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(54) **LUBRICANT COMPRISING ALKOXYLATED POLYTETRAHYDROFURAN, THICKENER AND MINERAL BASE OIL**

(57) The present invention relates to a lubricant comprising an alkoxyated polytetrahydrofuran, a poly(meth)acrylate thickener, and a mineral base oil; to a use of the lubricant as a hydraulic oil; and to a method

for preparing the lubricant comprising the step of contacting the alkoxyated polytetrahydrofuran, the polymethacrylate thickener, and the mineral base oil.

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[0002] Lubricating compositions, such as hydraulic oils, are well known. There is an ongoing need for further improving them, for example with regard to viscosity index (VI), pour point, shear stability, or friction coefficient. A main goal was here to improve the shear stability, e.g. as determined by the KRL test in the examples, and the friction coefficient, e.g. as determined by the Stribeck curve in the examples.

- an alkoxyated polytetrahydrofuran,
- a poly(meth)acrylate thickener, and
- a mineral base oil.

[0005] The object was also solved by a method for preparing the lubricant comprising the step of contacting

- the alkoxyated polytetrahydrofuran,
- the polymethacrylate thickener, and
- the mineral base oil, and optionally
- the ester base oil.

$$\text{H}-\left[\text{O}-\text{CH}(\text{R}_3)-\text{CH}_2\right]_p-\left[\text{O}-\text{CH}(\text{R}_2)-\text{CH}_2\right]_n-\left[\text{O}-\text{CH}(\text{R}_1)-\text{CH}_2\right]_m-\left[\text{O}-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2-\text{O}\right]_k-\left[\text{O}-\text{CH}(\text{R}_1)-\text{CH}_2\right]_{m'}-\left[\text{O}-\text{CH}(\text{R}_2)-\text{CH}_2\right]_{n'}-\left[\text{O}-\text{CH}(\text{R}_3)-\text{CH}_2\right]_{p'}-\text{H} \quad (\text{I}),$$

R³ identical or different, denotes a hydrogen atom or methyl, and

n is an integer in the range of ≥ 0 to ≤ 45 ,

	n'	is an integer in the range of ≥ 0 to ≤ 45 ,
	$(n+n')$	is an integer in the range of ≥ 0 to ≤ 80 ,
	p	is an integer in the range of ≥ 0 to ≤ 25 ,
	p'	is an integer in the range of ≥ 0 to ≤ 25 ,
5	$(p+p')$	is an integer in the range of ≥ 0 to ≤ 30 ,
	k	is an integer in the range of ≥ 2 to ≤ 30 ,
	R^1	denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms,
	R^2	denotes $-\text{CH}_2-\text{CH}_3$,
10	R^3	identical or different, denotes a hydrogen atom or $-\text{CH}_3$, and

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

[0008] As used herein, "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.

[0009] "Alkyl radical" denotes a moiety constituted solely of atoms of carbon and of hydrogen.

[0010] The alkoxyated polytetrahydrofuran may have a kinematic viscosity in the range of ≥ 200 mm²/s to ≤ 700 mm²/s, more preferably in the range of ≥ 250 mm²/s to ≤ 650 mm²/s, at 40 °C, determined according to ASTM D 445.

[0011] The alkoxyated polytetrahydrofuran may have a kinematic viscosity in the range of ≥ 25 mm²/s to ≤ 90 mm²/s, more preferably in the range of ≥ 30 mm²/s to ≤ 80 mm²/s, at 100 °C, determined according to ASTM D 445.

[0012] The alkoxyated polytetrahydrofuran may have a pour point in the range of ≥ -60 °C to ≤ 20 °C, more preferably in the range of ≥ -50 °C to ≤ 15 °C, determined according to DIN ISO 3016.

[0013] The alkoxyated polytetrahydrofuran may have a weight average molecular weight M_w in the range of 500 to 20000 g/mol, more preferably in the range of 2000 to 10000 g/mol, most preferably in the range of 2000 to 7000 g/mol, even more preferably in the range of 4000 to 7000 g/mol determined, determined according to DIN 55672-1.

[0014] The alkoxyated polytetrahydrofuran may have 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.

[0015] Preferably k is an integer in the range of ≥ 3 to ≤ 25 , more preferably k is an integer in the range of ≥ 3 to ≤ 20 , most preferably in the range of ≥ 5 to ≤ 20 , even more preferably in the range of ≥ 6 to ≤ 16 . In another preferred form k is an integer in the range of ≥ 6 to ≤ 25 .

[0016] Preferably m is an integer in the range of ≥ 1 to ≤ 25 and m' is an integer in the range of ≥ 1 to ≤ 25 , more preferably m is an integer in the range of ≥ 1 to ≤ 20 and m' is an integer in the range of ≥ 1 to ≤ 20 . In another preferred form m is an integer in the range of ≥ 5 to ≤ 50 and m' is an integer in the range of ≥ 5 to ≤ 50 , more preferably m is an integer in the range of ≥ 10 to ≤ 40 and m' is an integer in the range of ≥ 10 to ≤ 40 .

[0017] Preferably $(m+m')$ is an integer in the range of ≥ 3 to ≤ 65 , more preferably $(m+m')$ is an integer in the range of ≥ 3 to ≤ 50 , even more preferably $(m+m')$ is an integer in the range of ≥ 3 to ≤ 40 . In another preferred form $(m+m')$ is an integer in the range of ≥ 6 to ≤ 90 , more preferably $(m+m')$ is an integer in the range of ≥ 10 to ≤ 70 , even more preferably $(m+m')$ is an integer in the range of ≥ 20 to ≤ 60 .

[0018] 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. In another preferred form 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 6:1, and most preferably in the range of 1:1 to 4:1.

[0019] Preferably n is an integer in the range of ≥ 10 to ≤ 55 and n' is an integer in the range of ≥ 10 to ≤ 55 , more preferably n is an integer in the range of ≥ 20 to ≤ 45 and n' is an integer in the range of ≥ 20 to ≤ 45 .

[0020] Preferably $(n+n')$ is an integer in the range of ≥ 20 to ≤ 90 , more preferably $(n+n')$ is an integer in the range of ≥ 30 to ≤ 90 .

[0021] Preferably p is an integer in the range of ≥ 5 to ≤ 25 and p' is an integer in the range of ≥ 5 to ≤ 25 , more preferably p is an integer in the range of ≥ 5 to ≤ 15 and p' is an integer in the range of ≥ 5 to ≤ 15 .

[0022] Preferably $(p+p')$ is an integer in the range of ≥ 10 to ≤ 30 , more preferably $(p+p')$ is an integer in the range of ≥ 15 to ≤ 30 .

[0023] Preferably R^1 denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms. More preferably R^1 denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11, 12, 13, 14, 15 or 16 carbon atoms. Most preferably R^1 denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms.

[0024] In case the alkoxyated polytetrahydrofuran comprises units, wherein R^2 denotes $-\text{CH}_2-\text{CH}_3$, 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 6:1, most preferably in the range of 2:1 to 5:1.

[0025] In case the alkoxyated polytetrahydrofuran comprises units, wherein R^3 denotes $-\text{CH}_3$, the ratio of $(p+p')$ to k is in the range of 1.2:1 to 10:1, more preferably in the range of 1.2:1 to 6:1.

[0026] In another preferred form the alkoxyated polytetrahydrofuran is of general formula (I), wherein

	m	is an integer in the range of ≥ 1 to ≤ 30 ,
	m'	is an integer in the range of ≥ 1 to ≤ 30 ,
5	(m+m')	is an integer in the range of ≥ 3 to ≤ 50 ,
	n	is an integer in the range of ≥ 3 to ≤ 45 ,
	n'	is an integer in the range of ≥ 3 to ≤ 45 ,
	(n+n')	is an integer in the range of ≥ 6 to ≤ 90 ,
	p	is an integer in the range of ≥ 0 to ≤ 75 ,
10	p'	is an integer in the range of ≥ 0 to ≤ 75 ,
	k	is an integer in the range of ≥ 3 to ≤ 25 ,
	(p+p')	is an integer in the range of ≥ 0 to ≤ 30 ,
	R ¹	denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms,
	R ²	denotes -CH ₂ -CH ₃ , and
15	R ³	denotes -CH ₃ ,

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

[0027] In a more preferred form the alkoxyated polytetrahydrofuran is of general formula (I) wherein

20	m	is an integer in the range of ≥ 1 to ≤ 30 ,
	m'	is an integer in the range of ≥ 1 to ≤ 30 ,
	(m+m')	is an integer in the range of ≥ 3 to ≤ 50 ,
	n	is an integer in the range of ≥ 3 to ≤ 45 ,
25	n'	is an integer in the range of ≥ 3 to ≤ 45 ,
	(n+n')	is an integer in the range of ≥ 6 to ≤ 90 ,
	p	is an integer in the range of ≥ 0 to ≤ 75 ,
	p'	is an integer in the range of ≥ 0 to ≤ 75 ,
	k	is an integer in the range of ≥ 3 to ≤ 25 ,
30	(p+p')	is an integer in the range of ≥ 0 to ≤ 30 ,
	R ¹	denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms,
	R ²	denotes -CH ₂ -CH ₃ ,
	R ³	denotes -CH ₃ , and

35 whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure, and wherein the ratio of (m+m') to k is in the range of 0.3:1 to 6:1 and the ratio of (n+n') to k is in the range of 1.5:1 to 10:1.

[0028] In a most preferred form the alkoxyated polytetrahydrofuran is of general formula (I) wherein

40	m	is an integer in the range of ≥ 1 to ≤ 25 ,
	m'	is an integer in the range of ≥ 1 to ≤ 25 ,
	(m+m')	is an integer in the range of ≥ 3 to ≤ 40 ,
	n	is an integer in the range of ≥ 6 to ≤ 40 ,
	n'	is an integer in the range of ≥ 6 to ≤ 40 ,
45	(n+n')	is an integer in the range of ≥ 12 to ≤ 90 ,
	p	is an integer in the range of ≥ 0 to ≤ 25 ,
	p'	is an integer in the range of ≥ 0 to ≤ 25 ,
	(p+p')	is an integer in the range of ≥ 0 to ≤ 30 ,
	k	is an integer in the range of ≥ 5 to ≤ 20 ,
50	R ¹	denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms,
	R ²	denotes -CH ₂ -CH ₃ ,
	R ³	denotes -CH ₃ ,

55 whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure, and wherein the ratio of (m+m') to k is in the range of 0.3:1 to 4:1 and the ratio of (n+n') to k is in the range of 1.5:1 to 5:1.

[0029] In another preferred form the alkoxyated polytetrahydrofuran is of general formula (I) wherein

- m is an integer in the range of ≥ 1 to ≤ 25 ,
 m' is an integer in the range of ≥ 1 to ≤ 25 ,
 (m+m') is an integer in the range of ≥ 3 to ≤ 50 ,
 n is an integer in the range of ≥ 1 to ≤ 45 ,
 5 n' is an integer in the range of ≥ 1 to ≤ 45 ,
 (n+n') is an integer in the range of ≥ 2 to ≤ 80 ,
 p is an integer in the range of ≥ 0 to ≤ 45 ,
 p' is an integer in the range of ≥ 0 to ≤ 45 ,
 (p+p') is an integer in the range of ≥ 0 to ≤ 90 ,
 10 k is an integer in the range of ≥ 3 to ≤ 25 ,
 R¹ denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms,
 R² denotes -CH₂-CH₃,
 R³ denotes -CH₃,

- 15 whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure.
[0030] In another more preferred form the alkoxyated polytetrahydrofuran is of general formula (I) wherein

- m is an integer in the range of ≥ 1 to ≤ 30 ,
 20 m' is an integer in the range of ≥ 1 to ≤ 30 ,
 (m+m') is an integer in the range of ≥ 3 to ≤ 50 ,
 n is an integer in the range of ≥ 1 to ≤ 45 ,
 n' is an integer in the range of ≥ 1 to ≤ 45 ,
 (n+n') is an integer in the range of ≥ 2 to ≤ 80 ,
 25 p is an integer in the range of ≥ 0 to ≤ 45 ,
 p' is an integer in the range of ≥ 0 to ≤ 45 ,
 (p+p') is an integer in the range of ≥ 0 to ≤ 90 ,
 k is an integer in the range of ≥ 3 to ≤ 25 ,
 R¹ denotes an unsubstituted, linear alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 or 18 carbon atoms,
 30 R² denotes -CH₂-CH₃,
 R³ denotes -CH₃,

- whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure,
 35 and wherein the ratio of (m+m') to k is in the range of 0.3:1 to 6:1 and the ratio of (p+p') to k is in the range of 1.5:1 to 10:1.
[0031] In another most preferred form the alkoxyated polytetrahydrofuran is of general formula (I) wherein

- m is an integer in the range of ≥ 1 to ≤ 25 ,
 m' is an integer in the range of ≥ 1 to ≤ 25 ,
 40 (m+m') is an integer in the range of ≥ 3 to ≤ 50 ,
 n is an integer in the range of ≥ 0 to ≤ 45 ,
 n' is an integer in the range of ≥ 0 to ≤ 45 ,
 (n+n') is an integer in the range of ≥ 0 to ≤ 80 ,
 p is an integer in the range of ≥ 0 to ≤ 20 ,
 45 p' is an integer in the range of ≥ 0 to ≤ 20 ,
 (p+p') is an integer in the range of ≥ 0 to ≤ 30 ,
 k is an integer in the range of ≥ 5 to ≤ 20 ,
 R¹ denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms,
 R² denotes -CH₂-CH₃,
 50 R³ denotes -CH₃,

- whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure,
 and wherein the ratio of (m+m') to k is in the range of 0.3:1 to 4:1 and the ratio of (p+p') to k is in the range of 1.5:1 to 5:1.
 55 **[0032]** In another most preferred form the alkoxyated polytetrahydrofuran is of general formula (I) wherein

- m is an integer in the range of ≥ 1 to ≤ 35 ,
 m' is an integer in the range of ≥ 1 to ≤ 35 ,

	(m+m')	is an integer in the range of ≥ 3 to ≤ 60 ,
	n	is an integer in the range of ≥ 0 to ≤ 45 ,
	n'	is an integer in the range of ≥ 0 to ≤ 45 ,
	(n+n')	is an integer in the range of ≥ 0 to ≤ 90 ,
5	p	is an integer in the range of ≥ 0 to ≤ 20 ,
	p'	is an integer in the range of ≥ 0 to ≤ 20 ,
	(p+p')	is an integer in the range of ≥ 0 to ≤ 30 ,
	k	is an integer in the range of ≥ 5 to ≤ 20 ,
	R ¹	denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11 or 12 carbon atoms,
10	R ²	denotes -CH ₂ -CH ₃ ,
	R ³	denotes -CH ₃ ,

whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure, and wherein the ratio of (m+m') to k is in the range of 0.3:1 to 4:1 and the ratio of (p+p') to k is in the range of 1.5:1 to 5:1.

[0033] The alkoxyated polytetrahydrofurans are obtainable by reacting at least one polytetrahydrofuran block polymer with at least one C₈-C₃₀ 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 C₈-C₃₀ 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.

[0034] Preferably the at least one C₈-C₃₀ epoxy alkane is selected from the group consisting of 1,2-epoxyoctane; 1,2-epoxynonane; 1,2-epoxydecane; 1,2-epoxyundecane; 1,2-epoxydodecane; 1,2-epoxytridecane; 1,2-epoxytetradecane; 1,2-epoxypentadecane; 1,2-epoxyhexadecane; 1,2-epoxyheptadecane; 1,2-epoxyoctadecane; 1,2-epoxynonadecane; 1,2-epoxyicosane; 1,2-epoxytricosane; 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.

[0035] 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 caesium 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.

[0036] In case the catalyst is a base, any inert solvents capable of dissolving alkoxyated 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.

[0037] 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 alkoxyated 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 3 to 30 bar.

[0038] The lubricant may comprise at least 0.5 wt%, preferably at least 1 wt% and in particular at least 2.5 wt% of the alkoxyated polytetrahydrofuran.

[0039] The lubricant may comprise up to 15 wt%, preferably up to 25 wt% and in particular up to 40 wt% of the alkoxyated polytetrahydrofuran.

[0040] The lubricant may comprise 0.5 - 40 wt%, preferably 1 - 25 wt% and in particular 2 - 15 wt% of the alkoxyated polytetrahydrofuran.

[0041] Suitable **poly(meth)acrylate thickener** are poly(meth)acrylate copolymers, such as polyacrylate copolymers and polymethacrylate copolymers. Preferred poly(meth)acrylate thickener are polymethacrylate copolymers.

[0042] The polyacrylate copolymers and the polymethacrylate copolymers comprise in polymerized form acrylic acid esters or methacrylic acid esters, respectively (also referred to as "(meth)acrylic acid esters").

[0043] Suitable **(meth)acrylic acid esters** are linear or branched C₁- to C₂₂-alkyl (meth)acrylates, and hydroxyl-, epoxy- and amino-functional (meth)acrylic acid esters, where linear or branched C₁- to C₂₂-alkyl (meth)acrylates are preferred.

[0044] Preferred (meth)acrylic acid esters are linear or branched C₁- to C₁₈-alkyl (meth)acrylates, in particular linear or branched C₁- to C₁₈-alkyl methacrylates. In general, the (meth)acrylic acid esters are methyl, ethyl, n-propyl, i-propyl,

n-butyl, i-butyl, sec-butyl, tert-butyl, pentyl, hexyl, heptyl, octyl, 2-ethylhexyl, 2-propyl heptyl, nonyl, decyl, stearyl, lauryl, octadecyl, heptadecyl, nonadecyl, eicosyl, henicosyl, docosyl, tricosyl, tetracosyl, pentacosyl, hexacosyl, heptacosyl, octacosyl, nonacosyl, triacontyl, behenyl methacrylate or acrylate, preferably methyl, lauryl, heptadecyl and stearyl, or mixtures of these monomers.

[0045] The preferred (meth)acrylic acid esters methyl (meth)acrylate and one or more selected from C₅ - to C₂₂-alkyl (meth)acrylate.

[0046] The (meth)acrylic acid esters are generally employed in amounts in the range from 50 to 100 wt%, preferably from 80 to 100 wt%, based on the total amount of monomers of the poly(meth)acrylate thickener.

[0047] Preferably, the poly(meth)acrylate thickener is a poly(meth)acrylate copolymer, which comprises in polymerized form linear or branched C₁- to C₂₂-alkyl (meth)acrylates.

[0048] In another preferred form, the poly(meth)acrylate thickener is a poly(meth)acrylate copolymer, which comprises in polymerized form linear or branched C₁- to C₁₈-alkyl (meth)acrylates in the range from 50 to 100 wt%, preferably from 80 to 100 wt%, based on the total amount of monomers of the poly(meth)acrylate thickener, and optionally .

[0049] In addition to the meth)acrylic acid esters **further comonomers** may be present in polymerized form in the poly(meth)acrylate thickener. Suitable further comonomers are

- vinylaromatic compounds, such as styrene, alpha-methylstyrene, vinyltoluene or p-(tert-butyl) styrene;
- acrylic and methacrylic acid;
- acrylamide and methacrylamide;
- maleic acid and the imides and C₁ -C₁₀ -alkyl esters thereof;
- fumaric acid and the imides and C₁ -C₁₀ -alkyl esters thereof;
- itaconic acid and the imides and C₁ -C₁₀ -alkyl esters thereof;
- acrylonitrile and methacrylonitrile.

[0050] The further comonomers are generally employed in amounts in the range from 0 to 50 wt%, preferably from 0 to 20 wt%, based on the total amount of monomers of the poly(meth)acrylate thickener.

[0051] The poly(meth)acrylate thickener may have a weight average molecular weight ranging from about 10,000 g/mol to about 1,000,000 g/mol, preferably from about 20,000 g/mol to about 600,000 g/mol. The molecular weight can be determined for example by GPC using a poly methyl methacrylate standard. The poly(meth)acrylate thickener may have a PDI number ranging from 1 to 10, preferably 2 to 8, mostly preferred 2 to 6.

[0052] Conventional methods of free-radical polymerization can be used to prepare the poly(meth)acrylate thickener. Polymerization of the alkyl methacrylate monomers can take place under a variety of conditions, including bulk polymerization, solution polymerization, usually in an organic solvent. In the solution polymerization, the reaction mixture comprises a diluent, the alkyl(meth)acrylate monomers, a polymerization initiator and usually a chain transfer agent and optionally a crosslinker.

[0053] The lubricant may comprise at least 3 wt%, preferably at least 10 wt% and in particular at least 15 wt% of the poly(meth)acrylate thickener.

[0054] The lubricant may comprise up to 45 wt%, preferably up to 35 wt% and in particular up to 25 wt% of the poly(meth)acrylate thickener.

[0055] The lubricant may comprise 3 - 45 wt%, preferably 8 - 35 wt% and in particular 15 - 25 wt% of the poly(meth)acrylate thickener.

[0056] The **mineral base oil** may selected from the group consisting of mineral oils (Group I, II or III oils). Preferably, the mineral base oil is selected from Group I, Group II, Group III base oils according to the definition of the API, or mixtures thereof. Definitions for the base oils 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 oils as follows:

- a) Group I base oils contain less than 90 percent saturates (ASTM D 2007) and/or greater than 0.03 percent sulfur (ASTM D 2622) and have a viscosity index (ASTM D 2270) greater than or equal to 80 and less than 120.
- 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.
- 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.

[0057] The mineral base oil may have a pour point of below -15 °C, preferably below -35 °C, and in particular below -60 °C. The pour point may be determined according to ASTM D97.

[0058] The mineral base oil may have a kinematic viscosity at 40 °C (also known as KV40) of below 15 mm²/s, preferably below 10 mm²/s, more preferably below 7 mm²/s, and in particular below 5 mm²/s. The KV40 may be deter-

mined according to ASTM D445.

[0059] The lubricant may comprise at least 30 wt%, preferably at least 45 wt% and in particular at least 60 wt% of the mineral base oil.

[0060] The lubricant may comprise up to 95 wt%, preferably up to 90 wt% and in particular up to 85 wt% of the mineral base oil.

[0061] The lubricant may comprise 30 - 95 wt%, preferably 45 - 90 wt% and in particular 60 - 85 wt% of the mineral base oil.

[0062] The lubricant may comprise a Group IV or Group V base oil in addition to the mineral base oil, which can be a Group I, II or III base oil. The lubricant usually comprises less than 20 wt%, preferably less than 10 wt%, and in particular less than 3 wt% of a Group IV or Group V base oil. Group IV or Group V base oils typically categorized as follows:

d) Group IV base oils contain polyalphaolefins. Polyalphaolefins (PAO) include known PAO materials which typically comprise relatively low molecular weight hydrogenated polymers or oligomers of alphaolefins which include but are not limited to C2 to about C32 alphaolefins with the C8 to about C16 alphaolefins, such as 1-octene, 1-decene, 1-dodecene and the like being preferred. The preferred polyalphaolefins are poly-1-octene, poly-1-decene, and poly-1-dodecene.

e) Group V base oils contain any base oils not described by Groups I to IV. Examples of Group V base oils include alkyl naphthalenes, silicone oils. The ester base oils are not considered a Group V base oil.

[0063] The lubricant may optionally comprise an **ester base oil** selected from the group consisting of diester base oils and complex ester base oils. Preferably, the ester base oil is selected from the diester base oils.

[0064] The lubricant may preferably comprise an ester base oil selected from the group consisting of diester base oils and complex ester base oils, where the ester base oil is in particular selected from the diester base oils.

[0065] Suitable **diester base oils** are carboxylic acid esters obtainable by reacting at least one linear or branched C₂-C₂₀ dicarboxylic acid with at least one linear or branched C₁-C₂₀ monoalcohol.

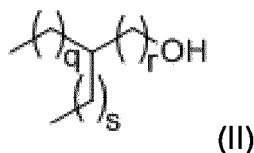
[0066] The diester base oil may be obtainable by reacting

- at least one linear or branched C₃-C₁₂ 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-decahydro-naphthalenedicarboxylic acid with

- at least one branched C₅-C₁₄ monoalcohol selected from the group consisting of pentanol, hexanol, heptanol, isopentanol, 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-iso-propylheptanol, 2-butyl-1-octanol and 2-pentyl-1-nonanol.

[0067] In one form the diester base oils are obtainable by reacting at least one linear or branched C₄-C₈ di-carboxylic acid with at least one branched C₆-C₁₆ monoalcohol. In one form the diesters are obtainable by reacting at least one linear or branched C₆-C₈ dicarboxylic acid with at least one branched C₆-C₁₄ monoalcohol. Examples for diesters are diisodecyl adipate, diisotridecyl adipate, di-(isopropylheptyl)-adipate (DPHA) and diisononyladipate (DNA).

[0068] Also suitable as diester base oil is a dicarboxylic acid ester component which is formed from a dicarboxylic acid selected from the list consisting of adipic acid, phthalic acid, pimilic acid, suberic acid, azelaic acid and sebacic acid, and mixtures thereof and a branched aliphatic alcohol R-OH which is defined according to the following formula (II)



whereas q, r and s are q + r = 4 to 9, s = 0 to 5, q = 1 to 8, and r = 1 to 6.

[0069] Preferably, the branched aliphatic alcohol R-OH according to formula (II) can be a primary C₇ to C₁₂ alcohol, wherein the alkyl side chain is C₁ to C₆ alkyl (s = 0 to 5). The alkyl side chain can be linear or branched alkyl group while linear alkyl group is preferred for the alkyl side chain.

[0070] Accordingly, the main alkyl chain in residue R is C₆ to C₁₁. Accordingly, the residue R in R-OH of formula (II) includes methylhexyl, ethylhexyl, propylhexyl, butylhexyl, pentylhexyl and hexylhexyl, methylheptyl, ethylheptyl, propyl-

heptyl, butylheptyl and pentylheptyl, methyloctyl, ethyloctyl, propyloctyl, and butyloctyl, methylnonyl, ethylnonyl, and propylnonyl, methyldecyl and ethyldecyl, and methylundecyl. Especially preferred alcohols R-OH from the above list include residue R being ethylhexyl, methyloctyl, propylheptyl and butyloctyl. Most preferably, the residue R in R-OH in the above lubricant composition is selected from ethylhexyl, methyloctyl, propylheptyl, butyloctyl and mixtures thereof defined by q, r and s as follows:

R in R-OH of formula (II)				
Ethylhexyl	$q + r = 4$	$s = 1$	$q = 1$	$r = 3$
			$q = 2$	$r = 2$
			$q = 3$	$r = 1$
Methyloctyl	$q + r = 6$	$s = 0$	$q = 1$	$r = 5$
			$q = 2$	$r = 4$
			$q = 3$	$r = 3$
			$q = 4$	$r = 2$
Propylheptyl	$q + r = 5$	$s = 2$	$q = 1$	$r = 4$
			$q = 2$	$r = 3$
			$q = 3$	$r = 2$
			$q = 4$	$r = 1$
Butyloctyl	$q + r = 6$	$s = 3$	$q = 1$	$r = 5$
			$q = 2$	$r = 4$
			$q = 3$	$r = 3$
			$q = 4$	$r = 2$
			$q = 5$	$r = 1$

[0071] Especially preferred are the alcohols having $q + r = 4$ to 9 , $r = 1$ and $q = 3$ to 8 , i.e. the primary aliphatic C_7 to C_{12} alcohols in which the linear (which is preferred) or branched alkyl side chain C_1 to C_6 alkyl ($s = 0$ to 5) is located at the 2-position of the primary alcohol. Such alcohols are typically named Guerbet alcohols. In one preferred embodiment the Guerbet alcohol is derived at least partly from 2-hexyl decanol, 2-hexyl dodecanol, 2-octyl decanol and/or 2-octyl dodecanol.

[0072] The diester base oil preferably is derived from the reaction of a dicarboxylic acid with an aliphatic alcohol. Preferred dicarboxylic acids are adipic acid, pimelic acid, suberic acid, azelaic acid and sebacic acid and mixtures thereof. The diester base oil is preferably formed from such dicarboxylic acids by esterification with medium-size aliphatic alcohols, which can be linear or branched, preferably C_5 to C_{20} alcohol, more preferably C_9 to C_{15} aliphatic alcohol and most preferably nonanol, isodecanol, isotridecanol and 2-propyl heptanol.

[0073] Suitable **complex ester base oils** are usually obtainable by reacting 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.

[0074] In another form the complex ester base oils are obtainable by reacting 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, octanedioic 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-

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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.

[0075] In another form the complex ester base oils are obtainable by reacting a mixture comprising

- at least one linear or branched C₆-C₁₈ monocarboxylic acid and
- at least one linear or branched C₄-C₁₀ dicarboxylic acid and
- at least one C₂-C₁₄ polyol having 2-6 hydroxyl group.

[0076] In another form the complex ester base oils are obtainable by reacting a mixture comprising

- at least one linear or branched C₁₂-C₁₈ monocarboxylic acid and
- at least one linear or branched C₆-C₈ dicarboxylic acid and
- at least one C₃-C₁₀ polyol having 3-5 hydroxyl group.

[0077] The lubricant may comprise at least 0.5 wt%, preferably at least 1 wt% and in particular at least 2.5 wt% of the ester base oil.

[0078] The lubricant may comprise up to 15 wt%, preferably up to 25 wt% and in particular up to 40 wt% of the ester base oil.

[0079] The lubricant may comprise 0.5 - 40 wt%, preferably 1 - 25 wt% and in particular 2 - 15 wt% of the ester base oil.

[0080] In one form the lubricant comprises

- 0.5 - 40 wt% of the alkoxyated polytetrahydrofuran,
- 8 - 35 wt% of the poly(meth)acrylate thickener, and
- 30 - 95 wt% of the mineral base oil, and optionally
- up to 40 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%. The lubricant may comprise additionally the lubricant additives which can be added on top of the 100 wt%.

[0081] In another form the lubricant comprises

- 1 - 25 wt% of the alkoxyated polytetrahydrofuran,
- 3 - 45 wt% of the poly(meth)acrylate thickener, and
- 45 - 90 wt% of the mineral base oil, and optionally
- up to 25 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%.

[0082] In another form the lubricant comprises

- 2 - 15 wt% of the alkoxyated polytetrahydrofuran,
- 15 - 25 wt% of the poly(meth)acrylate thickener, and
- 60 - 85 wt% of the mineral base oil, and optionally
- up to 15 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%.

[0083] In another form the lubricant comprises

- 0.5 - 40 wt% of the alkoxyated polytetrahydrofuran,
- 8 - 35 wt% of the poly(meth)acrylate thickener, and
- 30 - 95 wt% of the mineral base oil, and
- 0.5 - 40 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%.

[0084] In another form the lubricant comprises

- 2 - 15 wt% of the alkoxyated polytetrahydrofuran,
- 15 - 25 wt% of the poly(meth)acrylate thickener, and
- 60 - 85 wt% of the mineral base oil, and
- 1 - 25 wt% of the ester base oil,

5

where the total amount of these components sums up to 100 wt%.

[0085] In another form the lubricant comprises

10

- 2 - 15 wt% of the alkoxyated polytetrahydrofuran,
- 15 - 25 wt% of the poly(meth)acrylate thickener, and
- 60 - 85 wt% of the mineral base oil, and
- 2 - 15 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%.

15

[0086] In another form the lubricant comprises

20

- 0.5 - 40 wt% of the alkoxyated polytetrahydrofuran,
- 8 - 35 wt% of the poly(meth)acrylate thickener, and
- 30 - 95 wt% of the mineral base oil, and optionally
- up to 40 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%, and

where the alkoxyated polytetrahydrofuran is a compound of formula (I) wherein

25

m is an integer in the range of ≥ 1 to ≤ 50 ,

m' is an integer in the range of ≥ 1 to ≤ 50 ,

(m+m') is an integer in the range of ≥ 1 to ≤ 90 ,

n is an integer in the range of ≥ 0 to ≤ 75 ,

n' is an integer in the range of ≥ 0 to ≤ 75 ,

30

p is an integer in the range of ≥ 0 to ≤ 75 ,

p' is an integer in the range of ≥ 0 to ≤ 75 ,

k is an integer in the range of ≥ 2 to ≤ 30 ,

R¹ denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms,

35

R² -CH₂-CH₃,

R³ identical or different, denotes a hydrogen atom or methyl, and

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

40

where the poly(meth)acrylate thickener is a poly(meth)acrylate copolymer, which comprises in polymerized form linear or branched C₁- to C₂₂-alkyl (meth)acrylates, and where the ester base oil is a diester base oil, which is a carboxylic acid ester obtainable by reacting at least one linear or branched C₂-C₂₀ dicarboxylic acid with at least one linear or branched C₁-C₂₀ monoalcohol.

[0087] In another form the lubricant comprises

45

- 1 - 25 wt% of the alkoxyated polytetrahydrofuran,
- 3 - 45 wt% of the poly(meth)acrylate thickener, and
- 45 - 90 wt% of the mineral base oil, and optionally
- up to 25 wt% of the ester base oil,

50

where the total amount of these components sums up to 100 wt%, and

where the alkoxyated polytetrahydrofuran is a compound of formula (I) wherein

55

m is an integer in the range of ≥ 1 to ≤ 50 ,

m' is an integer in the range of ≥ 1 to ≤ 50 ,

(m+m') is an integer in the range of ≥ 1 to ≤ 90 ,

n is an integer in the range of ≥ 0 to ≤ 75 ,

n' is an integer in the range of ≥ 0 to ≤ 75 ,

- p is an integer in the range of ≥ 0 to ≤ 75 ,
 p' is an integer in the range of ≥ 0 to ≤ 75 ,
 k is an integer in the range of ≥ 2 to ≤ 30 ,
 R¹ denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms,
 R² -CH₂-CH₃,
 R³ identical or different, denotes a hydrogen atom or methyl, and

whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure, where the poly(meth)acrylate thickener is a poly(meth)acrylate copolymer, which comprises in polymerized form linear or branched C₁- to C₂₂-alkyl (meth)acrylates, and where the ester base oil is a diester base oil, which is a carboxylic acid ester obtainable by reacting at least one linear or branched C₂-C₂₀ dicarboxylic acid with at least one linear or branched C₁-C₂₀ monoalcohol.

[0088] In another form the lubricant comprises

- 1 - 25 wt% of the alkoxyated polytetrahydrofuran,
- 3 - 45 wt% of the poly(meth)acrylate thickener, and
- 45 - 90 wt% of the mineral base oil, and optionally
- up to 25 wt% of the ester base oil,

where the total amount of these components sums up to 100 wt%, and
 where the alkoxyated polytetrahydrofuran is a compound of formula (I) wherein

- m is an integer in the range of ≥ 1 to ≤ 30 ,
 m' is an integer in the range of ≥ 1 to ≤ 30 ,
 (m+m') is an integer in the range of ≥ 2 to ≤ 60 ,
 n is an integer in the range of ≥ 0 to ≤ 45 ,
 n' is an integer in the range of ≥ 0 to ≤ 45 ,
 (n+n') is an integer in the range of ≥ 0 to ≤ 80 ,
 p is an integer in the range of ≥ 0 to ≤ 25 ,
 p' is an integer in the range of ≥ 0 to ≤ 25 ,
 (p+p') is an integer in the range of ≥ 0 to ≤ 30 ,
 k is an integer in the range of ≥ 2 to ≤ 30 ,
 R¹ denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17,
 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms,
 R² denotes -CH₂-CH₃,
 R³ identical or different, denotes a hydrogen atom or -CH₃, and

whereby the concatenations denoted by k are distributed to form a block polymeric structure and the concatenations denoted by p, p', n, n', m and m' are distributed to form a block polymeric structure or a random polymeric structure. where the poly(meth)acrylate thickener is a poly(meth)acrylate copolymer, which comprises in polymerized form linear or branched C₁- to C₂₂-alkyl (meth)acrylates, and where the ester base oil is a diester base oil, which is a carboxylic acid ester obtainable by reacting at least one linear or branched C₂-C₂₀ dicarboxylic acid with at least one linear or branched C₁-C₂₀ monoalcohol.

[0089] The lubricant may comprise **lubricant additives** which are different from the alkoxyated polytetrahydrofuran, the poly(meth)acrylate thickener and the ester base oil. Suitable lubricant additives are viscosity index improvers, polymeric thickeners, corrosion inhibitors, detergents, dispersants, anti-foam agents, dyes, wear protection additives, extreme pressure additives (EP additives), anti-wear additives (AW additives), friction modifiers, metal deactivators, pour point depressants.

[0090] The lubricant may comprise at least 1 wt%, preferably at least 5 wt% and in particular at least 10 wt% of the lubricant additives.

[0091] The lubricant may comprise up to 50 wt%, preferably up to 30 wt% and in particular up to 10 wt% of the lubricant additives.

[0092] **Corrosion inhibitors** may include various oxygen-, nitrogen-, sulfur-, and phosphorus-containing materials, and may include metal-containing compounds (salts, organometallics, etc.) and nonmetal-containing or ashless materials. Corrosion inhibitors may include, but are not limited to, additive types such as, for example, hydrocarbyl-, aryl-, alkyl-, arylalkyl-, and alkylaryl- versions of detergents (neutral, overbased), sulfonates, phenates, salicylates, alcoholates,

carboxylates, salixarates, phosphites, phosphates, thiophosphates, amines, amine salts, amine phosphoric acid salts, amine sulfonic acid salts, alkoxylated amines, etheramines, polyetheramines, amides, imides, azoles, diazoles, triazoles, benzotriazoles, benzothiadiazoles, 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.

[0093] Detergents include cleaning agents that adhere to dirt particles, preventing them from attaching to critical surfaces. Detergents may also adhere to the metal surface itself to keep it clean and prevent corrosion from occurring. Detergents include calcium alkylsalicylates, calcium alkylphenates and calcium alkarylsulfonates with alternate metal ions used such as magnesium, barium, or sodium. Examples of the cleaning and dispersing agents which can be used include metal-based detergents such as the neutral and basic alkaline earth metal sulphonates, alkaline earth metal phenates and alkaline earth metal salicylates alkenylsuccinimide and alkenylsuccinimide esters and their borohydrides, phenates, salienius complex detergents and ashless dispersing agents which have been modified with sulphur compounds. These agents can be added and used individually or in the form of mixtures, conveniently in an amount within the range of from ≥ 0.01 to ≤ 1.0 % by weight in relation to the weight of the base stock; these can also be high total base number (TBN), low TBN, or mixtures of high/low TBN.

[0094] Dispersants are lubricant additives that help to prevent sludge, varnish and other deposits from forming on critical surfaces. The dispersant may be a succinimide dispersant (for example N-substituted long chain alkenyl succinimides), a Mannich dispersant, an ester-containing dispersant, a condensation product of a fatty hydrocarbyl monocarboxylic acylating agent with an amine or ammonia, an alkyl amino phenol dispersant, a hydrocarbyl-amine dispersant, a polyether dispersant or a polyetheramine dispersant. In one embodiment, the succinimide dispersant includes a polyisobutylene-substituted succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of about 400 to about 5000, or of about 950 to about 1600. In one embodiment, the dispersant includes a borated dispersant. Typically, the borated dispersant includes a succinimide dispersant including a polyisobutylene succinimide, wherein the polyisobutylene from which the dispersant is derived may have a number average molecular weight of about 400 to about 5000. Borated dispersants are described in more detail above within the extreme pressure agent description.

[0095] Anti-foam agents may be selected from silicones, polyacrylates, and the like. The amount of anti-foam agent in the lubricant compositions described herein may range from ≥ 0.001 wt.-% to ≤ 0.1 wt.-% based on the total weight of the formulation. As a further example, an anti-foam agent may be present in an amount from about 0.004 wt.-% to about 0.008 wt.-%.

[0096] Suitable extreme pressure agent is a sulfur-containing compound. In one embodiment, the sulfur-containing compound may be a sulfurised olefin, a polysulfide, or mixtures thereof. Examples of the sulfurised olefin include a sulfurised olefin derived from propylene, isobutylene, pentene; an organic sulfide and/or polysulfide including benzyldisulfide; bis-(chlorobenzyl) disulfide; dibutyl tetrasulfide; di-tertiary butyl polysulfide; and sulfurised methyl ester of oleic acid, a sulfurised alkylphenol, a sulfurised dipentene, a sulfurised terpene, a sulfurised Diels-Alder adduct, an alkyl sulphenyl N'N'-dialkyl dithiocarbamates; or mixtures thereof. In one embodiment, the sulfurised olefin includes a sulfurised olefin derived from propylene, isobutylene, pentene or mixtures thereof. In one embodiment the extreme pressure additive sulfur-containing compound includes a dimercaptothiadiazole or derivative, or mixtures thereof. Examples of the dimercaptothiadiazole include compounds such as 2,5-dimercapto-1,3,4-thiadiazole or a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole, or oligomers thereof. The oligomers of hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically form by forming a sulfur-sulfur bond between 2,5-dimercapto-1,3,4-thiadiazole units to form derivatives or oligomers of two or more of said thiadiazole units. Suitable 2,5-dimercapto-1,3,4-thiadiazole derived compounds include for example 2,5-bis(tert-nonyldithio)-1,3,4-thiadiazole or 2-tert-nonyldithio-5-mercapto-1,3,4-thiadiazole. The number of carbon atoms on the hydrocarbyl substituents of the hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole typically include 1 to 30, or 2 to 20, or 3 to 16. Extreme pressure additives include compounds containing boron and/or sulfur and/or phosphorus. The extreme pressure agent may be present in the lubricant compositions at 0 wt.-% to about 20 wt.-%, or at about 0.05 wt.-% to about 10.0 wt.-%, or at about 0.1 wt.-% to about 8 wt.-% of the lubricant composition.

[0097] Examples of anti-wear additives include organo borates, organo phosphites such as didodecyl phosphite, organic sulfur-containing compounds such as sulfurized sperm oil or sulfurized terpenes, zinc dialkyl dithiophosphates, zinc diaryl dithiophosphates, phosphosulfurized hydrocarbons and any combinations thereof.

[0098] Friction modifiers may include metal-containing compounds or materials as well as ashless compounds or materials, or mixtures thereof. Metal-containing friction modifiers include metal salts or metal-ligand complexes where the metals may include alkali, alkaline earth, or transition group metals. Such metal-containing friction modifiers may also have low-ash characteristics. 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.

[0099] Ashless friction modifiers may also include lubricant materials that contain effective amounts of polar groups, for example, hydroxyl-containing hydrocarbyl base oils, glycerides, partial glycerides, glyceride derivatives, and the like. Polar groups in friction modifiers may include hydrocarbyl groups containing effective amounts of O, N, S, or P, individually or in combination. Other friction modifiers that may be particularly effective include, for example, salts (both ash-containing and ashless derivatives) of fatty acids, fatty alcohols, fatty amides, fatty esters, hydroxyl-containing carboxylates, and comparable synthetic long-chain hydrocarbyl acids, alcohols, amides, esters, hydroxy carboxylates, and the like. In some instances, fatty organic acids, fatty amines, and sulfurized fatty acids may be used as suitable friction modifiers. Examples of friction modifiers include fatty acid esters and amides, organo molybdenum compounds, molybdenum dialkylthiocarbamates and molybdenum dialkyl dithiophosphates.

[0100] Suitable **metal deactivators** include benzotriazoles and derivatives thereof, for example 4- or 5-alkylbenzotriazoles (e.g. triazole) and derivatives thereof, 4,5,6,7-tetrahydrobenzo-triazole and 5,5'-methylenebisbenzotriazole; Mannich bases of benzotriazole or triazole, e.g. 1-[bis(2-ethyl-hexyl) aminomethyl] triazole and 1-[bis(2-ethylhexyl) aminomethyl]-benzotriazole; and alkoxy-alkylbenzotriazoles such as 1-(nonyloxymethyl) benzotriazole, 1-(1-butoxyethyl) benzotriazole and 1-(1-cyclohexyloxybutyl) triazole, and combinations thereof. Additional non-limiting examples of the one or more metal deactivators include 1,2,4-triazoles and derivatives thereof, for example 3-alkyl(or aryl)-1, 2,4-triazoles, and Mannich bases of 1,2,4-triazoles, such as 1-[bis(2-ethylhexyl) aminomethyl]-1, 2,4-triazole; alkoxyalkyl-1, 2,4-triazoles such as 1-(1-butoxyethyl)-1, 2,4-triazole; and acylated 3-amino-1, 2,4-triazoles, imidazole derivatives, for example 4,4'-methylenebis(2-undecyl-5-methylimidazole) and bis[(N-methyl)imidazol-2-yl]-carbinol octyl ether, and combinations thereof. Further non-limiting examples of the one or more metal deactivators include sulfur-containing heterocyclic compounds, for example 2-mercapto-benzothiazole, 2,5-dimercapto-1, 3,4-thia-diazole and derivatives thereof; and 3,5-bis[di(2-ethylhexyl) aminomethyl]-1, 3,4-thiadiazolin-2-one, and combinations thereof. Even further non-limiting examples of the one or more metal deactivators include amino compounds, for example salicylidene-propylenediamine, salicylami-noguanidine and salts thereof, and combinations thereof. The one or more metal deactivators are not particularly limited in amount in the composition but are typically present in an amount of from about 0.01 to about 0.1, from about 0.05 to about 0.01, or from about 0.07 to about 0.1, wt.-% based on the weight of the composition. Alternatively, the one or more metal deactivators may be present in amounts of less than about 0.1, of less than about 0.7, or less than about 0.5, wt.-% based on the weight of the composition.

[0101] **Pour point depressants** (PPD) include polymethacrylates, alkylated naphthalene derivatives, and combinations thereof. Commonly used additives such as alkylaromatic polymers and polymethacrylates are also useful for this purpose. Typically, the treat rates range from ≥ 0.001 wt.-% to ≤ 1.0 wt.-%, in relation to the weight of the base stock.

[0102] **Demulsifiers** include trialkyl phosphates, and various polymers and copolymers of ethylene glycol, ethylene oxide, propylene oxide, or mixtures thereof.

[0103] The term "**lubricant**" usually refers to a composition which is capable of reducing friction between surfaces (preferably metal surfaces), such as surfaces of mechanical devices. A mechanical device may be a mechanism consisting of a device that works on mechanical principles. The lubricant is usually a lubricating liquid, lubricating oil or lubricating grease, preferably a lubricating liquid, such as a hydraulic oil.

[0104] The lubricant can be used for various **applications** such as light, medium and heavy duty engine oils, industrial engine oils, marine engine oils, automotive engine oils, crankshaft oils, compressor oils, refrigerator oils, hydrocarbon compressor oils, very low-temperature lubricating oils and fats, high temperature lubricating oils and fats, wire rope lubricants, textile machine oils, refrigerator oils, aviation and aerospace lubricants, aviation turbine oils, transmission oils, gas turbine oils, spindle oils, spin oils, traction fluids, transmission oils, plastic transmission oils, passenger car transmission oils, truck transmission oils, industrial transmission oils, industrial gear oils, insulating oils, instrument oils, brake fluids, transmission liquids, shock absorber oils, heat distribution medium oils, transformer oils, fats, chain oils, minimum quantity lubricants for metalworking operations, oil to the warm and cold working, oil for water-based metalworking liquids, oil for neat oil metalworking fluids, oil for semi-synthetic metalworking fluids, oil for synthetic metalworking fluids, drilling detergents for the soil exploration, hydraulic oil, in biodegradable lubricants or lubricating greases or waxes, chain saw oils, release agents, moulding fluids, gun, pistol and rifle lubricants or watch lubricants and food grade approved lubricants.

[0105] The lubricant is preferably a hydraulic oil. Hydraulic oils are often used to transfer power and to lubricating the hydraulic equipment. Typical machines which use hydraulic oils are excavators, backhoes, hydraulic brakes, power steering systems, automatic transmissions, garbage trucks, aircraft flight control systems, lifts, and industrial machinery.

[0106] The invention also relates to a use of the lubricant comprising

- the alkoxyated polytetrahydrofuran,
- the poly(meth)acrylate thickener, and

- the mineral base oil, and optionally
- the ester base oil

as a hydraulic oil.

Examples

[0107]

- Hydraulic Oil A: A commercial hydraulic oil comprising a mineral oil base stock and lubricant additives, pour point below -60 °C, KV40 below 5 mm²/s.
- Hydraulic Oil B: A commercial mineral base oil, pour point below -35 °C, KV40 below 10 mm²/s.
- Thickener A: Alkyl methacrylate co-polymer in a highly refined mineral oil, commercially available as Irgaflo® 1100 V from BASF SE.
- Thickener B: A polyacrylate thickener, commercially available as Viscoplex® 7-199 from Evonik.
- Thickener C: A polyacrylate thickener, commercially available as Viscoplex® 7-302 from Evonik.
- Diester A: Diisotridecyl adipate
- Alkoxylate A: A butoxylated (70 equivalents) and C₁₂ alkoxyated (40 equivalents) polytetrahydrofuran (polyTHF average Mw 1000 g/mol).
- Additive Pack: A commercial additive package for use in antiwear hydraulic fluids.
- PAO 100: A polyalphaolefin fluid with a KV100 of about 100 mm²/s.
- PAO 300: A polyalphaolefin fluid with a KV100 of about 300 mm²/s.

Example 1 - Preparation of Blends and Testing

[0108] Hydraulic oil formulations were blended from the components as listed in Table 1. The application data were analyzed and the results are summarized also in Table 1.

[0109] The kinematic viscosity was determined at 40 °C (KV40) and at 100 °C (KV100) according to ASTM D445. The viscosity index VI was calculated from the KV40 and KV100.

[0110] The KV40 was adjusted to about 32 mm²/s for all blends in Table 1.

[0111] KRL: This test method is used to evaluate the shear loss, and was calculated by the KV100 before and after the test according to CEC L-45-99. A shear loss of less than 25 % KRL 20 h is advantageous.

Table 1

	Blend 1	Blend 2	Blend A ^a	Blend B ^a	Blend C ^a	Blend D ^a
Hydraulic Oil A	62,6 %	59,6 %	65,1 %	35,7 %	38,04 %	42,1 %
Hydraulic Oil B				35,7 %	38,04 %	34,45 %
Thickener A	27,0 %	27,0 %	28,5 %	20,2 %		23,0 %
Thickener B				8,0 %		
Thickener C					23,5 %	
Diester A	5,0 %	5,0 %				
Alkoxylate A	5,0 %	8,0 %				
PAO 100			6,0 %			
Additive Pack	0,40 %	0,40 %	0,40 %	0,45 %	0,45 %	0,45 %
KV40 mm ² /s	31,8	32,9	30,83	32,85	31,83	32,40
KV100 mm ² /s	9,3	9,3	9,43	9,96	10,10	10,26
VI	297	286	313	311	330	328
KRL shear loss	24,6 %	20,5 %	29,9 %	28,5 %	42,2 %	38,1 %

a) Comparative Example

Example 2 - Stibeck Curve Analysis

[0112] The friction coefficient [μ] vs speed [mm/s] was determined by the MTM test on a MTM machine from PCS Instruments with a steel ball of 19.05 mm diameter and a test disk with 50 mm diameter, contact pressure 1 GPa, SRR 50%, test temperature 40 °C, test time 3 sec. The contact friction was measured by a torque converter, which was firmly mounted between the drive shaft and the test ball. The frictional force was determined perpendicular to the direction of loading. During the Stribeck test the average speed between test disc and ball were kept constant and the frictional force was applied in two directions measured. During the first measurement (TF1) the disc has a higher speed than the ball, in the second measurement (TF2) is the speed of the ball is greater. The coefficient of friction was thus calculated.

[0113] The resulting data are shown in Figure 1. The continuing line with the diamonds was determined with Blend 1. The dotted line with the circles was determined with the comparative Blend E.

[0114] The results demonstrated that the friction coefficient was reduced for Blend 1 compared to the Blend E, where the Alkoxyate A was substituted by a polyalphaolefin.

Table 2

	Blend 1	Blend E ^a
Hydraulic Oil A	62,6 %	61,1
Thickener A	27,0 %	28,5 %
Diester A	5,0 %	5,0 %
Alkoxylate A	5,0 %	
PAO 300		5,0 %
Additive Pack	0,40 %	0,40 %

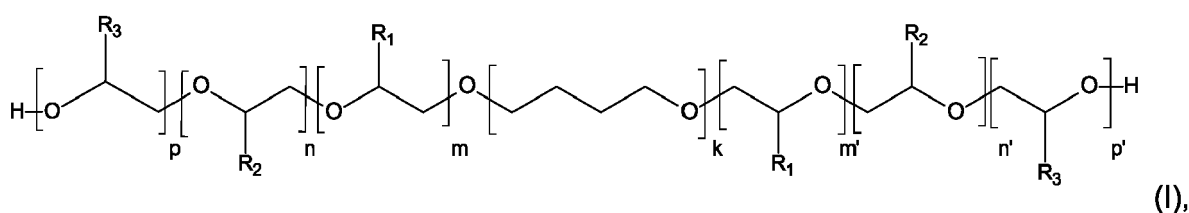
a) Comparative Example

Claims

1. A lubricant comprising

- an alkoxyated polytetrahydrofuran,
- a poly(meth)acrylate thickener, and
- a mineral base oil.

2. The lubricant according to claim 1 where the alkoxyated polytetrahydrofuran is a compound of formula (I)



wherein

m is an integer in the range of ≥ 1 to ≤ 50 .

m' is an integer in the range of ≥ 1 to ≤ 50 ,

$(m+m')$ is an integer in the range of ≥ 1 to ≤ 90 .

n is an integer in the range of ≥ 0 to ≤ 75 .

n' is an integer in the range of ≥ 0 to ≤ 75 .

p is an integer in the range of ≥ 0 to ≤ 75 .

p' is an integer in the range of ≥ 0 to ≤ 75 ,

k is an integer in the range of ≥ 2 to ≤ 30 ,

R¹ denotes an unsubstituted, linear or branched, alkyl radical having 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 carbon atoms,

R² -CH₂-CH₃,

R³ identical or different, denotes a hydrogen atom or methyl, and

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

3. The lubricant according to claim 2 where R¹ denotes an unsubstituted, linear alkyl radical having 8, 9, 10, 11, 12, 13, 14, 15 or 16 carbon atoms.

4. The lubricant according to any of claims 2 or 3 where (m+m') is an integer in the range of ≥ 3 to ≤ 65 .

5. The lubricant according to any of claims 2 to 4 where (n+n') is an integer in the range of ≥ 20 to ≤ 90 .

6. The lubricant according to any of claims 1 to 5 further comprising an ester base oil selected from the group consisting of diester base oils and complex ester base oils.

7. The lubricant according to claim 6 where the diester base oil is a carboxylic acid ester obtainable by reacting at least one linear or branched C₂-C₂₀ dicarboxylic acid with at least one linear or branched C₁-C₂₀ monoalcohol.

8. The lubricant according to any of claims 1 to 7 where the poly(meth)acrylate thickener is a poly(meth)acrylate copolymer, which comprises in polymerized form linear or branched C₁- to C₂₂-alkyl (meth)acrylates.

9. The lubricant according to any of claims 1 to 8 where the mineral base oil has a kinematic viscosity at 40 °C of below 15 mm²/s, preferably below 10 mm²/s, and in particular below 5 mm²/s.

10. The lubricant according to any of claims 1 to 9 where the lubricant comprises 1 - 25 wt% of the alkoxyated polytetrahydrofuran.

11. The lubricant according to any of claims 1 to 10 where the lubricant comprises at least 45 wt% of the mineral base oil.

12. The lubricant according to any of claims 1 to 11 where the lubricant comprises 8 - 35 wt% of the polymethacrylate thickener.

13. The lubricant according to any of claims 1 to 12 where the lubricant comprises up to 25 wt% of the ester base oil.

14. The lubricant according to any of claims 1 to 13 where the lubricant is a hydraulic oil.

15. A use of the lubricant as defined in any of claims 1 to 14 comprising

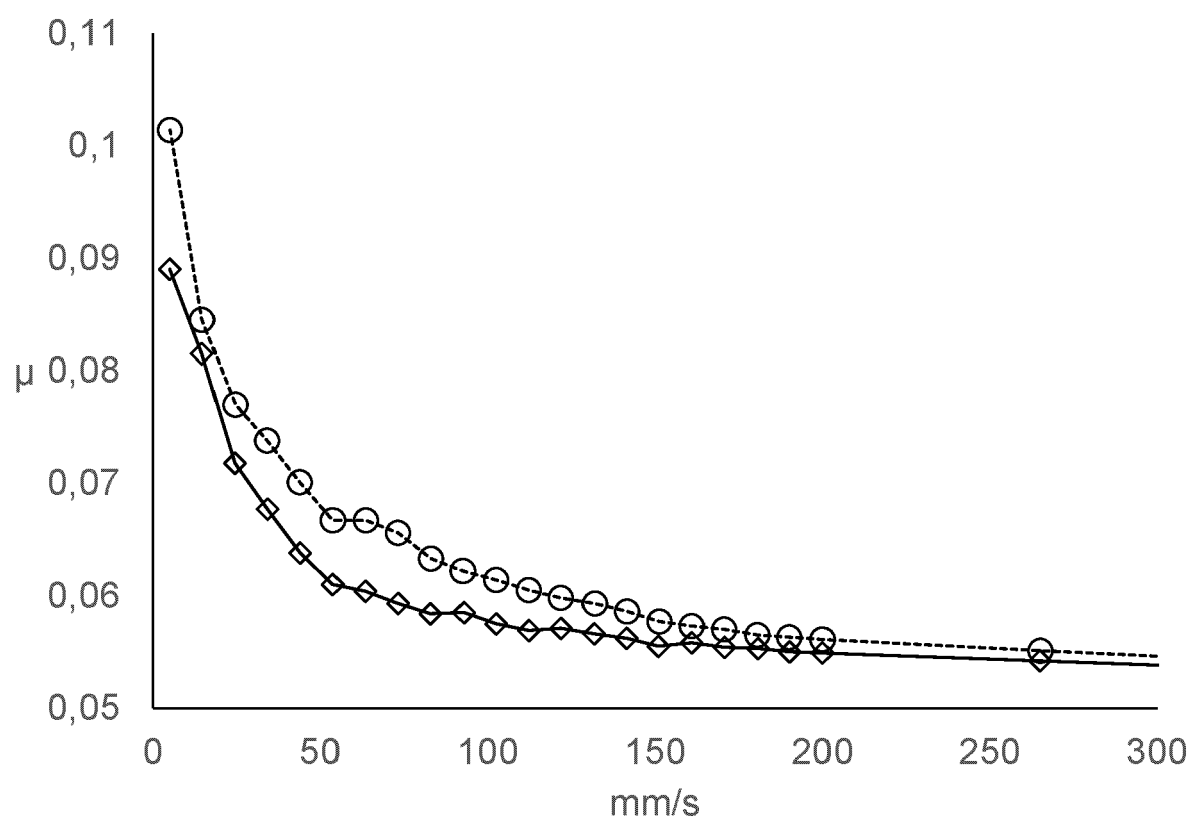
- the alkoxyated polytetrahydrofuran,
- the poly(meth)acrylate thickener, and
- the mineral base oil, and optionally
- the ester base oil,

as a hydraulic oil.

16. A method for preparing the lubricant as defined claims 1 to 14 comprising the step of contacting

- the alkoxyated polytetrahydrofuran,
- the polymethacrylate thickener, and
- the mineral base oil, and optionally
- the ester base oil.

Fig. 1





EUROPEAN SEARCH REPORT

Application Number

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EPO FORM 1503 03.82 (P04C01)

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC)
			C10M C10N
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 24 March 2023	Examiner Pöllmann, Klaus
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date 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.

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5 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 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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