(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 August 2013 (15.08.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/119186 A1

(51) International Patent Classification:
C10M 135/10 (2006.01) *C10M 133/06* (2006.01)
C10M 137/04 (2006.01) *C10N 30/06* (2006.01)
C10M 139/04 (2006.01) *C10N 40/02* (2006.01)
C10M 131/08 (2006.01) *C10N 40/04* (2006.01)
C10M 131/10 (2006.01) *C10N 40/25* (2006.01)
C10M 131/12 (2006.01)

(21) International Application Number:
PCT/SI2013/000004

(22) International Filing Date:
18 January 2013 (18.01.2013)

(25) Filing Language: Slovenian

(26) Publication Language: English

(30) Priority Data:
P-201200038 10 February 2012 (10.02.2012) SI

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

WO 2013/119186 A1

(54) Title: LUBRICANT ADDITIVE AND LUBRICANT CONTAINING SUCH ADDITIVE

(57) Abstract: The present invention refers to a lubricant additive, which is intended for lubricating of at least two steel machine parts, which are engaged with each other by means of sliding or rolling relative to each other, and moreover also to a lubricant containing such additive. A chemical structure of such additive is based on a linear molecule of alkane with preferably 10 to 20 carbon atoms, in which all hydrogen atoms, or all hydrogen atoms except of the terminal one, which is bound to the terminal carbon atom, are substituted with a fluorine atom or with such functional group on the basis of fluorine, which leads to oleophobicity of such substituted molecule, and wherein simultaneously at least one polar functional group is bound to at least one terminal carbon atom in order to assure adhesiveness of the additive towards the iron oxides on the surface of each lubricated machine part by simultaneously enabling sliding along the surface of the said machine part.

LUBRICANT ADDITIVE AND LUBRICANT CONTAINING SUCH ADDITIVE

The invention belongs to chemistry, namely on the one hand to lubricants on the basis of aliphatic hydrocarbons, and on the other hand to additives comprising halogen.

The purpose of the invention is to improve the ability of sliding of the lubricant and to reduce resistance of the lubricant during displacements along the surface of each lubricated machine part, in particular in conditions of hydrodynamic or elasto-hydrodynamic friction, by which however adhesiveness towards the surface layer of each machine part consisting substantially of iron oxides should be maintained. Accordingly, such cooperating machine parts should despite to maintaining each required lubricating performances become easily slidable relative to each other i.e. under essentially reduced resistance, when compared with lubricating by means of state of the art lubricants and additives.

Lubricants are known, which consist of aliphatic hydrocarbons consisting of relatively long linear molecules, in which carbon atoms are bound by means of a single or double or triple bond, and hydrogen atoms are bound to said carbon atoms, wherein such molecule comprises a polar end portion, by which a required adhesiveness is achieved towards a non-polar steel basis, which is substantially covered with iron oxides.

Properties of such lubricants are e.g. described in

A. E. Jimenez, M. D. Bermudez, P. Iglesias, J. Carrion, G. Martinez-Nicolas: Wear, 260 (7-8). 766-782 (2006);

I. Minami, M. Kita, T. Kubo, H. Nanao, S. Mori: Tribology Letters, 30(3), 215-223 (2008);

T. Itoh, N-Watanabe, K-Inada, A. Ishioka, S. Hayase, M. Kawatsura, I. Minami, S. Mori: Chemistry Letters, 38(1), 64-65 (2009).

In such cases, excellent adhesiveness of molecules of the lubricant against each disposable surface is obtained, by which a layer of the lubricant is present between each two mutually engaged machine parts, and molecules of the lubricant are adhered to the material on the surface of each machine part. To this aim, a polar group like e.g. SO_3^- can be bound to a chain C_nH_{2n+1}. However, in such case adhesive forces are acting between molecules of the lubricant and molecules of the surface layer of each lubricated machine part, and relative movements between both lubricated and cooperating machine parts are hindered, so that consequently and under provision that each desired lubricating performances and thickness of the layer of the lubricant shall be maintained, the resistance against each movement of said machine part relative to each other is relatively high.

The invention provides that an additive in amount of 0,1 - 1,5%, per weight of the lubricant is added to the lubricant, namely an additive with a linear molecular structure on the basis of a substituted hydrocarbon with added polar functional group of the type

$$X\text{-}C_nF_{2n}\text{-}Y \qquad \text{(Formula 1)}$$

wherein *n* is 5 to 25, preferably 10 to 20, and wherein at least one of X and Y, preferably both of them, represent(s) a polar group, which is during the use i.e. during the lubrication of each machine part, which is made of steel and is covered with iron oxides on its surface, capable to adhere to said oxidized surface layer, and wherein

optionally each residual terminal end portion X or Y represents a hydrogen or fluorine atom.

When each desired functional group Y is bound to just one of two terminal carbon atoms of the molecule of the additive, then X is optionally a hydrogen or fluorine atom. In such case, the polar group is during the use, i.e. by lubricating of each steel machine part, adhered to the iron oxides on the surface, while the residual part of the molecule is oleophobic and prevents the lubricant to access said surface.

Said compound according to Formula 1 is for example realized such that in a molecule of a hydrocarbon, which belongs to the group of alkanes C_nH_{2n+1} with at least 10 carbon atoms, either all disposable hydrogen atoms or all hydrogen atoms except of the terminal one are substituted with fluorine atoms, and that simultaneously at least one polar group X and/or Y is bound to at least one of terminal carbon atoms. Consequently, a linear molecule is obtained with a base portion, which is due to substitution of hydrogen atoms with fluorine atoms oleophobic and is repelled from fat, but the same time at least one end portion of said molecule in the area of one terminal carbon atom remains polar and shows tendency of adhesion towards the surface layer consisting of iron oxides, which is present on each machine part lubricated by means of the lubricant containing the additive according to the invention.

In accordance with the invention, said linear molecule of a hydrocarbon in accordance with Formula 1, in which all hydrogen atoms, optionally except of one terminal hydrogen atom, are substituted with fluorine, is completed either with

- one polar functional group X, which is bound to one terminal carbon atom, wherein a hydrogen atom H or fluorine atom F is bound to each residual terminal carbon atom, and wherein said polar functional group is optionally a carboxy or amid or amino or hydroxy group or an alcohol, in particular methanol CH_2OH, under the condition $10 \leq n \leq 18$, and wherein Y is hydrogen or fluorine; or with

- a combination of two identical or different polar functional groups, which are in the molecule of additive bound to each corresponding terminal carbon atom, either in accordance with combinations pursuant to Formula 1, wherein optionally

X = carboxy and Y = carboxy, wherein $10 \leq n \leq 20$;

X = carboxy and Y = alcohol, in particular methanol, wherein $13 \leq n \leq 14$;

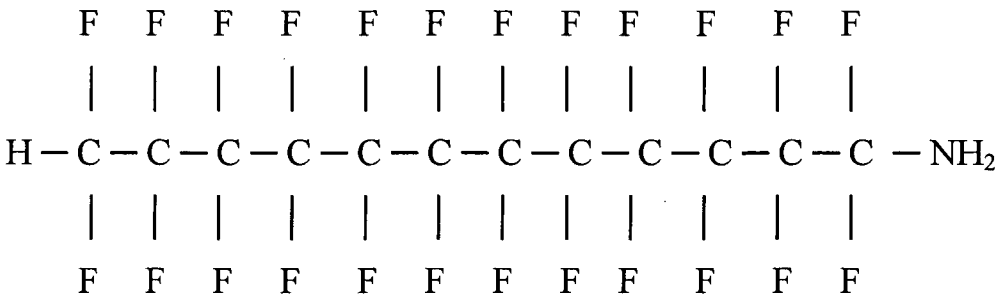
X = alcohol and Y = alcohol, in particular methanol, wherein n is preferably 16;

- or with at least one complex polar functional group X, which is optionally

- glycerol monoleat;
- oleamid;
- sulphonate SO_3;
- sulphate SO_4,
- phosphate PO_4, or
- n-alkyltrihydroxy silan $Si(OH)_3$, wherein $10 \leq n \leq 18$ and wherein Y is a hydrogen or a fluorine atom.

Example 1

The basis for a compound according to Formula 2 represents a molecule of alkane $C_{12}H_{25}$, in which hydrogen atoms except of that, which is bound to one of terminal carbon atoms, are substituted with fluorine atoms, and in which amino group is bound on the residual carbon atom.



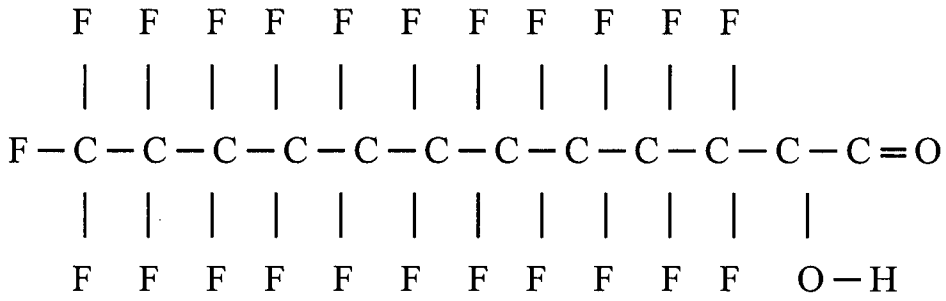
(Formula 2)

Molecules of such obtained compound, which are present within a lubricant as an additive, are by means of the polar end portion NH_2 adhered to iron oxides on the

surface of each lubricated steel part, while the residual end portion of the molecule is oleophobic and prevents molecules of the lubricant from contacting said surface.

Example 2

In accordance with Formula 3, a carboxyl group is used as a functional group, which is bound to one of both terminal carbon atoms of a molecule, in which hydrogen atoms are substituted with fluorine atoms

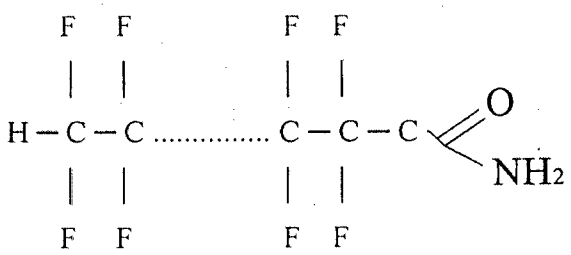


(Formula 3)

In such case, polar end portions of molecules are adhered to iron oxides on the surface of each lubricated machine part of steel on the side of said carboxyl group, while the residual part of the molecule is oleophobic.

Example 3

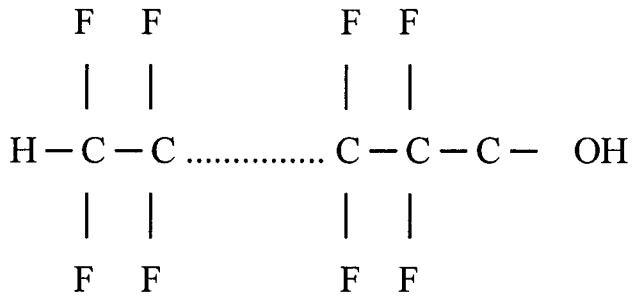
Amine group is used as a polar functional group, wherein the molecule of additive is presented by means of Formula 4. The residual part of the molecule is oleophobic.



(Formula 4)

Example 4

A hydroxyl i.e. hydroxy group is used as a polar functional group, wherein the molecule of additive is presented by means of Formula 5.

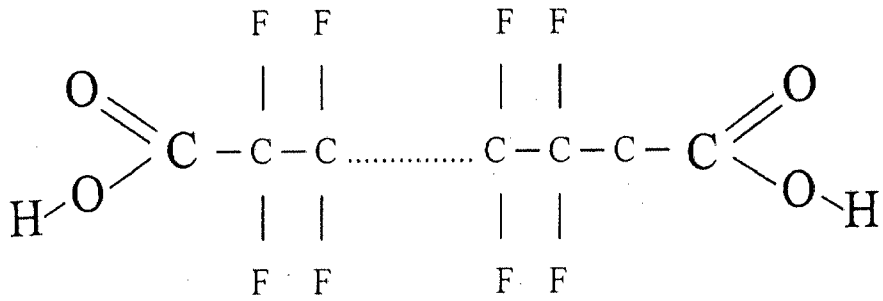


(Formula 5)

In such case, polar end portions of molecules are adhered to iron oxides on the surface of each lubricated machine part of steel on the side of said carboxyl group, while the residual part of the molecule is oleophobic.

Example 5

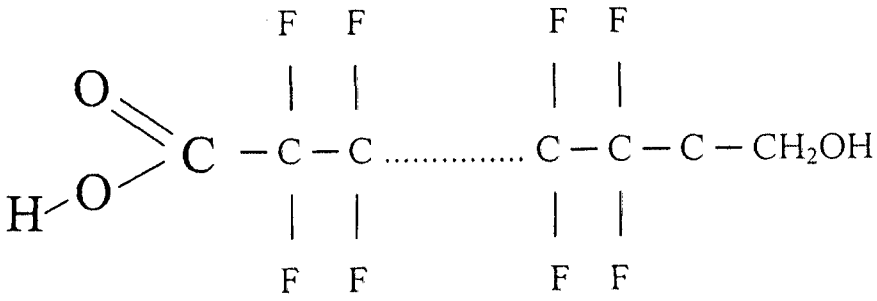
In such case, a n-alkane molecule ($10 \leq n \leq 18$) according to Formula 1 is used, wherein each desired polar functional group is bound to one of both terminal carbon atoms. In the Formula 6 below, both functional groups are carboxyl groups



(Formula 6)

Example 6

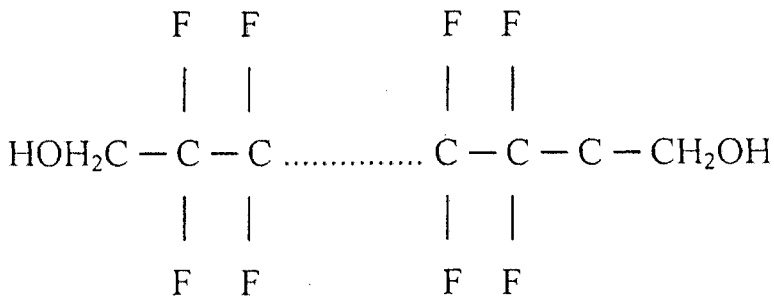
In such case, a n-alkane molecule ($13 \leq n \leq 14$) according to Formula 1 is used, wherein each desired polar functional group is bound to one of both terminal carbon atoms, wherein the first functional group X of the additive molecule according to Formula 7 is a carboxyl group, while the other polar functional group is an alcohol group, namely methanol.



(Formula 7)

Example 7

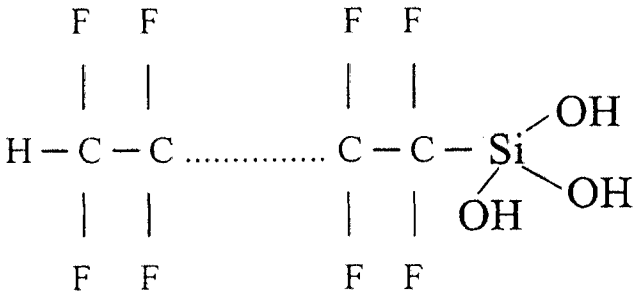
In such case, a hexadecane ($n = 16$) is used in accordance with Formula 1, in which each desired polar functional group is bound to each of both terminal carbon atoms, wherein both polar functional groups X and Y of the additive molecule according to Formula 8 are alcohol groups.



(Formula 8)

Example 8

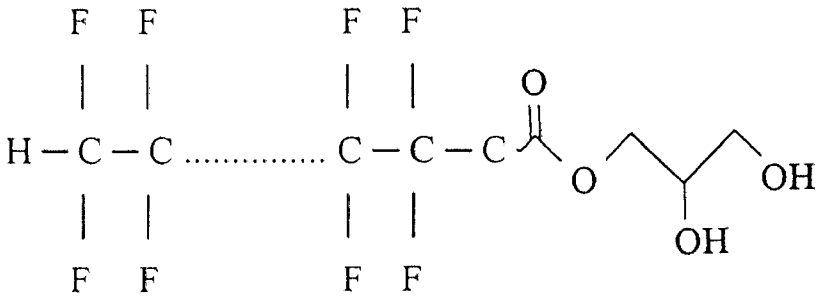
In this case a molecule in accordance with Formula 9 is used, where the polar functional group is alkyl trihydroxy silane.



(Formula 9)

Example 9

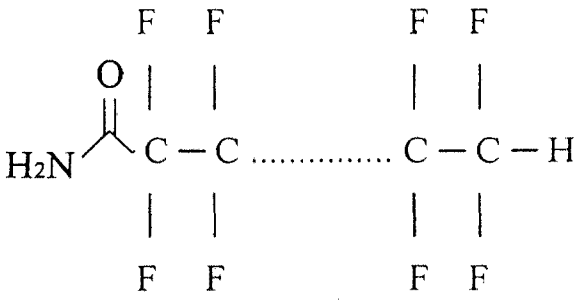
In this case a molecule in accordance with Formula 10 is used, where the polar functional group is glycerol monooleate (GMO)



(Formula 10)

Example 10

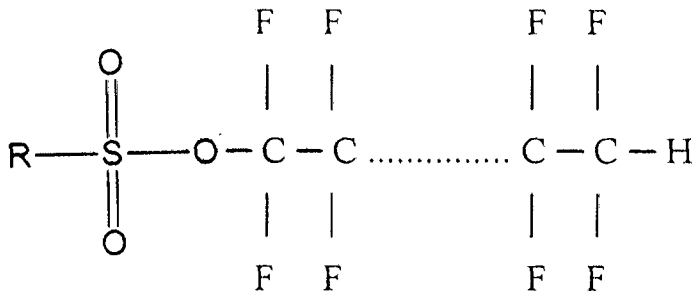
In this case a molecule in accordance with Formula 11 is used, where the polar functional group is oleamid.



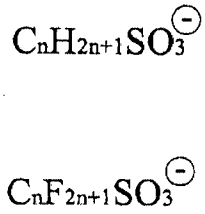
(Formula 11)

Example 11

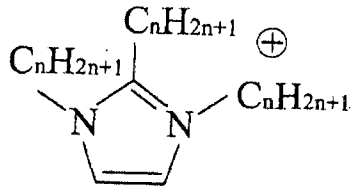
In such case, a molecule is used in accordance with Formula 1, in which the polar functional group is sulphonate in accordance with Formula 12, wherein the sulphonate cations and anions, which may be different, are separately shown in Formulas 12a and 12b.



(Formula 12)



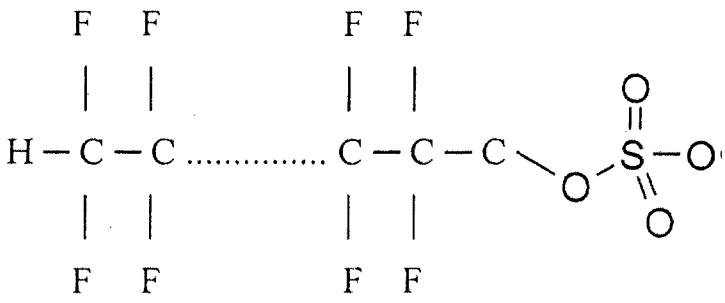
(Formula 12a)



(Formula 12b)

Example 12

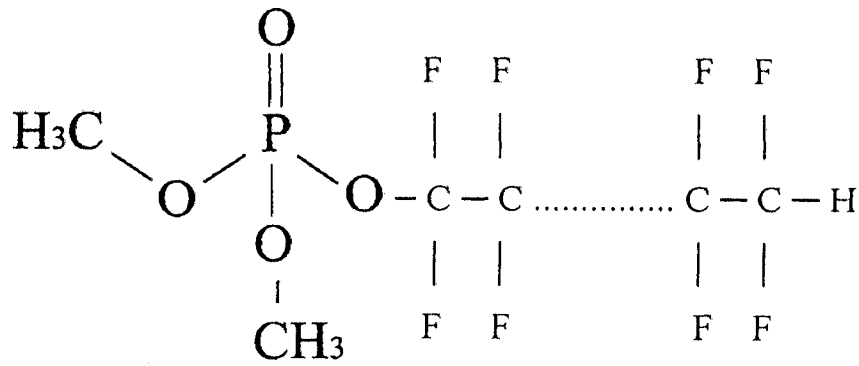
In this case an additive molecule is used, where the polar functional group is a sulphate group according to Formula 13.



(Formula 13)

Example 13

In this case an additive molecule is used, where the polar functional group is a phosphate group according to Formula 14.



(Formula 14)

Those skilled in the art shall understand that the invention relates both to the lubricant additive in accordance with Formula 1 and with previously discussed examples, and also to the lubricant containing such additive, namely in amount between 0,5 and 1,5% per weight of the lubricant together with added additive.

Due to the fact that each molecule of the additive according to Formula 1 comprises a polar end portion, which can be adhered to the oxidized surface of each lubricated steel machine part, as well as an oleophobic residual end portion, which prevents the lubricant to access said surface, shear forces within the lubricant layer are reduced, and consequently, the resistance against relative movement of both lubricated cooperating machine parts is also essentially reduced.

PATENT CLAIMS

1. Additive for a lubricant suitable for lubricating of at least two machine parts, which cooperate with each other in the sense of sliding or rolling along each other, wherein the basis for said additive represents a molecule of alkane, in which all hydrogen atoms, or all hydrogen atoms except of the terminal atom, which is bond to the terminal carbon atom, are substituted with a fluorine atom or such functional group on the basis of fluorine, which assures oleophobic properties of such group, **characterized in that** its chemical structure is defined with formula

$$X\text{-}C_nF_{2n}\text{-}Y \qquad \text{(formula 1)}$$

wherein *n* is 5 to 25, preferably 10 to 20, and wherein at least one of X and Y, preferably both of them, represent(s) a polar group, which is during the use i.e. during the lubrication of each machine part, which is made of steel and is therefore covered with iron oxides on the surface, capable to adhere to said oxidized surface layer, and wherein optionally each residual terminal end portion X or Y represents a hydrogen or fluorine atom.

2. Additive according to Claim 1, **characterized in that** each compound according to Formula 1, in which all hydrogen atoms, optionally except of one terminal hydrogen atom, are substituted with fluorine, is completed either with
- one polar functional group X, which is bond to one terminal carbon atom, wherein a hydrogen H atom or F fluorine atom is bound to each residual terminal carbon atom, and wherein said polar functional group is optionally a carboxy or amid or amino or hydroxy group or an alcohol, in particular methanol CH_2OH, under the condition $10 \leq n \leq 18$, and wherein Y is hydrogen or fluorine; or with

- combination of two identical or different polar functional groups, which are in the molecule of additive bound to each corresponding terminal carbon atom, either in accordance with combinations pursuant to Formula 1, wherein optionally

X = carboxy and Y = carboxy, wherein $10 \leq n \leq 20$;

X = carboxy and Y = alcohol, in particular methanol, wherein $13 \leq n \leq 14$;

X = alcohol and Y = alcohol, in particular methanol, wherein n is preferably 16;

- or with at least one complex polar functional group X, which is optionally

- glycerol monoleat;
- oleamid;
- sulphonate SO_3;
- sulphate SO_4,
- phosphate PO_4, or
- n-alkyltrihydroxy silan $Si(OH)_3$, wherein $10 \leq n \leq 18$ and wherein Y is a hydrogen or a fluorine atom.

3. Lubricant containing 0,1 - 1,5%, per weight of the lubricant, of additive according to anyone of Claims 1 or 2.

INTERNATIONAL SEARCH REPORT

International application No
PCT/SI2013/000004

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10M135/10 C10M137/04 C10M139/04 C10M131/08 C10M131/10
C10M131/12 C10M133/06
ADD. C10N30/06 C10N40/02 C10N40/04 C10N40/25
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Y	US 5 112 662 A (NG QUOCK Y [US]) 12 May 1992 (1992-05-12) column 1, lines 59-61; column 2, lines 4-16; column 2, line 63 to column 3, line 3; column 3, lines 10-15; claims 1,5,8	1,2 1-3
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 July 2013	10/07/2013

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INTERNATIONAL SEARCH REPORT

International application No
PCT/SI2013/000004

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 2004/041978 A1 (SOLUTIA INC [US]; SILVERMAN DAVID C [US]; HIRZEL TIMOTHY K [US]) 21 May 2004 (2004-05-21)	1
Y	paragraphs [0006], [0011], [0023]; claims 1,5,49	1-3
X	EP 2 133 202 A1 (BAYER MATERIALSCIENCE AG [DE]) 16 December 2009 (2009-12-16) paragraphs [0018], [0034]; claims 1,4,6,7	1
Y	EP 0 488 273 A1 (HITACHI LTD [JP]) 3 June 1992 (1992-06-03) the whole document	1-3
Y	WO 02/094969 A2 (DRAPER LAB CHARLES S [US]) 28 November 2002 (2002-11-28) the whole document	1-3
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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