 40:60, most preferably in the range of 60:40 to 40:60 and in particular 1:1.

[0023] When the alkoxylated polytetrahydrofuran of general formula (I) and the carboxylic acid esters are added in the lubricant composition within certain ratios, the friction lowering efficiency of the composition is super-additive (synergistic) relative to the friction lowering efficiency of the alkoxylated polytetrahydrofuran or carboxylic acid esters, alone.

[0024] More specifically, the combination of alkoxylated polytetrahydrofuran (a) and the carboxylic acid ester (b) that is used according to the present invention reduces the friction and therefore additional friction-reducers are not required in lubricant compositions according to the present invention.

[0025] The terms "lubricant", "lubricant concentrate" and "lubricant composition", as used herein shall be understood to mean a substance or mixture of substances capable of reducing friction between surfaces.

[0026] The term "linear" denotes a chain of atoms with no side chains attached to it.

[0027] The term "branched" denotes a chain of atoms with one or more side chains attached to it. Branching occurs by the replacement of a substituent, e.g., a hydrogen atom, with a covalently bonded alkyl radical.

[0028] "Alkyl" denotes a moiety constituted solely of atoms of carbon and of hydrogen.

[0029] The term "energy efficient lubricant", "energy efficient lubricant concentrate" and "energy efficient lubricant composition", respectively as used herein shall be understood to mean a lubricant, lubricant concentrate and lubricant composition, respectively, which reduces friction.

[0030] The term "synergistic or super additive", as used herein, means an effect which is greater than the effect resulting from the sum of the effects of the individual compounds, i.e. the sum of the effects of the alkoxylated polytetrahydrofuran of general formula (I) and the carboxylic acid ester (b).

[0031] "M_n" represents the number average molecular weight and is determined according to DIN 55672-1 and referred to polystyrene calibration standard.

[0032] "M_w' represents the weight average molecular weight and is determined according to DIN 55672-1 and referred to polystyrene calibration standard.

In an another aspect, the presently claimed invention is directed to a lubricant composition comprising

≥ 1.0 to ≤ 90.0 % by weight of the lubricant concentrate (LC) as described herein;

≥ 10.0 to ≤ 75.0% by weight of at least one base oil (c) selected from Group I mineral oils, Group II mineral oils, Group III mineral oils, Group IV oils and Group V oils and;

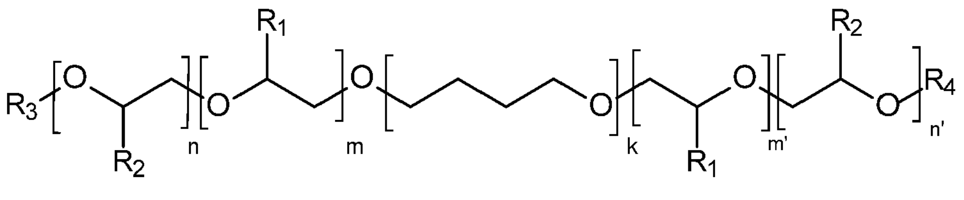
≥ 0.1 to ≤ 15.0 % by weight of at least one additive component (d),

in each case by weight of the total weight of lubricant composition.

Detailed description of the invention

(a) Alkoxylated polytetrahydrofurans

[0033] The alkoxylated polytetrahydrofuran of the present invention are the compounds of the general formula (I)



(I)

wherein

m	is in the range of ≥ 1 to ≤ 50,
m'	is in the range of ≥ 1 to ≤ 50,
(m+m')	is in the range of ≥ 1 to ≤ 90
n	is in the range of ≥ 0 to ≤ 75,
n'	is in the range of ≥ 0 to ≤ 75,
(n+n')	is in the range of ≥ 0 to ≤ 90,
k	is in the range of ≥ 2 to ≤ 30,
R_1	denotes an unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl,
R_2	denotes CH_2-CH_3, CH_3 or H, and
R_3 and R_4	denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H,

wherein the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure as the value ranges of m, m', n and n' include fractions and real numbers.

[0034] The above formula gives a general definition of the alkoxylated polytetrahydrofurans of general formula (I). These substances are mixtures of substances of the type indicated having different chain lengths. For the indices, therefore, average values are calculated which may differ from an integer. Hence, the indices have been kept as real numbers, which takes into account possibilities such as 4.1, 5.7 etc.

[0035] Alkoxylated polytetrahydrofurans are inter alia described in U.S. Pat. No. 6,423,107 B1.

[0036] The alkoxylated polytetrahydrofuran (a) has a kinematic viscosity in the range of ≥ 25 mm^2/s to ≤ 150 mm^2/s, more preferably in the range of ≥ 30 mm^2/s to ≤ 130 mm^2/s, at 100° C, determined according to ASTM D 445.

[0037] Preferably the alkoxylated polytetrahydrofuran (a) has a pour point in the range of $\geq$ - 60° C to $\leq$ 20° C, more preferably in the range of $\leq$ - 50° C to $\leq$ 15° C, determined according to DIN ISO 3016.

The alkoxylated polytetrahydrofuran (a) has a weight average molecular weight M_w in the range of 500 to 20000 g/mol, preferably in the range of 1000 to 20000 g/mol, more preferably in the range of 1500 to 12500 g/mol, determined, determined according to DIN 55672-1 (polystyrene calibration standard).

[0038] The alkoxylated polytetrahydrofuran (a) has a polydispersity in the range of 1.05 to 1.60, more preferably in the range of 1.05 to 1.50, most preferably in the range of 1.05 to 1.45, determined according to DIN 55672-1.

[0039] Preferably k is in the range of ≥ 4 to ≤ 28, more preferably k is in the range of ≥ 4 to ≤ 26, most preferably in the range of ≥ 4 to ≤ 24, even more preferably in the range of ≥ 6 to ≤ 20.

[0040] Preferably m is in the range of ≥ 1 to ≤ 40, more preferably a in the range of ≥ 2 to ≤ 30, even more preferably m in the range of ≥ 3 to ≤ 25 and most preferably in the range of ≥ 4 to ≤ 25.

[0041] Preferably m' is in the range of ≥ 1 to ≤ 40, more preferably a in the range of ≥ 2 to ≤ 30, even more preferably m in the range of ≥ 3 to ≤ 25 and most preferably in the range of ≥ 4 to ≤ 25. Preferably (m+m') is in the range of ≥ 4 to ≤ 60, more preferably (m+m') is in the range of ≥ 6 to ≤ 50, even more preferably (m+m') is in the range of ≥ 10 to ≤ 45.

[0042] Preferably the ratio of (m+m') to k is in the range of 0.3:1 to 6:1, more preferably in the range of 0.3:1 to 5:1, most preferably in the range of 0.3:1 to 4:1, even more preferably in the range of 0.3:1 to 3:1.

[0043] Preferably n is in the range of ≥ 2 to ≤ 40, more preferably in the range of ≥ 3 to ≤ 40, even more preferably in the range of ≥ 4 to ≤ 40.

[0044] Preferably n' is in the range of ≥ 2 to ≤ 40, more preferably in the range of ≥ 3 to ≤ 40, even more preferably in the range of ≥ 4 to ≤ 40.

[0045] Preferably (n+n') is in the range of ≥ 4 to ≤ 80, more preferably (n+n') in the range of ≥ 6 to ≤ 78, even more preferably (n+n') in the range of ≥ 10 to ≤ 75.

[0046] Preferably R_1 denotes, identically, an unsubstituted, linear or branched C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl group. More preferably R_1 denotes, identical, unsubstituted, linear C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} or C_{18} alkyl. Even more preferably R_1 denotes, identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11}, C_{12} alkyl group.

[0047] Preferably R_2 denotes CH_2-CH_3 or CH_3.

[0048] Preferably R_3 and R_4 denote identically H or CH_3, more preferably R_3 and R_4 denote identically H.

[0049] In case the alkoxylated polytetrahydrofuran (a) comprises units, wherein R_2 denotes CH_2-CH_3 or CH_3, the ratio of (n+n') to k is in the range of 1.5:1 to 10:1, more preferably in the range of 1.5:1 to 7:1, most preferably in the range of 2:1 to 6:1.

[0050] The alkoxylated polytetrahydrofurans (a) are obtained by reacting at least one polytetrahydrofuran block polymer with at least one C_8-C_{30} epoxy alkane and optionally at least one epoxide selected from the group consisting of ethylene oxide, propylene oxide and butylene oxide in the presence of at least one catalyst. In case at least one epoxide selected from the group consisting of ethylene oxide, propylene oxide and butylene oxide is used, the at least one C_8-C_{30} epoxy alkane and the at least one epoxide selected from the group consisting of ethylene oxide, propylene oxide and butylene oxide can either be added as a mixture of epoxides to obtain a random copolymer or in portions, whereby each portion contains a different epoxide, to obtain a block copolymer.

[0051] Preferably the at least one C_8-C_{30} epoxy alkane is selected from the group consisting of 1,2-epoxyoctane; 1,2-epoxynonane; 1,2-epoxydecane; 1,2-epoxyundecane; 1,2-epoxydodecane; 1,2-epoxytridecane; 1,2-epoxytetradecane; 1,2-epoxypentadecane; 1,2-epoxyhexadecane; 1,2-epoxyheptadecane; 1,2-epoxyoctadecane; 1,2-epoxynonadecane; 1,2-epoxylcosane; 1,2-epoxyunicosane; 1,2-epoxydocosane; 1,2-epoxytricosane; 1,2-epoxytetracosane; 1,2-epoxypentacosane; 1,2-epoxyhexacosane; 1,2-epoxyheptacosane; 1,2-epoxyoctacosane; 1,2-epoxynonacosane and 1,2-epoxytriacontane.

[0052] Preferably the at least one catalyst is a base or a double metal cyanide catalyst (DMC catalyst). More preferably the at least one catalyst is selected from the group consisting of alkaline earth metal hydroxides such as calcium hydroxide, strontium hydroxide and barium hydroxide, alkali metal hydroxides such as lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide and cesium hydroxide and alkali metal alkoxylates such as potassium tert-butoxylate. Most preferably the at least one catalyst is sodium hydroxide or potassium tert-butoxylate. Most preferably the at least one catalyst is potassium tert-butoxylate.

[0053] In case the catalyst is a base, any inert solvents capable of dissolving alkoxylated polytetrahydrofuran and polytetrahydrofuran may be used as solvents during the reaction or as solvents required for working up the reaction mixture in cases where the reaction is carried out without solvents. The following solvents are mentioned as examples: methylene chloride, trichloroethylene, tetrahydrofuran, dioxane, methyl ethyl ketone, methylisobutyl ketone, ethyl acetate and isobutyl acetate.

[0054] In case the catalyst is a base, the amount of catalysts used is preferably in the range from 0.01 to 1.0 %, more preferably in the range from 0.05 to 0.5 % by weight, based on the total amount of the alkoxylated polytetrahydrofuran. The reaction is preferably carried out at a temperature in the range of 70 to 200° C, more preferably from 100 to 160° C. The pressure is preferably in the range from 1 bar to 150 bar, more preferably in the range from 2 to 30 bar.

[0055] In case a DMC catalyst is used, it is in principle possible to use all types of DMC catalysts known from the prior art. Preference is given to using double metal cyanide catalysts of the general formula (II):

$$M^1_a[M^2(CN)_b(A)_c]_d fM^1 gX_n h(H_2O).eL, \qquad \text{(II)}$$

wherein

M^1 is a metal ion selected from the group comprising Zn^{2+}, Fe^{2+}, Co^{3+}, Ni^{2+}, Mn^{2+}, Co^{2+}, Sn^{2+}, Pb^{2+}, Mo^{4+}, Mo^{6+}, Al^{3+}, V^{4+}, V^{5+}, Sr^{2+}, W^{6+}, Cr^{2+}, Cr^{3+} and Cd^{2+};
M^2 is a metal ion selected from the group comprising Fe^{2+}, Fe^{3+}, Co^{2+}, Co^{3+}, Mn^{2+}, Mn^{3+}, V^{4+}, V^{5+}, Cr^{2+}, C^{3+}, Rh^{3+}, Ru^{2+} and Ir^{3+},
M^1 and M^2 are identical or different,
A is an anion selected from the group comprising halide, hydroxide, sulfate, carbonate, cyanide, thiocyanate, isocyanate, cyanate, carboxylate, oxalate and nitrate,
X is an anion selected from the group comprising halide, hydroxide, sulfate, carbonate, cyanide, thiocyanate, Isocyanate, cyanate, carboxylate, oxalate and nitrate,
L is a water-miscible ligand selected from the group comprising alcohols, aldehydes, ketones, ethers, poly-ethers, esters, ureas, amides, nitriles and sulfides,
and
a, b, c, d, g and n are selected so that the compound is electrically neutral, and
e is the coordination number of the ligand or zero,
f is a fraction or integer greater than or equal to zero,
h is a fraction or integer greater than or equal to zero.

[0056] Such compounds are generally known and can be prepared, for example, by the process described in EP 0 862 947 B1 by combining the aqueous solution of a water-soluble metal salt with the aqueous solution of a hexacyanometallate compound, in particular of a salt or an acid, and, if necessary, adding a water-soluble ligand thereto either during or after the combination of the two solutions.

[0057] DMC catalysts are usually prepared as a solid and used as such. The catalyst is typically used as powder or in suspension. However, other ways known to those skilled in the art for using catalysts can likewise be employed. In a preferred embodiment, the DMC catalyst is dispersed with an Inert or non-inert suspension medium which can be, for example, the product to be produced or an intermediate by suitable measures, e.g. milling. The suspension produced in this way is used, if appropriate after removal of interfering amounts of water by methods known to those skilled in the art, e.g. stripping with or without use of inert gases such as nitrogen and/or noble gases. Suitable suspension media are, for example, toluene, xylene, tetrahydrofuran, acetone, 2-methylpentanone, cyclohexanone and also polyether alcohols according to the invention and mixtures thereof. The catalyst is preferably used in a suspension in a polyol as described, for example, in EP 0 090 444 A, which is incorporated by reference in its entirety.

(b) Esters of carboxylic acid

[0058] In an embodiment, at least one carboxylic acid ester (b) is obtainable by reacting

(i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol or;
(ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol or;
(iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group or;
(iv) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group or;
(v) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one linear or branched C_1-C_{20} monoalcohol or;
(vi) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group;
(vii) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group and at least one C_1-C_{20} monoalcohol

[0059] In a more preferred embodiment the at least one carboxylic acid ester (b) is obtainable by reacting

(i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol or;
(ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol or;
(iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group or;
(iv) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group.

[0060] In yet another preferred embodiment the at least one carboxylic acid ester (b) is obtainable by reacting

(i) at least one linear or branched C_5-C_{20} monocarboxylic acid selected from the group consisting of pentanoic acid, iso-pentanoic acid, hexanoic acid, iso-hexanoic acid, heptanoic acid, iso-heptanoic acid, octanoic acid, iso-octanoic acid, nonanoic acid, iso-nonanoic acid, decanoic acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, palmitic acid, heptadecanoic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, nonadecanoic acid, eicosanoic acid with at least one linear or branched C_1-C_{18} monoalcohol selected from the group consisting of methanol, ethanol, propanol, butanol, pentanol, hexanol, heptanol, 1-octanol, 3-methyl-1-butanol, nonanol, decanol, undecanol, dodecanol, tridecanol, tetradecanol, pentadecanol, hexadecanol, heptadecanol, octadecanol, iso-propanol, iso-butanol, 2-octanol, 3-octanol, iso-nonanol, iso-decanol, iso-undecanol, iso-dodecanol iso-tridecanol, iso-tetradecanol, iso-pentadecanol, iso-hexadecanol, iso-heptadecanol, iso-octadecanol, neo-pentanol , t-butanol, 2-methyl-2-butanol, 2,3-dimethyl-2-butanol, 2-methyl-2-pentanol, 3-methyl-3-pentanol, 3-ethyl-3-pentanol, 2,3-dimethyl-2-pentanol, 2,3-dimethyl-2-pentanol, 2,3-dimehtyl-2-pentanol, 2,3-dimethyl-3-pentaol, 2,3,4-trimethyl-3-pentanol, 2-methyl-2-hexanol and 3-methyl-3-hexanol;
or;
(ii) at least one linear or branched C_3-C_{12} dicarboxylic acid selected from the group consisting of malonic acid, succinic acid, glutaric acid, adipic acid, maleic acid, fumaric acid, azelaic acid, sebacic acid, brassilic acid, docdecanedioic acid, diglycolic acid, 1,4-cyclohexanedicarboxylic acid, 1,3-cyclohexanedicarboxylic acid and 2,6-decahydronaphthalenedicarboxylic acid with at least one branched C_5-C_{14} monoalcohol selected from the group consisting of pentanol, hexanol, heptanol, iso-pentanol, iso-hexanol, iso-heptanol, 2-ethylhexanol, 2-propylheptanol, 2-propyl-4-methyl-hexanol, 2-propyl-5-methyl-hexanol, 2-isopropyl-4-methyl-hexanol, 2-isopropyl-5-methyl-hexanol, 2-propyl-4,4-dimethylpentanol, 2-ethyl-2,4-dimethylhexanol, 2-ethyl-2-methyl-heptanol, 2-ethyl-2,5-dimethylhexanol, 2-isopropyl-heptanol, 2-butyl-1-octanol and 2-pentyl-1-nonanol or;
(iii) at least one linear or branched C_5-C_{18} monocarboxylic acid selected from the group consisting of pentanoic acid, caproic acid, heptanoic acid, caprylic acid, nonanoic acid capric acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic

acid, oleic acid, palmitoleic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group selected from the group consisting of ethylene glycol, 1,2-propylene glycol, 1,3-propylene glycol, 1,2-butylene glycol, 1,3-butylene glycol, 2,3-butylene glycol, neopentyl glycol, trimethylol propane, trimethylol ethane, pentaerythritol, sorbitol, and dipentaerythritol or;

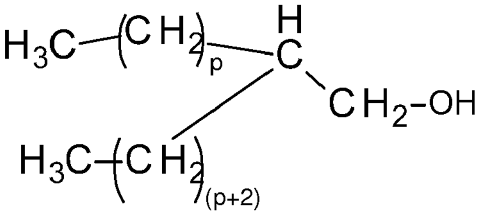
(iv) a mixture comprising at least one linear or branched C_5-C_{18} monocarboxylic acid selected from the group consisting of pentanoic acid, caproic acid, heptanoic acid, caprylic acid, nonanoic acid capric acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, oleic acid, palmitoleic acid and at least one linear or branched C_3-C_{10} dicarboxylic acid selected from the group consisting of malonic acid, succinic acid, glutaric acid, adipic acid, heptanedioic acid, octananedioic acid, nonanedioic acid, decanedioic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group selected from the group consisting of ethylene glycol, 1,2-propylene glycol, 1,3-propylene glycol, 1,2-butylene glycol, 1,3-butylene glycol, 2,3-butylene glycol neopentyl glycol, trimethylol propane, trimethylol ethane, pentaerythritol, sorbitol, and dipentaerythritol.

[0061] In an even more preferred embodiment, the at least one carboxylic acid ester (b) is obtainable by reacting at least one linear C_3-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol.

[0062] In yet another even more preferred embodiment the at least one carboxylic acid ester (b) is obtainable by reacting at least one C_3-C_{12} dicarboxylic acid selected from the group consisting of malonic acid, succinic acid, glutaric acid, adipic acid, maleic acid, fumaric acid, azelaic acid, sebacic acid, brassilic acid, docdecanedioic acid, diglycolic acid, 1,4-cyclohexanedicarboxylic acid, 1,3-cyclohexanedicarboxylic acid and 2,6-decahydronaphthalenedicarboxylic acid with at least one branched C_5-C_{14} monoalcohol selected from the group consisting of pentanol, hexanol, heptanol, iso-pentanol, iso-hexanol, iso-heptanol, 2-ethylhexanol, 2-propylheptanol, 2-propyl-4-methyl-hexanol, 2-propyl-5-methyl-hexanol, 2-isopropyl-4-methyl-hexanol, 2-isopropyl-5-methyl-hexanol, 2-propyl-4,4-dimethylpentanol, 2-ethyl-2,4-dimethylhexanol, 2-ethyl-2-methyl-heptanol, 2-ethyl-2,5-dimethylhexanol, 2-isopropyl-heptanol, 2-butyl-1-octanol and 2-pentyl-1-nonanol.

[0063] The carboxylic ester preferably is derived from the reaction of a carboxylic acid with a linear or branched aliphatic alcohol.

[0064] Another preferred group of alcohols is derived from the so-called Guerbet alcohols represented by general formula (III). The trivial name of Guerbet alcohol is used for 2-alkyl-substituted 1-alkanols whose industrial synthesis is described inter alia in H. Machemer, Angewandte Chemie, Vol. 64, pages 213-220 (1952) and in G. Dieckelmann and H.J. Heinz in "The Basics of Industrial Oleochemistry", pages 145-145 (1988).



(III)

where p may be 1, 2, 3, 4.

[0065] In one preferred embodiment the Guerbet alcohol is selected from 2-ethylhexanol, 2-propylheptanol, 2-butyl-1-octanol and 2-pentyl-1-nonanol.

[0066] In a most preferred embodiment, the carboxylic acid ester (b) is selected from the list consisting of methyloleate, 2-ethylhexyloleate, 2-ethylhexylpalmitate, 2-ethylhexylstearate, and mixtures thereof.

[0067] In another most preferred embodiment, the carboxylic acid ester (b) is selected from the list consisting of di-(2-propylheptyl)adipate (DPHA), di-isononyladipate (DNA), di-(2-ethylhexyl)adipate (DOA), di-(2-propylheptyl)phthalate (DPHP), di-isodecyl adipate (DIDA) and di-isotridecyl adipate (DITA) and mixtures thereof.

[0068] In yet another most preferred embodiment, the carboxylic acid ester (b) can be a trimethylol propane-type ester formed from trimethylol propane and a mixture of C_8-C_{10} linear fatty acid and adipic acid, which is commercially available as Synative® ES 3345 (from BASF SE).

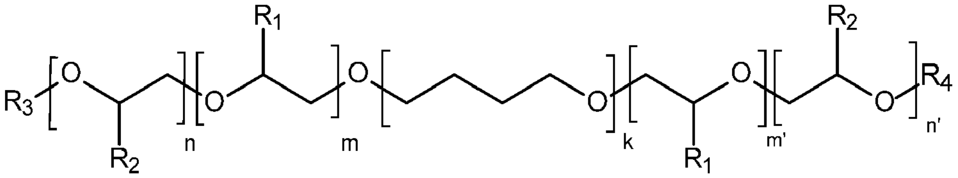
[0069] Alternatively, the carboxylic acid ester (b) can be a trimethylol propane-type ester, formed from trimethylol propane and C_8-C_{10} fatty acid, which is commercially available as Synative® ES 2925 (from BASF SE).

[0070] In a particularly preferred embodiment the carboxylic acid ester (b) is selected from the list consisting of methyl oleate, trimethylolpropane-type ester, formed from trimethylol propane and C_8-C_{10} fatty acid, di-(2-propylheptyl)-adipate, di-isodecyl adipate, diisotridecyl adipate, and diisononyladipate and mixtures thereof.

[0071] In another preferred embodiment, the carboxylic acid ester (b) has a kinematic viscosity according to DIN 51562-1 in the range of from 2 to 120 mm^2/s at 100°C.

[0072] In a preferred embodiment the presently claimed invention is directed to a lubricant concentrate (LC) consisting of

(a) at least one alkoxylated polytetrahydrofuran of general formula (I)



(I)

wherein

m	is in the range of ≥ 1 to ≤ 50,
m'	is in the range of ≥ 1 to ≤ 50,
(m+m')	is in the range of ≥ 1 to ≤ 90
n	is in the range of ≥ 0 to ≤ 75,
n'	is in the range of ≥ 0 to ≤ 75,
(n+n')	is in the range of ≥ 6 to ≤ 90,
k	is in the range of ≥ 2 to ≤ 30,
R_1	denotes an unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl,
R_2	denotes CH_2-CH_3, CH_3 or H, and
R_3 and R_4	denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H,

wherein the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure;

(b) at least one carboxylic acid ester obtainable by reacting

(i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol; or

(ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol; or

(iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or

(iv) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or

(v) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one linear or branched C_1-C_{20} monoalcohol; or

(vi) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or

(vii) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group and at least one C_1-C_{20} monoalcohol.

[0073] To the lubricant concentrate comprising at least one alkoxylated polyether of general formula (I) and at least one carboxylic acid ester is further added at least one base oil (c) and optionally at least one additive component (d) to prepare the lubricant compositions.

(c) Base Oil

[0074] The base oil (c) is selected from the group consisting of Group I mineral oils, Group II mineral oils, Group III mineral oils and Group IV oils and Group V oils.

[0075] Definitions for the base oils according to the present invention are the same as those found in the American

Petroleum Institute (API) publication "Engine Oil Licensing and Certification System", Industry Services Department, Fourteenth Edition, December 1996, Addendum 1, December 1998. Said publication categorizes base stocks as follows: a) Group I base oils contain less than 90 percent saturates and/or greater than 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120 using the test methods specified in the following table.

Group I base oils can comprise light overhead cuts and heavier side cuts from a vacuum distillation column and can also include, for example, Light Neutral, Medium Neutral, and Heavy Neutral base stocks. The petroleum derived base oil also may include residual stocks or bottoms fractions, such as, for example, bright stock. Bright stock is a high viscosity base oil which has been conventionally produced from residual stocks or bottoms and has been highly refined and dewaxed. Bright stock can have a kinematic viscosity greater than about 180 cSt at 40° C, or even greater than about 250 cSt at 40° C, or even ranging from about 500 to about 1100 cSt at 40° C.

In an embodiment, the one or more base oils can be a blend or mixture of one or more than one Group I base oils having different molecular weights and viscosities, wherein the blend is processed in any suitable manner to create a base oil having suitable properties (such as the viscosity and TBN values, discussed above) for use in a marine diesel engine.

b) Group II base oils contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 80 and less than 120 using the test methods specified in the following table.

c) Group III base oils contain greater than or equal to 90 percent saturates and less than or equal to 0.03 percent sulfur and have a viscosity index greater than or equal to 120 using the test methods specified in the following table.

Group III base oils derived from petroleum oils are severely hydrotreated mineral oils. Hydrotreating involves reacting hydrogen with the basestock to be treated to remove heteroatoms from the hydrocarbon, reduce olefins and aromatics to alkanes and cycloparaffins respectively, and in very severe hydrotreating, open up naphthenic ring structures to non-cyclic normal and iso-alkanes ("paraffins").

Analytical Methods for Base oils:

Property	Test Method
Saturates	ASTM D 2007
Viscosity Index	ASTM D 2270
Sulfur	ASTM D 2622
	ASTM D 4294
	ASTM D 4927
	ASTM D 3120

d) Group IV base oils contain polyalphaolefins. Synthetic lower viscosity fluids suitable for the present invention include the polyalphaolefins (PAOs) and the synthetic oils from the hydrocracking or hydro-isomerization of Fischer Tropsch high boiling fractions including waxes. These are both base oils comprised of saturates with low impurity levels consistent with their synthetic origin. The hydro-isomerized Fischer Tropsch waxes are highly suitable base oils, comprising saturated components of iso-paraffinic character (resulting from the isomerization of the predominantly n-paraffins of the Fischer Tropsch waxes) which give a good blend of high viscosity index and low pour point. Processes for the hydro-isomerization of Fischer Tropsch waxes are described in U.S. Patents 5,362,378; 5,565,086; 5,246,566 and 5,135,638, as well in EP 710710, EP 321302 and EP 321304.

Polyalphaolefins suitable for the lubricant compositions according to the present invention, include known PAO materials which typically comprise relatively low molecular weight hydrogenated polymers or oligomers of alphaolefins which include but are not limited to C_2 to about C_{32} alphaolefins with the C_8 to about C_{16} alphaolefins, such as 1-octene, 1-decene, 1-dodecene and the like being preferred. The preferred polyalphaolefins are poly-1-octene, poly-1-decene, and poly-1-dodecene, although the dimers of higher olefins in the range of C_{14} to C_{18} provide low viscosity base stocks.

Terms like PAO 2, PAO 4, PAO 6 or PAO 8 are commonly used specifications for different classes of polyalphaolefins characterized by their respective viscosity. For instance, PAO 2 refers to the class of polyalphaolefins which typically has viscosity in the range of 2 mm^2/s at 100°C. A variety of commercially available compositions are available for these specifications.

Low viscosity PAO fluids suitable for the lubricant compositions according to the present invention, may be conveniently made by the polymerization of an alphaolefin in the presence of a polymerization catalyst such as the Friedel-Crafts catalysts including, for example, aluminum trichloride, boron trifluoride or complexes of boron trifluoride with water, alcohols such as ethanol, propanol or butanol, carboxylic acids or esters such as ethyl acetate or ethyl propionate. For example, the methods disclosed by U.S. Patents 3,149,178 or 3,382,291 may be conveniently used herein. Other descriptions of PAO synthesis are found in the following U.S. Patents: 3,742,082 (Brennan); 3,769,363 (Brennan); 3,876,720 (Heilman); 4,239,930 (Allphin); 4,367,352 (Watts); 4,413,156 (Watts); 4,434,308 (Larkin); 4,910,355 (Shubkin); 4,956,122 (Watts); and 5,068,487 (Theriot).

e) Group V base oils contain any base stocks not described by Groups I to IV. Examples of Group V base oils include alkyl naphthalenes, alkylene oxide polymers, silicone oils, and phosphate esters.

[0076] Synthetic base oils include hydrocarbon oils and halo-substituted hydrocarbon oils such as polymerized and interpolymerized olefins (e.g., polypropylenes, propylene-isobutylene copolymers, chlorinated polybutylenes, poly(1-hexenes), poly(1-octenes), poly(1-decenes)); alkylbenzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di(2-ethylhexyl)benzenes); polyphenyls (e.g., biphenyls, terphenyls, alkylated polyphenols); and alkylated diphenyl ethers and alkylated diphenyl sulfides and derivative, analogs and homologs thereof.

[0077] Alkylene oxide polymers and interpolymers and derivatives thereof where the terminal hydroxyl groups have been modified by esterification, etherification, etc., constitute another class of known synthetic base oils. These are exemplified by polyoxyalkylene polymers prepared by polymerization of ethylene oxide or propylene oxide, and the alkyl and aryl ethers of polyoxyalkylene polymers (e.g., methyl-polyiso-propylene glycol ether having a molecular weight of 1000 or diphenyl ether of polyethylene glycol having a molecular weight of 1000 to 1500); and mono- and polycarboxylic esters thereof, for example, the acetic acid esters, mixed C_3-C_8 fatty acid esters and C_{13} Oxo acid diester of tetraethylene glycol.

[0078] Silicon-based oils such as the polyalkyl-, polyaryl-, polyalkoxy- or polyaryloxysilicone oils and silicate oils comprise another useful class of synthetic base oils; such base oils include tetraethyl silicate, tetraisopropyl silicate, tetra-(2-ethylhexyl)silicate, tetra-(4-methyl-2-ethylhexyl)silicate, tetra-(p-tert-butyl-phenyl) silicate, hexa-(4-methyl-2-ethylhexyl)disiloxane and poly(methylphenyl)siloxanes. Other synthetic base oils include liquid esters of phosphorous-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, diethyl ester of decylphosphonic acid) and polymeric tetrahydrofurans.

[0079] Preferably, for the presently claimed invention, synthetic base oils such as diester of a dicarboxylic acid are excluded from the category of base oil. Thus, base oil (c) does not encompass carboxylic acid esters (b).

[0080] Preferably the base oil (c) is a Group IV Base oil.

[0081] Preferably the base oil (c) is polyalphaolefin (PAO), more preferably PAO 4, PAO 6 and PAO 8.

(d) Additives

[0082] The lubricating oil composition of the invention optionally further includes at least one other additive.

[0083] In a preferred embodiment, the additive component is selected from the group consisting of antioxidants, dispersants, foam inhibitors, demulsifiers, seal swelling agents, friction reducers, anti-wear agents, detergents, corrosion inhibitors, extreme pressure agents, metal deactivators, rust inhibitors, pour point depressants and mixtures thereof.

[0084] The additive component as used in the present invention also includes an additive package and/or performance additives.

[0085] The additive package as used in the present invention as well as the compounds relating to performance additives are considered mixtures of additives that are typically used in lubricant compositions in limited amounts for mechanically, physically or chemically stabilizing the lubricant compositions while special performance characteristics can be further established by the individual or combined presence of such selected additives.

[0086] Additive packages are separately defined in the present invention since a variety of such additive packages are commercially available and typically used in lubricant compositions. One such preferred additive package that is commercially available is marketed under the name Anglamol6004J®.

[0087] However, the individual components contained in the additive packages and/or the compounds further defined in the present invention as so-called performance additives include a larger number of different types of additives including dispersants, metal deactivators, detergents, extreme pressure agents (typically boron- and/or sulfur- and/or phosphorus-containing), anti-wear agents, antioxidants (such as hindered phenols, aminic antioxidants or molybdenum compounds), corrosion inhibitors, foam inhibitors, demulsifiers, pour point depressants, seal swelling agents, friction modifiers and mixtures thereof.

[0088] The additive component (d) as the sum of all additives contained in the lubricant compositions according to the present invention also including all additives contained in an additive package or added separately is present in the lubricant compositions according to the present invention in an amount of 0.0 to 15 wt. %, preferably 0.1 to 15 wt. %.

[0089] Extreme pressure agents include compounds containing boron and/or sulfur and/or phosphorus. The extreme pressure agent may be present in the lubricant compositions at 0 % by weight to 10 % by weight, or 0.05 % by weight to 10 % by weight, or 0.1 % by weight to 8 % by weight of the lubricant composition.

[0090] In one embodiment according to the present invention, the extreme pressure agent is a sulfur-containing compound. In one embodiment, the sulfur-containing compound may be a sulfurised olefin, a polysulfide, or mixtures thereof. Examples of the sulfurised olefin include a sulfurised olefin derived from propylene, isobutylene, pentene; an organic sulfide and/or polysulfide including benzyldisulfide; bis-(chlorobenzyl) disulfide; dibutyl tetrasulfide; di-tertiary butyl polysulfide; and sulfurised methyl ester of oleic acid, a sulfurised alkylphenol, a sulfurised dipentene, a sulfurised terpene, a sulfurised Diels-Alder adduct, an alkyl sulphenyl N'N- dialkyl dithiocarbamates; or mixtures thereof.

[0091] In one embodiment the sulfurised olefin includes a sulfurised olefin derived from propylene, isobutylene, pentene or mixtures thereof.

[0092] In one embodiment according to the present invention, the extreme pressure agent sulfur-containing compound includes a dimercaptothiadiazole or derivative, or mixtures thereof. Examples of the dimercaptothiadiazole include compounds such as 2,5-dimercapto-1,3,4-thiadiazole or a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole, or oligomers thereof. The oligomers of hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically form by forming a sulfur-sulfur bond between 2,5-dimercapto-1,3,4-thiadiazole units to form derivatives or oligomers of two or more of said thiadiazole units. Suitable 2,5-dimercapto-1,3,4-thiadiazole derived compounds include for example 2,5-bis(tert-nonyldithio)-1,3,4-thiadiazole or 2-tert-nonyldithio-5-mercapto-1,3,4-thiadiazole. The number of carbon atoms on the hydrocarbyl substituents of the hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically include 1 to 30, or 2 to 20, or 3 to 16.

[0093] In one embodiment, the dimercaptothiadiazole may be a thiadiazole-functionalised dispersant. A detailed description of the thiadiazole-functionalised dispersant is described is paragraphs [0028] to [0052] of International Publication WO 2008/014315.

[0094] The thiadiazole-functionalised dispersant may be prepared by a method including heating, reacting or complexing a thiadiazole compound with a dispersant substrate. The thiadiazole compound may be covalently bonded, salted, complexed or otherwise solubilized with a dispersant, or mixtures thereof.

[0095] The relative amounts of the dispersant substrate and the thiadiazole used to prepare the thiadiazole-functionalised dispersant may vary. In one embodiment the thiadiazole compound is present at 0.1 to 10 parts by weight relative to 100 parts by weight of the dispersant substrate. In different embodiments the thiadiazole compound is present at greater than 0.1 to 9, or greater than 0.1 to less than 5, or 0.2 to less than 5: to 100 parts by weight of the dispersant substrate. The relative amounts of the thiadiazole compound to the dispersant substrate may also be expressed as (0.1-10):100, or (>0.1-9):100, (such as (>0.5-9):100), or (0.1 to less than 5): 100, or (0.2 to less than 5): 100.

[0096] In one embodiment the dispersant substrate is present at 0.1 to 10 parts by weight relative to 1 part by weight of the thiadiazole compound. In different embodiments the dispersant substrate is present at greater than 0.1 to 9, or greater than 0.1 to less than 5, or about 0.2 to less than 5: to 1 part by weight of the thiadiazole compound. The relative amounts of the dispersant substrate to the thiadiazole compound may also be expressed as (0.1-10):1, or (>0.1-9):1, (such as (>0.5-9):1, or (0.1 to less than 5): 1, or (0.2 to less than 5): 1.

[0097] The thiadiazole-functionalised dispersant may be derived from a substrate that includes a succinimide dispersant (for example, N-substituted long chain alkenyl succinimides, typically a polyisobutylene succinimide), a Mannich dispersant, an ester-containing dispersant, a condensation product of a fatty hydrocarbyl monocarboxylic acylating agent with an amine or ammonia, an alkyl amino phenol dispersant, a hydrocarbyl-amine dispersant, a polyether dispersant, a polyetheramine dispersant, a viscosity modifier containing dispersant functionality (for example polymeric viscosity index modifiers containing dispersant functionality), or mixtures thereof. In one embodiment the dispersant substrate includes a succinimide dispersant, an ester-containing dispersant or a Mannich dispersant.

[0098] In one embodiment according to the present invention, the extreme pressure agent includes a boron- containing compound. The boron-containing compound includes a borate ester (which in some embodiments may also be referred to as a borated epoxide), a borated alcohol, a borated dispersant, a borated phospholipid or mixtures thereof. In one embodiment the boron-containing compound may be a borate ester or a borated alcohol.

[0099] The borate ester may be prepared by the reaction of a boron compound and at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds, alcohols and mixtures thereof. The alcohols include dihydric alcohols, trihydric alcohols or higher alcohols, with the proviso for one embodiment that hydroxyl groups are on adjacent carbon atoms, i.e., vicinal.

[0100] Boron compounds suitable for preparing the borate ester include the various forms selected from the group consisting of boric acid (including metaboric acid, orthoboric acid and tetraboric acid), boric oxide, boron trioxide and alkyl borates. The borate ester may also be prepared from boron halides.

[0101] In one embodiment suitable borate ester compounds include tripropyl borate, tributyl borate, tripentyl borate, trihexyl borate, triheptyl borate, trioctyl borate, trinonyl borate and tridecyl borate. In one embodiment the borate ester compounds include tributyl borate, tri-2-ethylhexyl borate or mixtures thereof.

[0102] In one embodiment, the boron-containing compound is a borated dispersant, typically derived from an N-substituted long chain alkenyl succinimide. In one embodiment the borated dispersant includes a polyisobutylene succinimide. Borated dispersants are described in more detail in US Patents 3,087,936 and 3,254,025.

[0103] In one embodiment the borated dispersant may be used in combination with a sulfur-containing compound or a borate ester.

[0104] In one embodiment the extreme pressure agent is other than a borated dispersant.

The number average molecular weight M_n (GPC; kg/mol) of the hydrocarbon from which the long chain alkenyl group was derived includes ranges of 350 to 5000, or 500 to 3000, or 550 to 1500. The long chain alkenyl group may have a number average molecular weight Mn of 550, or 750, or 950 to 1000.

[0105] The N-substituted long chain alkenyl succinimides are borated using a variety of agents including boric acid (for example, metaboric acid, orthoboric acid and tetraboric acid), boric oxide, boron trioxide, and alkyl borates. In one embodiment the borating agent is boric acid which may be used alone or in combination with other borating agents.

[0106] The borated dispersant may be prepared by blending the boron compound and the N-substituted long chain alkenyl succinimides and heating them at a suitable temperature, such as, 80 °C to 250 °C, or 90 °C to 230 °C, or 100 °C to 210 °C, until the desired reaction has occurred. The molar ratio of the boron compounds to the N-substituted long chain alkenyl succinimides may have ranges including 10:1 to 1:4, or 4:1 to 1:3; or the molar ratio of the boron compounds to the N-substituted long chain alkenyl succinimides may be 1:2. Alternatively, the ratio of moles B : moles N (that is, atoms of B : atoms of N) in the borated dispersant may be 0.25:1 to 10:1 or 0.33:1 to 4:1 or 0.2:1 to 1.5:1, or 0.25:1 to 1.3:1 or 0.8:1 to 1.2:1 or about 0.5:1 An inert liquid may be used in performing the reaction. The liquid may include toluene, xylene, chlorobenzene, dimethylformamide or mixtures thereof.

[0107] In one embodiment, the additive component (d) in the lubricant composition according to the present invention further includes a borated phospholipid. The borated phospholipid may be derived from boronation of a phospholipid (for example boronation may be carried out with boric acid). Phospholipids and lecithins are described in detail in Encyclopedia of Chemical Technology, Kirk and Othmer, 3rd Edition, in "Fats and Fatty Oils", Volume 9, pages 795-831 and in "Lecithins", Volume 14, pages 250-269.

[0108] The phospholipid may be any lipid containing a phosphoric acid, such as lecithin or cephalin, or derivatives thereof. Examples of phospholipids include phosphatidylcholine, phosphatidylserine, phosphatidylinositol, phosphatidylethanolamine, phosphotidic acid and mixtures thereof. The phospholipids may be glycerophospholipids, glycerol derivatives of the above list of phospholipids. Typically, the glycerophospholipids have one or two acyl, alkyl or alkenyl groups on a glycerol residue. The alkyl or alkenyl groups may contain 8 to 30, or 8 to 25, or 12 to 24 carbon atoms. Examples of suitable alkyl or alkenyl groups include octyl, dodecyl, hexadecyl, octadecyl, docosanyl, octenyl, dodecenyl, hexadecenyl and octadecenyl.

[0109] Phospholipids may be prepared synthetically or derived from natural sources. Synthetic phospholipids may be prepared by methods known to those in the art. Naturally derived phospholipids are often extracted by procedures known to those in the art. Phospholipids may be derived from animal or vegetable sources. A useful phospholipid is derived from sunflower seeds. The phospholipid typically contains 35 % to 60 % phosphatidylcholine, 20 % to 35 % phosphatidylinositol, 1 % to 25 % phosphatidic acid, and 10 % to 25 % phosphatidylethanolamine, wherein the percentages are by weight based on the total phospholipids. The fatty acid content may be 20 % by weight to 30 % by weight palmitic acid, 2 % by weight to 10 % by weight stearic acid, 15 % by weight to 25 % by weight oleic acid, and 40 % by weight to 55 % by weight linoleic acid.

[0110] In another embodiment, the performance additive in the lubricant compositions according to the present invention may include a friction modifier. A friction modifier is any material or materials that can alter the coefficient of friction of a surface lubricated by any lubricant or fluid containing such material(s). Friction modifiers, also known as friction reducers, or lubricity agents or oiliness agents, and other such agents that change the ability of base oils, formulated lubricant compositions, or functional fluids, to modify the coefficient of friction of a lubricated surface may be effectively used in combination with the base oils or lubricant compositions according to the present invention if desired. Friction modifiers may include metal-containing compounds or materials as well as ashless compounds or materials, or mixtures thereof. Metal-containing friction modifiers may include metal salts or metal-ligand complexes where the metals may include alkali, alkaline earth, or transition group metals. Such metal-containing friction modifiers may also have low-ash characteristics. Transition metals may include Mo, Sb, Sn, Fe, Cu, Zn, and others. Ligands may include hydrocarbyl derivative of alcohols, polyols, glycerols, partial ester glycerols, thiols, carboxylates, carbamates, thiocarbamates, dithiocarbamates, phosphates, thiophosphates, dithiophosphates, amides, imides, amines, thiazoles, thiadiazoles, dithiazoles, diazoles, triazoles, and other polar molecular functional groups containing effective amounts of O, N, S, or P, individually or in combination. In particular, Mo-containing compounds can be particularly effective such as for example Mo-dithiocarbamates, Mo(DTC), Mo-dithiophosphates, Mo(DTP), Mo-amines, Mo (Am), Mo-alcoholates, Mo- alcohol-amides, and the like.

[0111] Ashless friction modifiers may also include lubricant materials that contain effective amounts of polar groups, for example, hydroxyl-containing hydrocarbyl base oils, glycerides, partial glycerides, glyceride derivatives, and the like. Polar groups in friction modifiers may include hydrocarbyl groups containing effective amounts of O, N, S, or P, individually or in combination. Other friction modifiers that may be particularly effective include, for example, salts (both ash-containing and ashless derivatives) of fatty acids, fatty alcohols, fatty amides, fatty esters, hydroxyl-containing carboxylates, and comparable synthetic long-chain hydrocarbyl acids, alcohols, amides, esters, hydroxy carboxylates, and the like. In some instances fatty organic acids, fatty amines, and sulfurized fatty acids may be used as suitable friction modifiers.

[0112] In one embodiment, the performance additive in the lubricant compositions according to the present invention may include phosphorus- or sulfur- containing anti-wear agents other than compounds described as an extreme pressure agent of the amine salt of a phosphoric acid ester described above. Examples of the anti-wear agent may include a non-ionic phosphorus compound (typically compounds having phosphorus atoms with an oxidation state of +3 or +5), a metal dialkyldithiophosphate (typically zinc dialkyldithiophosphates), amine dithiophosphate, ashless dithiophosphates and a metal mono- or di-alkylphosphate (typically zinc phosphates), or mixtures thereof.

[0113] The non-ionic phosphorus compound includes a phosphite ester, a phosphate ester, or mixtures thereof.

[0114] In one embodiment, the performance additive in the lubricant composition according to the present invention may further include at least one antioxidant. Antioxidants retard the oxidative degradation of base stocks during service. Such degradation may result in deposits on metal surfaces, the presence of sludge, or a viscosity increase in the lubricant. One skilled in the art knows a wide variety of oxidation inhibitors that are useful in lubricating oil compositions.

[0115] Useful antioxidants include hindered phenols. These phenolic antioxidants may be ashless (metal-free) phenolic compounds or neutral or basic metal salts of certain phenolic compounds. Typical phenolic antioxidant compounds are the hindered phenolics which are the ones which contain a sterically hindered hydroxyl group, and these include those derivatives of dihydroxy aryl compounds in which the hydroxyl groups are in the o- or p-position to each other. Typical phenolic antioxidants include the hindered phenols substituted with C6+ alkyl groups and the alkylene coupled derivatives of these hindered phenols. Examples of phenolic materials of this type 2-t-butyl-4-heptyl phenol; 2-t-butyl-4-octyl phenol; 2-t-butyl-4-dodecyl phenol; 2,6-di-t-butyl-4-heptyl phenol; 2,6-di-t-butyl-4-dodecyl phenol; 2-methyl-6-t-butyl-4-heptyl phenol; and 2-methyl-6-t-butyl-4-dodecyl phenol. Other useful hindered mono-phenolic antioxidants may include for example hindered 2,6-di-alkyl-phenolic propionic ester derivatives. Bis-phenolic antioxidants may also be advantageously used in combination with the instant invention. Examples of ortho-coupled phenols include: 2,2'-bis(4-heptyl-6-t-butyl-phenol); 2,2'-bis(4-octyl-6-t-butylphenol); and 2,2'-bis(4-dodecyl-6-t-butyl-phenol). Para-coupled bisphenols include for example 4,4'-bis(2,6-di-t-butyl phenol) and 4,4'-methylene-bis(2,6-di-t-butyl phenol).

[0116] Non-phenolic oxidation inhibitors which may be used include aromatic amine antioxidants and these may be used either as such or in combination with phenolics. Typical examples of non-phenolic antioxidants include: alkylated and non-alkylated aromatic amines such as aromatic monoamines of the formula $R_8R_9R_{10}N$, where R_8 is an aliphatic, aromatic or substituted aromatic group, R_9 is an aromatic or a substituted aromatic group, and R_{10} is H, alkyl, aryl or $R_{11}S(O)_xR_{12}$, where R_{11} is an alkylene, alkenylene, or aralkylene group, R_{12} is a higher alkyl group, or an alkenyl, aryl, or alkaryl group, and x is 0, 1 or 2. The aliphatic group R_8 may contain from 1 to about 20 carbon atoms, and preferably contains from about 6 to 12 carbon atoms. The aliphatic group is a saturated aliphatic group. Preferably, both R_8 and R_9 are aromatic or substituted aromatic groups, and the aromatic group may be a fused ring aromatic group such as naphthyl. Aromatic groups R_8 and R_9 may be joined together with other groups such as S.

[0117] Typical aromatic amines antioxidants have alkyl substituent groups of at least about 6 carbon atoms. Examples of aliphatic groups include hexyl, heptyl, octyl, nonyl, and decyl. Generally, the aliphatic groups will not contain more than about 14 carbon atoms. The general types of amine antioxidants useful in the present compositions include diphenylamines, phenyl naphthylamines, phenothiazines, imidodibenzyls and diphenyl phenylene diamines. Mixtures of two or more aromatic amines are also useful. Polymeric amine antioxidants can also be used. Particular examples of aromatic amine antioxidants useful in the present invention include: p,p'-dioctyldiphenylamine; t-octylphenyl-alpha-naphthylamine; phenyl-alphanaphthylamine; and p-octylphenyl-alpha-naphthylamine. Sulfurized alkyl phenols and alkali or alkaline earth metal salts thereof also are useful antioxidants.

[0118] In one embodiment, the performance additive in the lubricant compositions according to the present invention further includes a dispersant. The dispersant may be a succinimide dispersant (for example N-substituted long chain alkenyl succinimides), a Mannich dispersant, an ester-containing dispersant, a condensation product of a fatty hydrocarbyl monocarboxylic acylating agent with an amine or ammonia, an alkyl amino phenol dispersant, a hydrocarbyl-amine dispersant, a polyether dispersant or a polyetheramine dispersant.

[0119] In one embodiment the succinimide dispersant includes a polyisobutylene-substituted succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of 400 to 5000, or 950 to 1600. Succinimide dispersants and their methods of preparation are more fully described in U.S. Patents 4,234,435 and 3,172,892. Suitable ester-containing dispersants are typically high molecular weight esters. These materials are described in more detail in U.S. Patent 3,381,022.

[0120] In one embodiment the dispersant includes a borated dispersant. Typically the borated dispersant includes a succinimide dispersant including a polyisobutylene succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of 400 to 5000. Borated dispersants are described in more detail above within the extreme pressure agent description.

[0121] Dispersant viscosity modifiers (often referred to as DVMs) are considered additives in the context of the present invention due to their additional functionalization and are therefore not considered viscosity improving agents according to the present invention. Dispersant viscosity modifiers include functionalised polyolefins, for example, ethylene-propylene copolymers that have been functionalized with the reaction product of maleic anhydride and an amine, a polymethacrylate functionalised with an amine, or esterified styrene maleic anhydride copolymers reacted with an amine.

[0122] The corrosion inhibitors may be selected from oxygen-, nitrogen-, sulfur-, and phosphorus-containing materials, and may include metal-containing compounds (salts, organometallics, etc.) and nonmetal-containing or ashless materials. Corrosion inhibitors may include, but are not limited to, additive types such as, for example, hydrocarbyl-, aryl-, alkyl-, arylalkyl-, and alkylaryl-versions of detergents (neutral, overbased), sulfonates, phenates, salicylates, alcoholates, carboxylates, salixarates, phosphites, phosphates, thiophosphates, amines, amine salts, amine phosphoric acid salts, amine sulfonic acid salts, alkoxylated amines, etheramines, polyetheramines, amides, imides, azoles, diazoles, triazoles, benzotriazoles, benzothiadoles, mercaptobenzothiazoles, tolyltriazoles (TTZ-type), heterocyclic amines, heterocyclic-sulfides, thiazoles, thiadiazoles, mercaptothiadiazoles, dimercaptothiadiazoles (DMTD-type), imidazoles, benzimidazoles, dithiobenzimidazoles, imidazolines, oxazolines, Mannich reactions products, glycidyl ethers, anhydrides, carbamates, thiocarbamates, dithiocarbamates, polyglycols, etc., or mixtures thereof.

[0123] Corrosion inhibitors are used to reduce the degradation of metallic parts that are in contact with the lubricant composition. Suitable corrosion inhibitors include thiadiazoles. Aromatic triazoles, such as tolyltriazole, are suitable corrosion inhibitors for non-ferrous metals, such as copper. Metal deactivators include derivatives of benzotriazoles (typically tolyltriazole), 1,2,4-triazoles, benzimidazoles, 2-alkyldithiobenzimidazoles, thiadiazoles or 2-alkyldithiobenzothiazoles.

[0124] Foam inhibitors may also advantageously be added as a performance additive to the lubricant compositions according to the present invention. These agents retard the formation of stable foams. Silicones and organic polymers are typical foam inhibitors. For example, polysiloxanes, such as silicon oil, or polydimethylsiloxane, provide foam inhibiting properties. Further foam inhibitors include copolymers of ethyl acrylate and 2-ethylhexyl acrylate and optionally vinyl acetate.

[0125] Demulsifiers include trialkyl phosphates, and various polymers and copolymers of ethylene glycol, ethylene oxide, propylene oxide, or mixtures thereof.

[0126] As pour point depressants, esters of maleic anhydride-styrene, or polyacrylamides are included.

[0127] As a further performance additive to be used in the lubricant compositions according to the present invention, seal compatibility agents help to swell elastomeric seals by causing a chemical reaction in the fluid or physical change in the elastomer. Suitable seal compatibility agents for lubricant compositions include organic phosphates, aromatic esters, aromatic hydrocarbons, esters (butylbenzyl phthalate, for example), and polybutenyl succinic anhydride. Such additives may preferably be used in an amount of 0.01 to 3 % by weight, more preferably 0.01 to 2 % by weight of the total amount of the lubricant composition.

[0128] Preferred embodiments A to P of the lubricant concentrate (LC) according to the presently claimed invention are summarized in the Table-1 to 4 below:

Table-1

Component	A	B	C	D
(a) at least one alkoxylated polytetrahydrofuran of general formula (I)	m in the range of 1 to ≤ 40, m' in the range of 1 to ≤ 40, (m+m') in the range of ≥ 2 to ≤ 90, n in the range of 2 to ≤ 40, n' in the range of 2 to ≤ 40, (n+n') in the range of ≥ 4 to ≤ 85, k is in the range of ≥ 4 to ≤ 28, R_1 denotes, identical, unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl, R_2 denotes CH_2-CH_3, CH_3 or H,	m in the range of 2 to ≤ 30, m' in the range of 2 to ≤ 30, (m+m') in the range of ≥ 4 to ≤ 60, n in the range of 3 to ≤ 40, n' in the range of 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k in the range of ≥ 4 to ≤ 26, R_1 denotes, identical unsubstituted, linear C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} or C_{18} alkyl	m is in the range of ≥ 3 to ≤ 25, m' in the range of ≥ 3 to ≤ 25, (m+m') in the range of ≥ 6 to ≤ 50, n is in the range of ≥ 3 to ≤ 40, n' in the range of ≥ 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k is in the range of ≥ 4 to ≤ 24, R_1 denotes, identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11}, or C_{12}, alkyl and R_2 denotes CH_2-CH_3 or CH_3 or H,	m is in the range of ≥ 4 to ≤ 25, m' in the range of ≥ 4 to ≤ 25, (m+m') in the range of ≥ 10 to ≤ 45, n in the range of 4 to ≤ 40, n' in the range of 4 to ≤ 40, (n+n') in the range of ≥ 10 to ≤ 75, k in the range of ≥ 6 to ≤ 20, R_1 denotes identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11} or C_{12} alkyl,

(continued)

Component	A	B	C	D
	and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	R_2 denotes CH_3, CH_2-CH_3 or H, and R_3 and R_4 denote H or CH_3.
(b) at least one carboxylic acid ester	the at least one carboxylic acid ester is obtainable by reacting (i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol	the at least one carboxylic acid ester is obtainable by reacting (i) at least one linear or branched C_5-C_{20} monocarboxylic acid with at least one linear or branched C_1-C_{10} monoalcohol	the at least one carboxylic acid ester is obtainable by reacting (i) at least one linear or branched C_{10}-C_{20} monocarboxylic acid with at least one linear C_1-C_5 monoalcohol	the at least one carboxylic acid ester is obtainable by reacting (i) at least one linear C_{18} monocarboxylic acid with at least one linear C_1-C_5 monoalcohol

Table-2

Component	E	F	G	H
(a) at least one alkoxylated polytetrahydrofuran of general formula (I)	m in the range of 1 to ≤ 40, m' in the range of 1 to ≤ 40, (m+m') in the range of ≥ 2 to ≤ 90, n in the range of 2 to ≤ 40, n' in the range of 2 to ≤ 40, (n+n') in the range of ≥ 4 to ≤ 85, k is in the range of ≥ 4 to ≤ 28, R_1 denotes, identical, unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl, R_2 denotes CH_2-CH_3, CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m in the range of ≥ to ≤ 30, m' in the range of ≥ 2 to ≤ 30, (m+m') in the range of ≥ 4 to ≤ 60, n in the range of 3 to ≤ 40, n' in the range of ≥ 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k in the range of ≥ 4 to ≤ 26, R_1 denotes, identical unsubstituted, linear C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} or C_{18} alkyl R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m is in the range of ≥ 3 to ≤ 25, m' in the range of ≥ 3 to ≤ 25, (m+m') in the range of ≥ 6 to ≤ 50, n is in the range of ≥ 3 to ≤ 40, n' in the range of ≥ 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k is in the range of ≥ 4 to ≤ 24, R_1 denotes, identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11}, or C_{12}, alkyl and R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m is in the range of ≥ 4 to ≤ 25, m' in the range of ≥ 4 to ≤ 25, (m+m') in the range of ≥ 10 to ≤ 45, n in the range of 4 to ≤ 40, n' in the range of ≥ 4 to ≤ 40, (n+n') in the range of ≥ 10 to ≤ 75, k in the range of ≥ 6 to ≤ 20, R_1 denotes identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11} or C_{12}alkyl, R_2 denotes CH_3, CH_2-CH_3 or H, and R_3 and R_4 denote H or CH_3.
(b) at least one carboxylic acid ester	obtainable by reacting (ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol	the at least one carboxylic acid ester is obtainable by reacting (ii) at least one linear or branched C_3-C_{12} dicarboxylic acid with at least one branched C_5-C_{14} monoalcohol	the at least one carboxylic acid ester is obtainable by reacting (ii) at least one linear or branched C_3-C_8 dicarboxylic acid with at least one branched C_8-C_{13} monoalcohol	the at least one carboxylic acid ester is obtainable by reacting (ii) at least one linear C_6 dicarboxylic acid with at least one branched C_{10}-C_{13} monoalcohol

Table-3

Component	I	J	K	L
(a) at least one alkoxylated polytetrahydrofuran of general formula (I)	m in the range of 1 to ≤ 40, m' in the range of 1 to ≤ 40, (m+m') in the range of ≥ 2 to ≤ 90, n in the range of 2 to ≤ 40, n' in the range of 2 to ≤ 40, (n+n') in the range of ≥ 4 to ≤ 85, k is in the range of ≥ 4 to ≤ 28, R_1 denotes, identical, unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl, R_2 denotes CH_2-CH_3, CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m in the range of 2 to ≤ 30, m' in the range of 2 to ≤ 30, (m+m') in the range of ≥ 4 to ≤ 60, n in the range of 3 to ≤ 40, n' in the range of 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k in the range of ≥ 4 to ≤ 26, R_1 denotes, identical unsubstituted, linear C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} or C_{18} alkyl R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m is in the range of ≥ 3 to ≤ 25, m' in the range of ≥ 3 to ≤ 25, (m+m') in the range of ≥ 6 to ≤ 50, n is in the range of ≥ 3 to ≤ 40, n' in the range of ≥ 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k is in the range of ≥ 4 to ≤ 24, R_1 denotes, identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11}, or C_{12}, alkyl and R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m is in the range of ≥ 4 to ≤ 25, m' in the range of ≥ 4 to ≤ 25, (m+m') in the range of ≥ 10 to ≤ 45, n in the range of 4 to ≤ 40, n' in the range of 4 to ≤ 40, (n+n') in the range of ≥ 10 to ≤ 75, k in the range of ≥ 6 to ≤ 20, R_1 denotes identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11} or C_{12}alkyl, R_2 denotes CH_3, CH_2-CH_3 or H, and R_3 and R_4 denote H or CH_3.
(b) at least one carboxylic acid ester	obtainable by reacting (iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group	the at least one carboxylic acid ester is obtainable by reacting (iii) at least one linear or branched C_2-C_{15} monocarboxylic acid with at least one C_2-C_{10} polyol having 2-8 hydroxyl group	the at least one carboxylic acid ester is obtainable by reacting (iii) at least one linear C_2-C_{12} mono-carboxylic acid with at least one C_2-C_8 polyol having 2-5 hydroxyl group	the at least one carboxylic acid ester is obtainable by reacting (iii) at least one linear or branched C_4-C_{10} monocarboxylic acid with at least one C_5 polyol having 3 hydroxyl group

Table-4

Component	M	N	O	P
(a) at least one alkoxylated polytetrahydrofuran of general formula (I)	m in the range of 1 to ≤ 40, m' in the range of 1 to ≤ 40, (m+m') in the range of ≥ 2 to ≤ 90, n in the range of 2 to ≤ 40, n' in the range of 2 to ≤ 40, (n+n') in the range of ≥ 4 to ≤ 85, k is in the range of ≥ 4 to ≤ 28, R_1 denotes, identical, unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl, R_2 denotes CH_2-CH_3, CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m in the range of 2 to ≤ 30, m' in the range of 2 to ≤ 30, (m+m') in the range of ≥ 4 to ≤ 60, n in the range of 3 to ≤ 40, n' in the range of 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k in the range of ≥ 4 to ≤ 26, R_1 denotes, identical unsubstituted, linear C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} or C_{18} alkyl R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m is in the range of ≥ 3 to ≤ 25, m' in the range of ≥ 3 to ≤ 25, (m+m') in the range of ≥ 6 to ≤ 50, n is in the range of ≥ 3 to ≤ 40, n' in the range of ≥ 3 to ≤ 40, (n+n') in the range of ≥ 6 to ≤ 80, k is in the range of ≥ 4 to ≤ 24, R_1 denotes, identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11}, or C_{12}, alkyl and R_2 denotes CH_2-CH_3 or CH_3 or H, and R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H.	m is in the range of ≥ 4 to ≤ 25, m' in the range of ≥ 4 to ≤ 25, (m+m') in the range of ≥ 10 to ≤ 45, n in the range of 4 to ≤ 40, n' in the range of 4 to ≤ 40, (n+n') in the range of ≥ 10 to ≤ 75, k in the range of ≥ 6 to ≤ 20, R_1 denotes identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11} or C_{12}alkyl, R_2 denotes CH_3, CH_2-CH_3 or H, and R_3 and R_4 denote H or CH_3.
(b) at least one carboxylic acid ester	obtainable by reacting (vi) at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group	obtainable by reacting (vi) at least one linear or branched C_2-C_{15} monocarboxylic acid and at least one linear or branched C_3-C_{12} dicarboxylic acid and at least one C_2-C_{10} polyol having 2-8 hydroxyl group	obtainable by reacting (vi) at least one linear C_2-C_{12} monocarboxylic acid and at least one linear or branched C_3-C_8 dicarboxylic acid and at least one C_2-C_8 polyol having 2-5 hydroxyl group	obtainable by reacting (vi) at least one linear or branched C_4-C_{10} monocarboxylic acid and at least one linear C_6 dicarboxylic acid and at least one C_5 polyol having 3 hydroxyl group

[0129] Preferred variants 1 to 10 of the embodiments A to P are summarized in the Table-5 below:

Table-5

Component	1	2	3	4	5	6	7	8	9	10
(a) Alkoxylated polytetrahydrofuran of general formula (I)	≥ 0.1 to ≤ 99.9 % by weight	≥ 5.0 to ≤ 95.0 % by weight	≥ 10.0 to ≤ 90.0 % by weight	≥ 20.0 to 80.0% by weight	≥ 30.0 to ≤ 70.0 % by weight	≥ 40.0 to ≤ 60.0 % by weight	≥ 66.2 to ≤ 99.8 % by weight	≥ 60.0 to ≤ 71.0 % by weight	≥ 66.6 to ≤ 75.0 % by weight	50 % by weight
(b) carboxylic acid ester	≥ 0.1 to ≤ 99.9 % by weight	≥ 5.0 to ≤ 95.0 % by weight	≥ 10.0 to ≤ 90.0 % by weight	≥ 20.0 to ≤ 80.0 % by weight	≥ 30.0 to ≤ 70.0 % by weight	≥ 40.0 to ≤ 60.0 % by weight	≥ 0.2 to ≤ 33.8 % by weight	≥ 29.0 to ≤ 40.0 % by weight	≥ 25.0 to 33.4 % by weight	50 % by weight
Weight ratio (a) : (b)	99.9 : 0.1 to 0.1: 99.9	19:1 to 1: 19	9:1 to 1:9	4 : 1 to 1: 4	2.33:1 to 1: 2.33	3:2 to 2:3	49.9 : 0.1 to 1.96 : 1	2.44:1 to 1.5: 1	3:1 to 1.99:1	1:1

[0130] Preferred lubricant concentrates result from the following combinations of the embodiments A to P with variants 1 to 10: A^1, A^2, A^3, A^4, A^5, A^6, A^7, A^8, A^9, A^{10}, B^1, B^2, B^3, B^4, B^5, B^6, B^7, B^8, B^9, B^{10}, C^1, C^2, C^3, C^4, C^5, C^6, C^7, C^8, C^9, C^{10}, D^1, D^2, D^3, D^4, D^5, D^6, D^7, D^8, D^9, D^{10}, E^1, E^2 E^3, E^4, E^5, E^6, E^7, E^8, E^9, E^{10}, F^1, F^2, F^3, F^4, F^5, F^6, F^7, F^8, F^9, F^{10}, G^1, G^2, G^3, G^4, G^5, G^6, G^7, G^8, G^9, G^{10}, H^1, H^2, H3, H^4, H^5, H^6, H^7, H^8, H^9, H^{10}, I^1, I^2, I^3, I^4, I^5, I^6, I^7, I^8, I^9, I^{10}, J^1, J^2, J^3, J^4, J^5, J^6, J^7, J^8, J^9, J^{10}, K^1, K^2, K^3, K^4, K^5, K^6, K^7, K^8, K^9, K^{10}, L^1, L^2, L^3, L^4, L^5, L^6, L^7, L^8, L^9, L^{10}, M^1, M^2, M^3, M^4, M^5, M^6, M^7, M^8, M^9, M^{10}, N^1, N^2, N^3, N^4, N^5, N^6, N^7, N^8, N^9, N^{10}, O^1, O^2, O^3, O^4, O^5, O^6, O^7, O^8, O^9, O^{10}, P^1, P^2, P^3, P^4, P^5, P^6, P^7, P^8, P^9, P^{10}. For example "H^4" means a combination of embodiment H with variant 4, i.e a lubricant concentrate containing ≥ 20.0 to ≤ 80.0 % by weight of (a) in which m is in the range of ≥ 4 to ≤ 25, m' is in the range of ≥ 4 to ≤ 25, (m+m') in the range of ≥ 10 to ≤ 45, n is in the range of ≥ 4 to ≤ 40, n' in the range of ≥ 4 to ≤ 40, (n+n') in the range of ≥ 10 to ≤ 75, k is in the range of ≥ 4 to ≤ 20, R_1 denotes identical, unsubstituted, linear C_8, C_9, C_{10}, C_{11} or C_{12} alkyl, R_2 denotes CH_3, CH_2-CH_3 or H and R_3 and R_4 denote H or CH_3; and ≥ 20.0 to ≤ 80.0 % by weight of (b) at least one carboxylic acid ester obtainable by reacting (ii) at least one linear C_6 dicarboxylic acid with at least one branched C_{10}-C_{13} monoalcohol in a weight ratio of a: b of 4:1 to 1:4.

[0131] In another preferred embodiment, the presently claimed invention is directed to a lubricant composition consisting of

≥ 1.0 to ≤ 90.0 % by weight of the lubricant concentrate (LC) as defined above;

≥ 10.0 to ≤ 75.0 % by weight of at least one base oil (c) selected from Group I mineral oils, Group II mineral oils, Group III mineral oils, Group IV oils and Group V oils and;

≥ 0.1 to ≤ 15.0 % by weight of at least one additive component (d),

[0132] in each case by weight of the total weight of lubricant composition.

[0133] The components (a), (b) and (c) are in each case different from component (d), so that the at least one additive component (d) does not encompass any of components (a), (b) and (c).

[0134] In a preferred embodiment the lubricant composition of the presently claimed invention comprises the lubricant concentrate, the at least one base oil (c) and the at least one additive component (d) in the following amounts.

Table-6

Component	1	2	3	4	5	6	7
LC	≥ 1.0 to ≤ 90.0 % by weight	≥ 1.0 to ≤ 90.0 % by weight	≥ 5.0 to ≤ 80.0 % by weight	≥ 10.0 to ≤ 70.0 % by weight	≥ 20.0 to ≤ 60.0 % by weight	≥ 30.0 to ≤ 60.0 % by weight	50 % by weight
Base oil (c)	≥ 10 to ≤ 75.0 % by weight	≥ 9.9 to ≤ 70.0 % by weight	≥ 19.0 to ≤ 75.0 % by weight	≥ 20.0 to ≤ 60.0 % by weight	≥ 30.0 to ≤ 60.0 % by weight	≥ 40.0 to ≤ 60.0 % by weight	50 % by weight
Additive (d)	≥ 0.0 to ≤ 15.0 % by weight	≥ 0.1 to ≤ 15.0 % by weight	≥ 0.1 to ≤ 10.0 % by weight	≥ 1.0 to ≤ 10.0 % by weight	≥ 2.0 to ≤ 10.0 % by weight	≥ 3.0 to ≤ 10.0 % by weight	≥ 0.0 to ≤ 10.0% by weight

[0135] The preferred embodiments as described above also apply to the uses and methods as outlined in the following passages.

[0136] In another embodiment, the presently claimed invention is directed to a method of reducing friction in an engine using an engine oil comprising (a) at least one alkoxylated polytetrahydrofuran of general formula (I) and (b) at least one carboxylic acid ester, in an amount as defined in the embodiments derived from Table-1 to 5, as defined above.

[0137] In yet another embodiment, the presently claimed invention is directed to a method of enhancing the friction modification properties of a lubricating oil composition in the lubrication of a mechanical device comprising formulating said lubricating oil composition with at least one alkoxylated polytetrahydrofuran of general formula (I) and at least one ester of carboxylic acid, in an amount as defined in the embodiments derived from Table-1 to 5, as defined above.

[0138] In another embodiment, the presently claimed invention is directed to a method of reducing friction in an engine using an engine oil comprising

≥ 1.0 to ≤ 90.0 % by weight of the lubricant concentrate (LC) as defined above;

≥ 10.0 to ≤ 75.0 % by weight of at least one base oil (c) selected from Group I mineral oils, Group II mineral oils, Group III mineral oils, Group IV oils and Group V oils and;

≥ 0.1 to ≤ 15.0 % by weight of at least one additive component (d),

[0139] in each case by weight of the total weight of lubricant composition.

[0140] Enhancing the friction-modification properties means in the sense of the present invention that the friction coefficient of a lubricating oil composition comprising a lubricant concentrate (LC) which is a combination of alkoxylated polytetrahydrofuran of general formula (I) and carboxylic acid ester is lower than the friction coefficient of a lubricating oil composition that does not contain said lubricant concentrate (LC). The friction-modification properties are determined by measuring the friction coefficient at 20% slide roll ratio (SRR) using mini-traction machine (MTM) measurements at 70° C and 1 GPa.

[0141] A mechanical device in the sense of the presently claimed invention is a mechanism consisting of a device that works on mechanical principles.

[0142] The mechanical device is preferably selected from the group consisting of bearings, gears, joints and guidances. Preferably the mechanical device is operated at temperatures in the range of ≧ 10° C. to ≦ 80° C.

[0143] In an embodiment the lubricant composition has friction coefficient in the range of ≥ 0.003 to ≤ 0.030 at 20% slide roll ratio (SRR) determined using mini-traction machine (MTM) measurements at 70 °C and 1 GPa.

[0144] In an embodiment the lubricant composition has a wear scar in the range of ≥ 0.003 to ≤ 0.60 according to ASTM D 4172.

[0145] The lubricant composition according to the present invention has the following advantages:

- Excellent friction reducing capacity which obviates the need of additional friction reducers.
- Energy efficient as energy losses are minimized.
- The lubricant composition is stable to oxidation.
- The lubricant composition is efficient in working at higher operating loads.
- The lubricant composition exhibits increased hydrolytic stability.

[0146] The invention is now illustrated in detail by the working examples which follow. More particularly, the test methods specified hereinafter are part of the general disclosure of the application and are not restricted to the specific working examples.

Examples

Compounds

[0147] Synative® ES DPHA (di-(2-propyl-heptyl) adipate)
Ambosol® (magnesium silicate)
PolyTHF® 650 Polyether (Mw 650 g/mol)
PolyTHF® 1000 Polyether (Mw 1000 g/mol)
SYNATIVE AC AMH 2® (a nonionic surfactant which acts as a defoamer) are available from BASF SE, Ludwigshafen, Germany.

[0148] Polyalphaolefin 4 (PAO 4) having a kinematic viscosity at 100°C of 4 cSt is available from ExxonMobil.

[0149] Additive package 1: under the tradename ANGLAMOL® is available from the Lubrizol Corporation.

[0150] Additive package 2: under the tradename HITEC® is available from the Afton Chemical Corporation.

[0151] Antioxidant 1: is a commercially available antioxidant under the tradename IRGANOX® from the BASF Corporation.

[0152] Antioxidant 2: is an antioxidant different from Antioxidant 1 and is also commercially available under the tradename IRGANOX® from the BASF Corporation.

[0153] Dispersant 1 is a commercially available dispersant under the tradename HITEC® from the Afton Chemical Corporation

Methods

[0154] OHZ=hydroxyl number, determined according to DIN 53240.

[0155] M_n=number average molecular weight, determined according to DIN 55672-1 and referred to Polystyrene calibration standard.

[0156] M_w=weight average molecular weight, determined according to DIN 55672-1 and referred to Polystyrene calibration standard.

[0157] PD=polydispersity, determined according to DIN 55672-1.

Measuring Physical Properties:

[0158] The kinematic viscosity was measured according to the standard international method ASTM D 445.

[0159] The viscosity Index was measured according to the ASTM D 2270.

[0160] The pour point according was measured to DIN ISO 3016.

[0161] Friction Coefficient Evaluation

[0162] The fluids were tested in the MTM (Mini Traction Machine) instrument using the so-called traction test mode.

[0163] In a typical MTM configuration, a ¾" (19.05 mm) diameter steel ball (AISI 52100) is loaded and rotated against the flat surface of a rotating disk (AISI 52100). The disc is held in a bath containing a test lubricant so that the contact between the ball and flat is fully immersed. The ball shaft is aligned with respect to the disk so as to prevent spin in the contact and the slide-roll ratio is controlled independently by driving both the ball and the disk with separate motors.

Ball	Steel, AISI 52100, diameter = ¾" (19.05 mm) Hardness = 800-920 HV $R_a < 0.02\ \mu m$
Disc	Steel, AISI 52100, diameter = 46.00 mm Hardness = 720-780 HV $R_a < 0.01\ \mu m$
Contact Pressure Temperature	70 °C

[0164] Friction coefficient is measured at a constant mean speed (U) over a range of slide roll ratios (SRR) to give the traction curve.

[0165] SRR=sliding U/mean entrainment U
$=2\ (U_1-U_2)/(U_1+U_2)$
in which U_1 and U_2 are the ball and disc speeds respectively.

[0166] The disc and ball used for the experiments were made of steel (AISI 52100), with a hardness of 750 HV and Ra<0.02 μm. The diameter was 46.0 mm and 19.0 mm for the disc and the ball respectively. The tractions curves were run with 1.00 GPa contact pressure, 4 m/s mean speed and 70° C temperature. The slide-roll ratio (SRR) was varied from 0 to 25% and the friction coefficient measured.

Calculation of synergy value of the lubricant concentrate

[0167] The value of synergy (in %) can be derived for a lubricant concentrate comprising alkoxylated polytetrahydrofurans of general formula (I) and carboxylic acid esters from their coefficient of friction and viscosity values.

[0168] The synergy value (in %) is calculated using the following formula:

$$\text{Synergy \%} = \frac{\left(\text{linear assumption} - \dfrac{\text{Coefficient of friction of binary mixture at 20\% MTM}}{\text{Viscosity of binary mixture at 70}^\circ\text{C}}\right)}{\text{linear assumption}} \times 100\ \%$$

Linear assumption

$$= \left[\text{wt. fraction of component (a) in a binary mixture} \times \frac{\text{coefficient of friction of component (a)}}{\text{viscosity of component (a) at 70}^\circ\text{C}}\right] +$$

$$\left[\text{wt. fraction of component (b) in a binary mixture} \times \frac{\text{coefficient of friction of component (b)}}{\text{viscosity of component (b) at 70}^\circ\text{C}}\right]$$

[0169] The synergy value is indicative of the synergistic effect of the combination which shows that the effect is not additive. In case of the present invention, if the synergy value is negative or less than 5% then the two components of the binary mixture have an additive effect rather than a synergistic effect.

[0170] The higher the value of synergy for a given combination of alkoxylated polytetrahydrofuran of general formula (I) and carboxylic acid esters, the greater is the friction lowering efficiency.

Synthesis of the Polyalkylene Glycols

Example 1

[0171] PolyTHF 650 with 20 Equivalents of C_{12} Epoxide

[0172] A steel reactor (1.5 l) was loaded with polytetrahydrofuran (M_W 650 g/mol) (0.2 mol, 130 g), and 3.4 g KOtBu was mixed and the reactor was purged with nitrogen. The reactor was heated under vacuum (10 mbar) and heated to 140° C for 0.25 h. Then again nitrogen was loaded. At a pressure of 2 bar, 50 g C_{12} epoxide was brought in dropwise at 140° C. 686 g C_{12} epoxide of total (736 g; 4.0 mol) was added during 10 h at 140° C and under pressure of 6 bar.
Yield: 874 g, quantitative (theor.: 866 g) OHZ: 28.2 mg KOH/g, M_w: 4923 g/mol and M_n: 4517 g/mol, polydispersity: 1.09.

Example 2

[0173] PolyTHF 650 with 12 Equivalents of C_{12} Epoxide and 20 Equivalents of Butylene Oxide (Block)

[0174] A steel reactor (1.5 l) was loaded with polytetrahydrofuran (M_W 250 g/mol) (0.2 mol, 130 g), and 3.4 g KOtBu was mixed and the reactor was purged with nitrogen. The reactor was heated under vacuum (10 mbar) and heated to 140° C for 0.25 h. Then again nitrogen was loaded. At a pressure of 2 bar 50 g C_{12} epoxide was brought in dropwise at 140° C 390 g C_{12} epoxide of total (441 g; 2.4 mol) was added during 5 h at 140° C and under pressure of 6 bar. Then butylene oxide (288 g, 4.0 mol) was added within 4 h at 140° C. The reactor was stirred for 10 h at 140° C and cooled to 80° C. The product was stripped by nitrogen. Then the product was discharged and mixed with Ambosol® (30 g) and mixed on a rotary evaporator at 80° C. The purified product was obtained by filtration in a pressure strainer (Filtrations media: Seitz 900).
Yield: 866 g, quantitative (theor.: 859 g) OHZ: 30.1 mg KOH/g, M_w: 4602 g/mol and M_n: 3861 g/mol, polydispersity: 1.19.

Example 3

[0175] PolyTHF 650 with 12 Equivalents of C_{12} Epoxide and 20 Butylene Oxide (Random)

[0176] A steel reactor (5 l) was loaded with polytetrahydrofuran (Mw 650 g/mol) (0.732 mol, 476 g), and KOtBu (12.6 g) was mixed and the reactor was purged with nitrogen. At a pressure of 2 bar a mixture of butylene oxide and C_{12} epoxide (14.64 mol, 1104 g butylene oxide; 8.8 mol, 1617 g C_{12} epoxide) was brought in dropwise during 30 h at 140° C. and under pressure of 6 bar. The reactor was stirred for 10 h at 140° C and cooled to 80° C. The reactor was cooled to 80° C and the product was stripped by nitrogen. Then the product was discharged and mixed with Ambosol® (60 g) and mixed on a rotary evaporator at 80° C. The purified product was obtained by filtration in a pressure strainer (Filtrations media: Seitz 900).
Yield: 3077 g (96%) (Th.: 3200 g), OHZ: 31.4 mg KOH/g, M_w: 4650 g/mol and M_n: 4720 g/mol, polydispersity: 1.42.

Example 4

PolyTHF 650 with 12 Equivalents of C_{12} Epoxide and 20 Equivalents of Propylene Oxide (Random)

[0177] A steel reactor (1.5 l) was loaded with polytetrahydrofuran (M_W 650 g/mol) (0.2 mol, 130 g), and KOtBu (3.21 g) was mixed and the reactor was purged with nitrogen. At a pressure of 2 bar a mixture of propylene oxide and C_{12} epoxide (4.0 mol, 232 g PO; 2.4 mol, 441 g C_{12} epoxide) was brought in dropwise during 7 h at 140° C and under pressure of 6 bar. The reactor was stirred for 10 h at 140° C. The reactor was cooled to 80° C and the product was stripped by nitrogen. Then the product was discharged and mixed with Ambosol® (60 g) and mixed on a rotary evaporator at 80° C. The purified product was obtained by filtration in a pressure strainer (Filtrations media: Seitz 900).
Yield: 800 g (quantitative) (Th.: 803 g), OHZ: 30.8 mg KOH/g, M_w: 5074 g/mol and M_n: 4660 g/mol, polydispersity: 1.09.

Example 5

PolyTHF 1000 with 18 Equivalents of C_{12} Epoxide and 30 Equivalents of Butylene Oxide (Random)

[0178] A steel reactor (1.5 l) was loaded with polytetrahydrofuran (M_W 1000 g/mol) (0.1 mol, 100 g), and KOtBu (2.59 g) was mixed and the reactor was purged with nitrogen. At a pressure of 2 bar a mixture of butylene oxide and C_{12} epoxide (3.0 mol, 216 g butylene oxide; 1.8 mol, 331 g C_{12} epoxide) was brought in dropwise during 5 h at 140° C and under pressure of 6 bar. The reactor was stirred for 10 h at 140° C and cooled to 80° C. The reactor was cooled to 80° C and the product was stripped by nitrogen. Then the product was discharged and mixed with Ambosol® (60 g) and mixed on a rotary evaporator at 80° C. The purified product was obtained by filtration in a pressure strainer (Filtrations

media: Seitz 900).
Yield: 661 g (quantitative) (Th.: 647 g), OHZ: 24.7 mg KOH/g, M_w: 5667 g/mol and M_n: 4551 g/mol, polydispersity: 1.24.

Example 6

PolyTHF 1000 with 36 Equivalents of C_{12} Epoxide and 60 Equivalents of Butylene Oxide (Random)

[0179] A steel reactor (1.5 l) was loaded with polytetrahydrofuran (M_W 1000 g/mol) (0.1 mol, 100 g), and KOtBu (4.78 g) was mixed and the reactor was purged with nitrogen. At a pressure of 2 bar a mixture of butylene oxide and C_{12} epoxide (6.0 mol, 432 g butylene oxide; 3.6 mol, 662 g C_{12} epoxide) was brought in dropwise during 11 h at 140° C and under pressure of 6 bar. The reactor was stirred for 10 h at 140° C. and cooled to 80° C. The reactor was cooled to 80° C and the product was stripped by nitrogen. Then the product was discharged and mixed with Ambosol® (60 g) and mixed on a rotary evaporator at 80° C. The purified product was obtained by filtration in a pressure strainer (Filtrations media: Seitz 900).
Yield: 1236 g (quantitative) (Th.: 1194 g), OHZ: 9.4 mg KOH/g, M_w: 6629 g/mol and M_n: 5204 g/mol, polydispersity: 1.27.

Example 7

PolyTHF 650 with 4 Equivalents of C_{12} Epoxide and 40 Equivalents of Butylene Oxide (Random)

[0180] OHZ: 27 mg KOH/g, M_w: 5369 g/mol and M_n: 4872 g/mol, polydispersity: 1.10.

Example 8

PolyTHF 1000 with 40 Equivalents of C_{12} Epoxide and 70 Equivalents of Butylene Oxide (Random)

[0181] A steel reactor (1.5 l) was loaded with polytetrahydrofuran (M_W 1000 g/mol, 63.7 mmol, 63.7 g) and CsOH (50% aqueous solution, 6.9 g). The mixture was dried under vacuum (< 10 mbar) at 100°C to a water content below 0.1% (Karl-Fischer titration). At a pressure of 2 bar nitrogen a mixture of butylene oxide and C_{12} epoxide (4.45 mol, 321 g butylene oxide; 2.55 mol, 469 g C_{12} epoxide) was brought in dropwise during 10 h at 130° C. The reaction mixture was stirred for 20 h at 130° C and cooled to 80° C. Volatile compounds were removed by nitrogen stripping. Then the product was discharged and mixed with Ambosol® (13 g) and mixed on a rotary evaporator at 80° C for 2 h. The purified product was obtained by filtration in a pressure strainer (Filtrations media: Seitz 900).
Yield: 850 g, OHZ: 11,7 mg KOH/g, M_w: 10617 g/mol and M_n: 8356 g/mol, polydispersity: 1.27.

[0182] The friction data and the synergy effect are summarized in Table-7.

Table-7

Amount of (a)	(a)	Amount of (b)	(b)	Appearance	Viscosity at 70 °C	Coefficient of friction at 20% MTM	Coefficient of friction at 20%MTM / Viscosity at 70 °C	linear assumption	Synergy
_	_	100%	DPHA	Clear	5.17	0.0156	0.0030174		
100%	Example 4	0%		Clear	100.30	0.0150	0.0001495		
95%	Example 4	5%	DPHA	Clear	87.67	0.0163	0.0001859	0.0002929	37%
90%	Example 4	10%	DPHA	Clear	76.68	0.0162	0.0002113	0.0004363	52%
80%	Example 4	20%	DPHA	Clear	58.70	0.0159	0.0002709	0.0007231	63%

[0183] The above table readings demonstrate that the composition of the present invention, namely combination of alkoxylated polytetrahydrofuran (a) and carboxylic acid esters (b) provide low friction coefficients (≤ 0.015 at 20% SRR in MTM experiments) and also exhibit synergy as high as 63%.

[0184] Axle lubricating oil composition are provided below in Table 8 as Examples 9-11. Each individual component in Table 8 is provided in parts by weight based on 100 parts by weight of the respective example.

Table-8

Components	Example 9	Example 10	Example 11
Compounds of general formula (I)	28 %	28 %	29 %
DPHA	15 %	15 %	12 %
PAO 4	43.8 %	45.8 %	45.8 %
Additive package 1	10 %	-	10 %
Additive package 2	-	8 %	-
Antioxidant 1	0.5 %	0.5 %	0.5 %
Antioxidant 2	0.5 %	0.5 %	0.5 %
Dispersant	2.0 %	2.0 %	2.0 %
SYNATIVE AC AMH 2®	0.2 %	0.2 %	0.2 %

[0185] The viscosity profiles of Examples 9-11 were evaluated by measuring the kinematic viscosities at 40°C and 100°C and calculating the viscosity index. Additionally, the shear stability of Examples 9 and 10 was also evaluated by measuring the KRL Shear Loss according to CEC L-45-A-99. The results of this testing are provided below in Table-9.

Table-9

	Kinematic Viscosity (D445) (cSt)		Viscosity Index (D2270)	KRL Shear Loss (%)
	40°C	100°C		
Example 9	67.15	12.76	193	1.1
Example10	72.82	13.54	192	4.9
Example 11	66.46	12.60	193	-

[0186] As shown in Table-9, Examples 9-11 have greater low and high temperature performance as evidenced by the viscosity index values. In addition, Examples 9 and 10 demonstrate excellent shear stability as evidenced by the KRL Shear Loss values.

[0187] The oxidative stability of Examples 9 and 10 was evaluated by measuring the L-60 Oxidation / Thermal Stability at 200 hours in accordance with ASTM D5704.

[0188] The results of this testing are displayed in Table-10.

Table-10

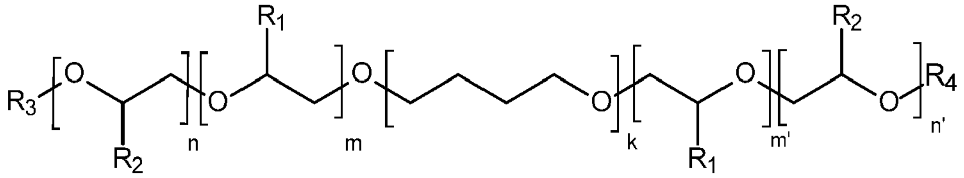
	L-60 Oxidation / Thermal Stability at 200 hours				
	Viscosity Increase, 100°C (%)	Pentane Insolubles (wt. %)	Toluene Insolubles (wt. %)	Carbon/Varnish (10=clean)	Sludge (10=clean)
Example 9	25	0.1	0.0	9.2	9.7
Example 10	3	0.1	0.1	8.9	9.6

[0189] As shown in Table-10, Examples 9 and 10 demonstrate superior oxidation performance as indicated by the relatively lower increase in viscosity after 200 hours of testing. This superior performance is also observable by contrasting the carbon/varnish and sludge values of Examples9 and 10.

Claims

1. A lubricant concentrate (LC) comprising

(a) at least one alkoxylated polytetrahydrofuran of general formula (I)



(I)

wherein

m is in the range of ≥ 1 to ≤ 50,
m' is in the range of ≥ 1 to ≤ 50,
(m+m') is in the range of ≥ 1 to ≤ 90
n is in the range of ≥ 0 to ≤ 75,
n' is in the range of ≥ 0 to ≤ 75,
(n+n') is in the range of ≥ 0 to ≤ 90,
k is in the range of ≥ 2 to ≤ 30,
R_1 denotes an unsubstituted, linear or branched, C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{27} or C_{28} alkyl,
R_2 denotes CH_2-CH_3, CH_3 or H, and
R_3 and R_4 denote, identical or different, substituted or unsubstituted, linear or branched C_1, C_2, C_3, C_4, C_5 alkyl or H,

wherein the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure;
(b) at least one carboxylic acid ester obtainable by reacting

(i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol; or
(ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol; or
(iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or
(iv) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or
(v) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one linear or branched C_1-C_{20} monoalcohol; or
(vi) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or
(vii) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group and at least one C_1-C_{20} monoalcohol.

2. The lubricant concentrate according to claim 1, wherein the weight ratio of (a) : (b) is in the range of 99 : 1 to 1 : 99.

3. The lubricant concentrate according to claim 1, wherein the weight ratio of (a) : (b) is in the range of 95 : 5 to 80 : 20.

4. The lubricant concentrate according to claim 1, wherein (b) the at least one carboxylic acid ester is obtainable by reacting

(i) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol; or
(ii) at least one linear or branched C_2-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol; or
(iii) at least one linear or branched C_2-C_{24} monocarboxylic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group; or
(iv) a mixture comprising at least one linear or branched C_2-C_{24} monocarboxylic acid and at least one linear or branched C_2-C_{20} dicarboxylic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group.

5. The lubricant concentrate according to claim 4, wherein (b) the at least one carboxylic acid ester is obtainable by reacting

(i) at least one linear or branched C_5-C_{20} monocarboxylic acid selected from the group consisting of pentanoic acid, iso-pentanoic acid, hexanoic acid, iso-hexanoic acid, heptanoic acid, iso-heptanoic acid, octanoic acid, iso-octanoic acid, nonanoic acid, iso-nonanoic acid, decanoic acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, palmitic acid, heptadecanoic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, nonadecanoic acid and eicosanoic acid with at least one linear or branched C_1-C_{18} monoalcohol selected from the group consisting of methanol, ethanol, propanol, butanol, pentanol, hexanol, heptanol, 1-octanol, 3-methyl-1-butanol, nonanol, decanol, undecanol, dodecanol, tridecanol, tetradecanol, pentadecanol, hexadecanol, heptadecanol, octadecanol, iso-propanol, iso-butanol, 2-octanol, 3-octanol, iso-nonanol, isodecanol, iso-undecanol, iso-dodecanol iso-tridecanol, iso-tetradecanol, iso-pentadecanol, iso-hexadecanol, iso-heptadecanol, iso-octadecanol, neo-pentanol , t-butanol, 2-methyl-2-butanol, 2,3-dimethyl-2-butanol, 2-methyl-2-pentanol, 3-methyl-3-pentanol, 3-ethyl-3-pentanol, 2,3-dimethyl-2-pentanol, 2,3-dimethyl-2-pentanol, 2,3-dimehtyl-2-pentanol, 2,3-dimethyl-3-pentaol, 2,3,4-trimethyl-3-pentanol, 2-methyl-2-hexanol and 3-methyl-3-hexanol;
or;
(ii) at least one linear or branched C_3-C_{12} dicarboxylic acid selected from the group consisting of malonic acid, succinic acid, glutaric acid, adipic acid, maleic acid, fumaric acid, azelaic acid, sebacic acid, brassilic acid, docdecanedioic acid, diglycolic acid, 1,4-cyclohexanedicarboxylic acid, 1,3-cyclohexanedicarboxylic acid and 2,6-decahydronaphthalenedicarboxylic acid with at least one branched C_5-C_{14} monoalcohol selected from the group consisting of pentanol, hexanol, heptanol, iso-pentanol, iso-hexanol, iso-heptanol, 2-ethylhexanol, 2-propylheptanol, 2-propyl-4-methyl-hexanol, 2-propyl-5-methyl-hexanol, 2-isopropyl-4-methyl-hexanol, 2-isopropyl-5-methyl-hexanol, 2-propyl-4,4-dimethylpentanol, 2-ethyl-2,4-dimethylhexanol, 2-ethyl-2-methyl-heptanol, 2-ethyl-2,5-dimethylhexanol, 2-isopropyl-heptanol, 2-butyl-1-octanol and 2-pentyl-1-nonanol or;
(iii) at least one linear or branched C_5-C_{18} monocarboxylic acid selected from the group consisting of pentanoic acid, caproic acid, heptanoic acid, caprylic acid, nonanoic acid capric acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, oleic acid and palmitoleic acid with at least one C_2-C_{20} polyol having 2-10 hydroxyl group selected from the group consisting of ethylene glycol, 1,2-propylene glycol, 1,3-propylene glycol, 1,2-butylene glycol, 1,3-butylene glycol, 2,3-butylene glycol, neopentyl glycol, trimethylol propane, trimethylol ethane, pentaerythritol, sorbitol, and dipentaerythritol
or;
(iv) a mixture comprising at least one linear or branched C_5-C_{18} monocarboxylic acid selected from the group consisting of pentanoic acid, caproic acid, heptanoic acid, caprylic acid, nonanoic acid capric acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, oleic acid, palmitoleic acid and at least one linear or branched C_3-C_{10} dicarboxylic acid selected from the group consisting of malonic acid, succinic acid, glutaric acid, adipic acid, heptanedioic acid, octananedioic acid, nonanedioic acid and decanedioic acid and at least one C_2-C_{20} polyol having 2-10 hydroxyl group selected from the group consisting of ethylene glycol, 1,2-propylene glycol, 1,3-propylene glycol, 1,2-butylene glycol, 1,3-butylene glycol, 2,3-butylene glycol neopentyl glycol, trimethylol propane, trimethylol ethane, pentaerythritol, sorbitol, and dipentaerythritol.

6. The lubricant concentrate according to claim 1, wherein (b) the at least one carboxylic acid ester is obtainable by reacting (ii) at least one linear C_3-C_{20} dicarboxylic acid with at least one linear or branched C_1-C_{20} monoalcohol.

7. The lubricant concentrate according to claim 6, wherein (b) the at least one carboxylic acid ester is obtainable by reacting (ii) at least one C_3-C_{12} dicarboxylic acid selected from the group consisting of malonic acid, succinic acid, glutaric acid, adipic acid, maleic acid, fumaric acid, azelaic acid, sebacic acid, brassilic acid, docdecanedioic acid, diglycolic acid, 1,4-cyclohexanedicarboxylic acid, 1,3-cyclohexanedicarboxylic acid and 2,6-decahydronaphthalenedicarboxylic acid with at least one branched C_5-C_{14} monoalcohol selected from the group consisting of pentanol, hexanol, heptanol, iso-pentanol, iso-hexanol, iso-heptanol, 2-ethylhexanol, 2-propylheptanol, 2-propyl-4-methylhexanol, 2-propyl-5-methyl-hexanol, 2-isopropyl-4-methyl-hexanol, 2-isopropyl-5-methyl-hexanol, 2-propyl-4,4-dimethylpentanol, 2-ethyl-2,4-dimethylhexanol, 2-ethyl-2-methyl-heptanol, 2-ethyl-2,5-dimethylhexanol, 2-isopropyl-heptanol, 2-butyl-1-octanol and 2-pentyl-1-nonanol.

8. The lubricant concentrate according to claim 1, wherein (a) the at least one alkoxylated polytetrahydrofuran of general formula (I) has a weight average molecular M_w weight in the range of 1000 to 20000 g/mol determined according to DIN 55672-1 (polystyrene calibration standard).

9. The lubricant concentrate according to claim 1, wherein R_1 denotes identical, unsubstituted, linear C_6, C_7, C_8, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17} or C_{18} alkyl.

10. The lubricant concentrate according to claim 1, wherein R_2 denotes CH_2-CH_3 or CH_3.

11. The lubricant concentrate according to claim 1, wherein R_3 and R_4 denote identically H.

12. The lubricant concentrate according to claim 1, wherein

m is in the range of ≥ 2 to ≤ 30,
m' is in the range of ≥ 2 to ≤ 30,
(m+m') is in the range of ≥ 4 to ≤ 60,
n is in the range of ≥ 2 to ≤ 40,
n' is in the range of ≥ 2 to ≤ 40,
(n+n') is in the range of ≥ 4 to ≤ 80,
k is in the range of ≥ 6 to ≤ 20,

whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted m, m', n and n' are distributed to form a block polymeric structure or a random polymeric structure.

13. The lubricant concentrate according to claim 1, wherein (b) the at least one carboxylic acid ester is selected from the group consisting of methyl oleate; ester obtainable by reacting trimethylol propane, adipic acid and C_8-C_{10} monocarboxylic acid; ester obtainable by reacting trimethylol propane and C_8-C_{10} monocarboxylic acid; di-(2-propylheptyl)-adipate; di-isodecyl adipate; diisotridecyl adipate and diisononyladipate.

14. Use of the lubricant concentrate according to one or more of claims 1 to 13 as lubricant in axel lubrication, medium and heavy duty engine oils, industrial engine oils, marine engine oils, automotive engine oils, crankshaft oils, compressor oils, refrigerator oils, hydrocarbon compressor oils, very low-temperature lubricating oils and fats, high temperature lubricating oils and fats, wire rope lubricants, textile machine oils, refrigerator oils, aviation and aerospace lubricants, aviation turbine oils, transmission oils, gas turbine oils, spindle oils, spin oils, traction fluids, transmission oils, plastic transmission oils, passenger car transmission oils, truck transmission oils, industrial transmission oils, industrial gear oils, insulating oils, instrument oils, brake fluids, transmission liquids, shock absorber oils, heat distribution medium oils, transformer oils, fats, chain oils, minimum quantity lubricants for metalworking operations, oil to the warm and cold working, oil for water-based metalworking liquids, oil for neat oil metalworking fluids, oil for semi-synthetic metalworking fluids, oil for synthetic metalworking fluids, drilling detergents for the soil exploration, hydraulic oils, in biodegradable lubricants or lubricating greases or waxes, chain saw oils, release agents, molding fluids, gun, pistol and rifle lubricants or watch lubricants and food grade approved lubricants.

15. A method for lubricating an engine comprising operating the engine with a lubricant concentrate according to one or more of claims 1 to 13.

16. A lubricant composition comprising
≥ 1 to ≤ 90 % by weight of the lubricant concentrate (LC) according to one or more of claims 1 to 13;
≥ 10 to ≤ 75 % by weight of at least one base oil (c) selected from Group I mineral oils, Group II mineral oils, Group

III mineral oils, Group IV oils and Group V oils and;
≥ 0.1 to ≤ 15.0 % by weight of at least one additive component (d),
in each case by weight of the total weight of lubricant composition.

17. The lubricant composition according to claim 16 wherein the at least one additive component (d) is selected from the group consisting of antioxidants, dispersants, foam inhibitors, demulsifiers, seal swelling agents, friction-reducers, anti-wear agents, detergents, corrosion inhibitors, extreme pressure agents, metal deactivators, rust inhibitors and pour point depressants.

18. The lubricant composition according to claim 16 or 17 having a KRL Shear loss after 100 hours of less than 8% when measured in accordance with CEC L-45-A-99.

19. Use of the lubricant composition according to one or more of claims 16 to 18 as lubricant in axel lubrication, medium and heavy duty engine oils, industrial engine oils, marine engine oils, automotive engine oils, crankshaft oils, compressor oils, refrigerator oils, hydrocarbon compressor oils, very low-temperature lubricating oils and fats, high temperature lubricating oils and fats, wire rope lubricants, textile machine oils, refrigerator oils, aviation and aerospace lubricants, aviation turbine oils, transmission oils, gas turbine oils, spindle oils, spin oils, traction fluids, transmission oils, plastic transmission oils, passenger car transmission oils, truck transmission oils, industrial transmission oils, industrial gear oils, insulating oils, instrument oils, brake fluids, transmission liquids, shock absorber oils, heat distribution medium oils, transformer oils, fats, chain oils, minimum quantity lubricants for metalworking operations, oil to the warm and cold working, oil for water-based metalworking liquids, oil for neat oil metalworking fluids, oil for semi-synthetic metalworking fluids, oil for synthetic metalworking fluids, drilling detergents for the soil exploration, hydraulic oils, in biodegradable lubricants or lubricating greases or waxes, chain saw oils, release agents, molding fluids, gun, pistol and rifle lubricants or watch lubricants and food grade approved lubricants.

20. A method for lubricating an engine comprising operating the engine with a lubricant composition according to one or more of claims 16 to 18.

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 6286

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	WO 2014/184062 A1 (BASF SE [DE]) 20 November 2014 (2014-11-20) * page 1, line 1 - page 2, line 9 * * page 2, line 22 - page 12, line 18 * * page 14, line 14 - page 18, line 15 * * page 23, line 31 - page 24, line 18 * * claims; examples * -----	1-20	INV. C10M111/04
A	WO 2015/078967 A1 (BASF SE [DE]) 4 June 2015 (2015-06-04) * the whole document * -----	1-20	
A	EP 0 045 209 A1 (EXXON RESEARCH ENGINEERING CO [US]) 3 February 1982 (1982-02-03) * the whole document * -----	1-20	
A	US 2012/184474 A1 (KAWATA KEN [JP] ET AL) 19 July 2012 (2012-07-19) * the whole document * -----	1-20	
			TECHNICAL FIELDS SEARCHED (IPC)
			C10M C10N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 May 2017	Elflein, Eleonore

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EPO FORM 1503 03.82 (P04C01)

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 16 19 6286

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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03-05-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014184062 A1	20-11-2014	AU 2014267528 A1	26-11-2015
		CA 2911374 A1	20-11-2014
		CN 105229129 A	06-01-2016
		EP 2997118 A1	23-03-2016
		HK 1219749 A1	13-04-2017
		JP 2016518500 A	23-06-2016
		KR 20160008629 A	22-01-2016
		US 2016090546 A1	31-03-2016
		WO 2014184062 A1	20-11-2014
WO 2015078967 A1	04-06-2015	EP 3074490 A1	05-10-2016
		EP 3074491 A1	05-10-2016
		US 2016376518 A1	29-12-2016
		WO 2015078967 A1	04-06-2015
		WO 2015078968 A1	04-06-2015
EP 0045209 A1	03-02-1982	CA 1159046 A	20-12-1983
		DE 3160314 D1	07-07-1983
		EP 0045209 A1	03-02-1982
		GB 2081300 A	17-02-1982
		US 4370247 A	25-01-1983
US 2012184474 A1	19-07-2012	JP 5662726 B2	04-02-2015
		JP 2011089106 A	06-05-2011
		US 2012184474 A1	19-07-2012
		WO 2011037217 A1	31-03-2011

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- DE 3210283 A1 **[0009]**
- EP 1076072 A1 **[0010]**
- US 20120295827 A **[0011]**
- WO 2014139935 A1 **[0012]**
- WO 2014184062 A1 **[0013]**
- WO 2014005932 A1 **[0014]**
- WO 2014184068 A1 **[0015]**
- EP 2721129 A1 **[0016]**
- US 6423107 B1 **[0035]**
- EP 0862947 B1 **[0056]**
- EP 0090444 A **[0057]**
- US 5362378 A **[0075]**
- US 5565086 A **[0075]**
- US 5246566 A **[0075]**
- US 5135638 A **[0075]**
- EP 710710 A **[0075]**
- EP 321302 A **[0075]**
- EP 321304 A **[0075]**
- US 3149178 A **[0075]**
- US 3382291 A **[0075]**
- US 3742082 A, Brennan **[0075]**
- US 3769363 A, Brennan **[0075]**
- US 3876720 A, Heilman **[0075]**
- US 4239930 A, Allphin **[0075]**
- US 4367352 A, Watts **[0075]**
- US 4413156 A, Watts **[0075]**
- US 4434308 A, Larkin **[0075]**
- US 4910355 A, Shubkin **[0075]**
- US 4956122 A, Watts **[0075]**
- US 5068487 A, Theriot **[0075]**
- WO 2008014315 A **[0093]**
- US 3087936 A **[0102]**
- US 3254025 A **[0102]**
- US 4234435 A **[0119]**
- US 3172892 A **[0119]**
- US 3381022 A **[0119]**

Non-patent literature cited in the description

- **H. MACHEMER.** *Angewandte Chemie,* 1952, vol. 64, 213-220 **[0064]**
- **G. DIECKELMANN ; H.J. HEINZ.** *The Basics of Industrial Oleochemistry,* 1988, 145-145 **[0064]**
- Engine Oil Licensing and Certification System. December 1996 **[0075]**
- Fats and Fatty Oils. **KIRK ; OTHMER.** Encyclopedia of Chemical Technology. vol. 9, 795-831 **[0107]**
- *Lecithins,* vol. 14, 250-269 **[0107]**