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(54) ETHER-BASED LUBRICANT COMPOSITIONS, METHODS AND USES

SCHMIERSTOFFZUSAMMENSETZUNG BASIEREND AUF EINER ETHERVERBINDUNG UND DEREN VERWENDUNG

COMPOSITION LUBRIFIANTE À BASE D' UN ÉTHER ET SON UTILISATION

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Description

[0001] The present invention relates to lubricant compositions containing base oils comprising certain ether base stock which are suitable for use in a lubricant composition intended for use in an internal combustion engine. Also provided are uses of the lubricant compositions and of the ether base stocks.

Background

[0002] Lubricating compositions generally comprise a base oil of lubricating viscosity together with one or more additives to deliver properties including for example, reduced friction and wear, improved viscosity index, improved dispersancy, detergency, and resistance to oxidation and corrosion. A lubricant base oil may comprise one or more lubricating base stocks.

[0003] Lubricant base stocks used in automotive engine lubricants are generally obtained from petrochemical sources, for example they may be obtained as the higher boiling fractions isolated during the refining of crude oil or as the products of chemical reactions of feedstocks from petrochemical sources. Lubricant base stocks can also be made from Fischer-Tropsch wax.

[0004] Lubricant base stocks may be classified as Group I, II, III, IV and V base stocks according to API standard 1509, "ENGINE OIL LICENSING AND CERTIFICATION SYSTEM", 17th Edition, Annex E (October 2013 with Errata March 2015), as set out in Table 1.

Table 1

Group	Saturated hydrocarbon content (% by weight) ASTM D2007		Sulphur content (% by weight) ASTM D2622, D4294, D4927, D3120 or D1552		Viscosity Index ASTM D2270
I	< 90	and/or	> 0.03	and	≥ 80 and < 120
II	≥ 90	and	≤ 0.03	and	≥ 80 and < 120
III	≥ 90	and	≤ 0.03	and	≥ 120
IV	Polyalphaolefins				
V	all base stocks not in Groups I, II, III or IV				

[0005] Group I base stocks are typically manufactured by known processes including, for example, solvent extraction and solvent dewaxing, or solvent extraction and catalytic dewaxing. Group II and Group III base stocks are typically manufactured by known processes including, for example, catalytic hydrogenation and/or catalytic hydrocracking, and catalytic hydroisomerisation. Group IV base stocks include for example, hydrogenated oligomers of alpha olefins.

[0006] A combination of properties is desirable in a base stock for conferring to a lubricant composition comprising it. In some instances, for example in passenger car engine oils, it may be desirable for a base stock to confer a low viscosity profile on the lubricant composition, since this leads to improved fuel economy. In particular, it is desirable for base stocks to have a low kinematic viscosity as well as good low-temperature viscosity characteristics, for example a low pour point or low viscosity as measured using a mini-rotary viscometer (MRV). However, the general trend is for an improvement in the viscosity profile (*i.e.* a reduction in viscosity parameters) of a base oil to be accompanied by an undesirable increase in volatility.

[0007] In addition, it is desirable for lubricant compositions to exhibit good oxidation stability, particularly when used in an internal combustion engine where oxidative degradation is exacerbated as a result of the high temperatures encountered in an engine. Good oxidation stability can extend the useful lifetime of a lubricant composition, for instance, by reducing oxidative thickening, which can otherwise rapidly lead to a loss of fuel economy, as well as decreasing deposit and sludge formation which may otherwise ultimately result in engine failure. Typically, oxidation stability of a lubricant composition is improved by the addition of anti-oxidants. An antioxidant level representative of a high performance engine oil may exceed 5 %, by weight of the lubricant composition. Thus, a significant proportion of the composition may be made up of anti-oxidants and therefore these represent a significant cost component of the lubricant composition. Common antioxidants used in lubricant compositions for use in an internal combustion engine include phenolic and aminic anti-oxidants. However, the presence of phenolic anti-oxidants is known to have detrimental environmental effects whilst the presence of aminic antioxidants has been found by the inventors to contribute to turbocharger deposits, piston varnish and copper corrosion and can also cause problems with elastomer compatibility. CN 101 006 164 is directed to a lubricating oil composition for fluid dynamic bearings comprising 50 to 100% by mass of an ether compound comprising

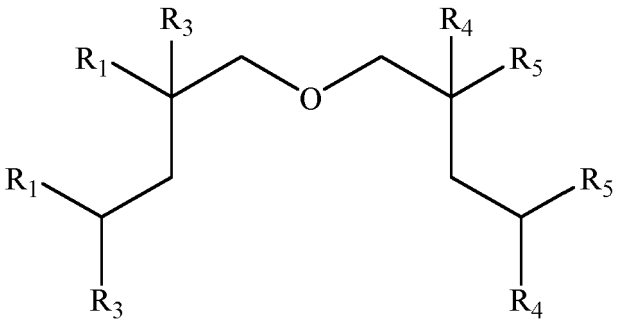
at least one ether bond and 11 to 34 carbon atoms as a base oil and a kinematic viscosity of at least 2.2 mm^2/s at 100° C. The ether compound may be a monoether compound represented by R^1-O-R^2, wherein R^1 is a monovalent hydrocarbon group comprising a side chain having 8 to 24 carbon atoms and R^2 represents a monovalent hydrocarbon group having 3 to 10 carbon atoms. Alternatively, the ether compound may be a diether compound represented by R^3-O-R^4-O-R^5, wherein R^3 and R^5 are each selected from a monovalent hydrocarbon group, R^4 represents a divalent hydrocarbon group, at least one of groups R^3, R^4 and R^5 has a side chain, and the total number of carbon atoms in R^3, R^4 and R^5 is 11 to 34. As a further alternative, the ether compound may be a tri- or tetraether compound of the formula R^6-O-$(R^7$-O$)_n$-R^8, wherein R^6 and R^8 are each selected from a monovalent hydrocarbon group, R^7 is a divalent hydrocarbon group, n is an integer of 2 or 3, at least one of the groups R^6, R^7 and R^8 has a side chain, and the total number of carbon atoms in R^6, R^7 and R^8 is 11 to 34. Particular examples of suitable ether compounds include 2-hexyldecyl decyl ether, branched eicosyl butyl ether, 2-hexyldecyl nonyl ether, 2-octyldodecyl pentyl ether, 2-octyldodecyl hexyl ether, 1,4-bis(3,5,5-trimethylhexoxy) butane, 1,5-bis(3,5,5-trimethylhexoxy)pentane, 1,6-bis(3, 5,5-trimethylhexoxy)hexane, 1,8-bis(3,5,5-trimethylhexoxy)octane, 1,8-bis(2-ethylhexoxy)octane, 1,5-bis(nonyloxy)-3-methylpentane, 1,5-bisdecyloxy)-3-methylpentane, 1,3-bis(decyloxy)-2,2-dimethylpropane, 1,6-bis(3, 7-dimethyloctoxy)hexane, 1,4-bis(3, 7-dimethyloctoxy)butane, 1,5-bis(octoxy)-3 ,3-diethylpentane and 1, 5-bis(octoxy/nonyloxy)-3,3-diethylpentane, tri(2,3-propylene glycol) dinonyl ether, and tri(2,3-propylene glycol) didecyl ether. The lubricating oil composition may comprise various additives such as antioxidants, lubricity improver additives, electrically conductive additives, rust preventives, metal deactivators, defoaming agents and viscosity index improvers.

[0008] Negative interactions between a lubricant composition and oil seals that are found in engines may, in some cases, lead to loss of lubricant through failure of the oil seals.

[0009] Accordingly, there is a need for a lubricant composition having low volatility for a given viscosity profile, but which is also suitable for use in an internal combustion engine. There is also a need for a lubricant composition which exhibits good oxidative stability without requiring a high anti-oxidant treat rate, as is typically associated with a high performance engine oil.

Summary

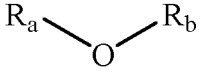
[0010] Accordingly, in a first aspect a lubricant composition for an internal combustion engine is provided comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (4):



(4)

where: R_1 and R_4 are alkyl;
R_3 and R_5 are H or alkyl;
the lubricant composition further comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant; and
wherein the total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 % by weight of the lubricant composition and wherein the base oil of the lubricant composition comprises greater than 10 % by weight of the ether base stock.

[0011] Disclosed herein but not encompassed within the present invention is a lubricant composition comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (A):



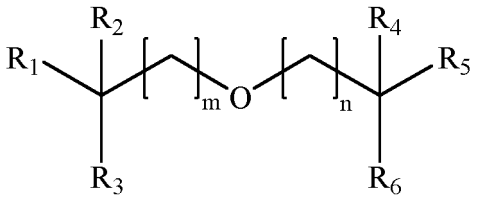
(A)

where: R_a and R_b are aliphatic hydrocarbyl groups and may be the same or different;

wherein at least one of R_a and R_b is branched-chain alkyl, alkoxy-substituted-alkyl or cycloalkyl-substituted-alkyl; the lubricant composition further comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant; and

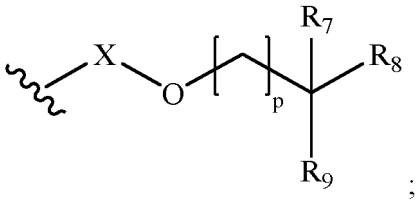
wherein the total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 % by weight of the lubricant composition.

[0012] Also disclosed herein but not encompassed within the present invention is an ether base stock of the lubricant composition selected from a subset of the compounds of formula (A), namely a compound of formula (1):



(1)

where: R_1 and R_2 are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_3, R_4 and R_5 are H or alkyl;
R_6 is alkyl or



;

where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent; and
p is 0, 1, 2 or 3; and
m and n are 0, 1, 2 or 3 provided that m is 0 when R_4 and R_5 are H.

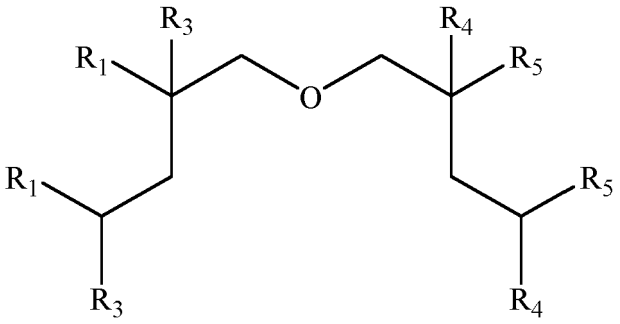
[0013] Also disclosed herein, but not encompassed within the present invention are methods of preparing lubricant compositions.

[0014] Also provided is the use of a lubricant composition for lubricating a surface.

[0015] Also provided are uses of improving the oxidative stability of a lubricant composition, as well as improving the fuel economy performance and/or piston cleanliness performance of an engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine.

Detailed description

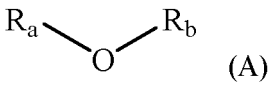
[0016] A lubricant composition for an internal combustion engine is provided comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (4):



(4)

where: R_1 and R_4 are alkyl;
R_3 and R_5 are H or alkyl;
the lubricant composition further comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant; and
wherein the total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 % by weight of the lubricant composition and wherein the base oil of the lubricant composition comprises greater than 10 % by weight of the ether base stock.

[0017] Also disclosed herein, but not encompassed within the present invention is a lubricant composition comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (A):



(A)

where: R_a and R_b are aliphatic hydrocarbyl groups and may be the same or different;
wherein at least one of R_a and R_b is branched-chain alkyl, alkoxy-substituted-alkyl or cycloalkyl-substituted-alkyl;
the lubricant composition further comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant; and
wherein the total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 % by weight of the lubricant composition.

[0018] For the purposes of the present invention, the following terms as used herein shall, unless otherwise indicated, be understood to have the following meanings:
The term "aliphatic hydrocarbyl" as used herein refers to a group comprising hydrogen and carbon atoms, where one or more carbon atoms may optionally be replaced with -O-, which group may be saturated or unsaturated, preferably saturated, and contains from 1 to 40 carbon atoms. Examples of hydrocarbyl groups include hydrocarbyl groups containing from 2 to 28 carbon atoms, such as from 3 to 26 carbon atoms or from 4 to 24 carbon atoms. Where one or more of the carbon atoms is replaced with -O-, from 2% to 35 % of the carbon atoms are preferably replaced with -O-, orfrom 5 % to 25%. In other examples, the aliphatic hydrocarbyl group has 1 to 3 carbon atoms replaced with -O-, for example 2 carbon atoms replaced with -O-. In other examples, none of the carbon atoms are replaced with -O-.
[0019] Examples of aliphatic hydrocarbyl groups include acyclic groups, non-aromatic cyclic groups and groups comprising both an acyclic portion and a non-aromatic cyclic portion. The aliphatic hydrocarbyl group may be straight chain or branched chain. The aliphatic hydrocarbyl group includes monovalent groups and polyvalent groups as specified. Examples of monovalent hydrocarbyl groups include alkyl, alkenyl, alkynyl and carbocyclyl (e.g. cycloalkyl or cycloalkenyl).
[0020] The term "alkyl" as used herein refers to a monovalent straight or branched chain alkyl moiety containing from 1 to 40 carbon atoms. Examples of alkyl groups include alkyl groups containing from 1 to 30 carbon atoms, e.g. from 2, 3 or 4 carbon atoms to 24, 25, or 26 carbon atoms, e.g. from 1 to 20 carbon atoms, from 1 to 14 carbon atoms, from 2 to 26 carbon atoms and from 3 to 24 carbon atoms. Particular examples include alkyl groups containing 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30 carbon atoms. Examples of alkyl groups include methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, tert- butyl, pentyl, hexyl and the like. Unless specifically indicated otherwise, the term "alkyl" does not include optional substituents.
[0021] The term "cycloalkyl" as used herein refers to a monovalent saturated aliphatic hydrocarbyl moiety containing from 3 to 40 carbon atoms and containing at least one ring, wherein said ring has at least 3 ring carbon atoms. The cycloalkyl groups mentioned herein may optionally have alkyl groups attached thereto. Examples of cycloalkyl groups include cycloalkyl groups containing from 3 to 16 carbon atoms, e.g. from 3 to 10 carbon atoms. Particular examples include cycloalkyl groups containing 3, 4, 5 or 6 ring carbon atoms. Examples of cycloalkyl groups include groups that are monocyclic, polycyclic (e.g. bicyclic) or bridged ring system. Examples of cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl and the like.
[0022] The term "alkenyl" as used herein refers to a monovalent straight or branched chain alkyl group containing from 2 to 40 carbon atoms and containing, in addition, at least one carbon-carbon double bond, of either E or Z configuration unless specified. Examples of alkenyl groups include alkenyl groups containing from 2 to 28 carbon atoms, e.g. from 3 to 26 carbon atoms, e.g. from 4 to 24 carbon atoms. Particular examples include alkenyl groups containing 2, 3, 4, 5 or 6 carbon atoms. Examples of alkenyl groups include ethenyl, 2-propenyl, 1-butenyl, 2-butenyl, 3-butenyl, 1-pentenyl, 2-pentenyl, 3-pentenyl, 1-hexenyl, 2-hexenyl, 3-hexenyl and the like.
[0023] The term "alkylene" refers to a divalent straight or branched chain saturated hydrocarbyl group consisting of hydrogen and carbon atoms and containing from 1 to 30 carbon atoms. Examples of alkylene groups include alkylene

groups that contain from 1 to 20 carbon atoms, e.g. from 1 to 12 carbon atoms, e.g. from 1 to 10 carbon atoms. Particular examples include alkylene groups that contain 1, 2, 3, 4, 5 or 6 carbon atoms.

[0024] The term "alkoxy" as used herein refers to -O-alkyl, wherein alkyl is as defined herein. In some examples an alkoxy group contains from 1 to 40 carbon atoms, e.g. from 1 to 28 carbon atoms, or from 1 to 26 carbon atoms, or from 1 to 24 carbon atoms e.g. from 1 to 10 carbon atoms. Particular examples include alkoxy groups that contain 1, 2, 3, 4, 5 or 6 carbon atoms. Examples of alkoxy groups include methoxy, ethoxy, propoxy, isopropoxy, butoxy, tert-butoxy, pentoxy, hexoxy and the like.

[0025] The terms "alkoxy-substituted-alkyl" and "cycloalkyl-substituted-alkyl" refer to a straight or branched chain alkyl group in which one of the hydrogens of the alkyl chain is replaced with an alkoxy or cycloalkyl group as described herein, respectively.

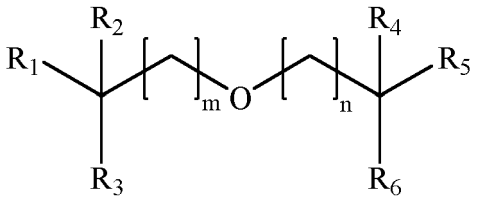
[0026] R_a and R_b, of formula (A) may be independently selected from alkyl, alkoxy-substituted-alkyl and cycloalkyl-substituted-alkyl, provided that where R_a and R_b are both alkyl at least one of R_a and R_b is branched-chain alkyl. Preferably, when R_a and R_b are both alkyl, both R_a and R_b are branched-chain alkyl.

[0027] In some examples disclosed herein but not encompassed within the scope of the present invention, R_a and R_b of formula (A) are independently selected from $C_{1\text{-}30}$ alkyl, such as $C_{2\text{-}20}$ alkyl, $C_{5\text{-}30}$ cycloalkyl-substituted-alkyl, such as $C_{5\text{-}25}$ cycloalkyl-substituted-alkyl, or $C_{2\text{-}30}$ alkoxy-substituted-alkyl, such as $C_{2\text{-}20}$ alkoxy-substituted-alkyl.

[0028] In some unclaimed examples, R_a of formula (A) contains more carbon atoms than R_b.

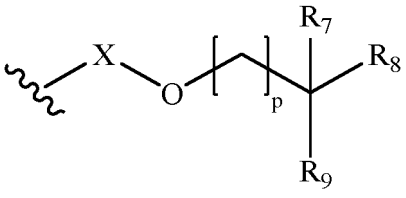
[0029] In some unclaimed examples, R_a of formula (A) contains from 12 to 30 carbon atoms, preferably from 12 to 26 carbon atoms, and/or R_b contains from 2 to 20 carbon atoms, preferably from 2 to 12 carbon atoms.

[0030] In some examples disclosed herein but not encompassed within the scope of the present invention, the ether base stock of the lubricant composition is a compound of formula (1):



(1)

where: R_1 and R_2 are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_3, R_4 and R_5 are H or alkyl;
R_6 is alkyl or



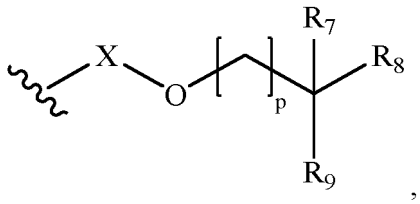
;

where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent; and
p is 0, 1, 2 or 3; and
m and n are 0, 1, 2 or 3 provided that m is 0 when R_4 and R_5 are H.

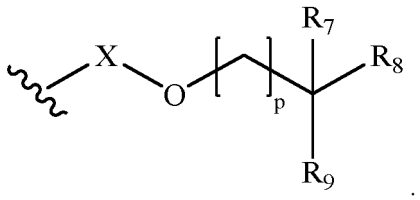
[0031] For example, R_1 and R_2 are $C_{1\text{-}15}$ alkyl or, together with the carbon atom to which they are attached, $C_{5\text{-}30}$ cycloalkyl, such as $C_{2\text{-}12}$ alkyl or, together with the carbon atom to which they are attached, $C_{5\text{-}25}$ cycloalkyl.

[0032] In some unclaimed examples, R_3, R_4 and R_5 are H or $C_{1\text{-}15}$ alkyl, such as H or $C_{2\text{-}12}$ alkyl. Preferably, R_5 is H.

[0033] In someunclaimed examples, R_6 is $C_{1\text{-}20}$ alkyl or



such as C_{1-16} alkyl or



[0034] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

[0035] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

[0036] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0037] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

[0038] In some unclaimed examples, m and n are 0, 1 or 2, such as 0 or 1.

[0039] R_1 and R_2 are as described as alkyl or, together with the carbon atom to which they are attached, cycloalkyl. It will be understood that, where R_1 and R_2 are both alkyl groups, they may be the same as or different from one another. Similar considerations apply to other substituents which are defined as part of a group of substituents. Thus, the considerations apply, for example, to R_3, R_4 and R_5; to R_7 and R_8; and to the values taken by m and n. For instance, where R_3, R_4 and R_5 are described as being H or alkyl, it will be understood that each of R_3, R_4 and R_5 may be H, each of R_3, R_4 and R_5 may be alkyl, or a subset of R_3, R_4 and R_5 may be H and another subset of R_3, R_4 and R_5 may be alkyl. Where R_3, R_4 and R_5, or a subset thereof, are alkyl, each of R_3, R_4 and R_5 may be the same alkyl group or they may be different alkyl groups. In contrast, where R_1 (or any other notation) is used at a number of locations in a formula, it is used to denote the presence of the same group at each of these locations.

[0040] In each of the embodiments disclosed herein, the ether compounds of the lubricant compositions may contain a total number of carbons atoms of from about 20 to about 50. For instance, the total number of carbons in the ether compounds may be from about 25 to about 45, such as from about 28 to about 40 or from about 28 to about 36.

[0041] As indicated previously, the alkyl and alkylene groups mentioned herein, *i.e.* those that may be represented by R_a, R_b, R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9 and X, may be straight chain alkyl or alkylene groups, though they may also be branched. Each alkyl group and each alkylene group contains a single branch point or is a straight chain alkyl or alkylene group. For example, when R_a and R_b are both alkyl groups, at least one of these alkyl groups is branched, preferably both. For instance with respect to R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9 and X groups, the alkyl and alkylene groups are straight chain alkyl or alkylene groups. It will be understood that, aside from alkyl branching (if present), the alkyl and alkylene groups are unsubstituted unless otherwise indicated and so may not contain any atoms other than carbon or hydrogen.

[0042] The unclaimed compounds of formula (A) and/or formula (1) may have a kinematic viscosity at 40 °C of less than about 25 cSt, such as less than about 20 cSt, or less than about 17 cSt. The compounds may have a kinematic viscosity at 100 °C of less than about 7 cSt, such as less than about 5 cSt, or less than about 4 cSt. The unclaimed compounds may have a viscosity index of greater than about 100, such as greater than about 110, or greater than about 120. The kinematic viscosity at 40 °C and the kinematic viscosity at 100 °C may be measured according to ASTM D7279. The viscosity index may be measured according to ASTM D2270.

[0043] The unclaimed compounds may have a Noack volatility of less than about 26%, such as less than about 20%, less than about 16 %, or less than about 12 % by weight. Noack volatility may be measured according to CEC-L-40-A-93.

[0044] The unclaimed compounds may have a viscosity at 150 °C and a shear rate of 10^6 s^{-1} of no greater than 1.7 cP, such as no greater than 1.5 cP. This high temperature high shear viscosity may be measured according to CEC-L-36-A-90.

[0045] The ether compounds described herein may be used for reducing the total amount of antioxidant additive required in a lubricant composition, the anti-oxidant comprising at least one aminic anti-oxidant and/or at least one

phenolic anti-oxidant, in order for the lubricant composition to achieve a particular level of oxidative stability performance, preferably where the lubricant composition is for an internal combustion engine, such as that associated with an automotive vehicle. In preferred embodiments, the lubricant compositions for improving through the use of the ether compounds described herein comprise aminic and/or phenolic anti-oxidant and have a total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 %, not more than 3.0 %, not more than 2.5 %, or not more than 2.0 %, by weight of the lubricant composition. In preferred embodiments, the lubricant compositions for improving through the use of the ether compounds described herein comprise aminic and/or phenolic anti-oxidant and have a total combined amount of aminic and phenolic antioxidant in the lubricant composition of at least 0.25 %, at least 0.5 %, or at least 1.0 %, by weight of the lubricant composition

[0046] Disclosed herein but not encompassed within the scope of the present invention is a method of reducing the total amount of anti-oxidant additive required in a lubricant composition, the antioxidant comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant, in order for the lubricant composition to achieve a particular level of oxidative stability performance, comprising the step of providing or supplying to the lubricant composition at least one of the ether compounds described herein. In preferred embodiments, the lubricant composition is for an internal combustion engine, such as that associated with an automotive vehicle. In preferred embodiments, the lubricant compositions for improving by means of the ether compounds described herein comprise aminic and/or phenolic anti-oxidant and have a total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 %, not more than 3.0 %, not more than 2.5 %, or not more than 2.0 %, by weight of the lubricant composition. In preferred embodiments, the lubricant compositions for improving by means of the ether compounds described herein comprise aminic and/or phenolic anti-oxidant and have a total combined amount of aminic and phenolic anti-oxidant in the lubricant composition of at least 0.25 %, at least 0.5 %, or at least 1.0 %, by weight of the lubricant composition.

[0047] The lubricant compositions described herein may be used to improve the fuel economy performance and/or piston cleanliness performance of an engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine. Accordingly, disclosed herein but not encompassed within the present invention is a method of improving the fuel economy performance and/or piston cleanliness performance of an engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine, comprising the step of providing the engine and/or the vehicle with a lubricant composition as described herein.

[0048] The ether compounds described herein may have a pour point of less than -10 °C, such as less than about -25 °C, or less than about -35 °C. Pour point may be measured according to ASTM D5950.

[0049] The ether compounds may have a cold-crankcase simulator viscosity at -35 °C of less than about 1800 cP, such as less than about 1500 cP, or less than about 1200 cP, for example as measured according to ASTM D5293.

[0050] The ether compounds may have a DSC oxidation onset temperature of greater than about 165 °C, such as greater than about 175 °C, or greater than about 185 °C, for example as measured according to ASTM E2009 (method B).

[0051] In particular, the unclaimed ether compounds of formula (A) or formula (1) may have a kinematic viscosity at 100 °C of about 3 to about 4 cSt and a Noack volatility of less than about 20%, such as less than about 16 %, or less than about 12 %, by weight; or a kinematic viscosity at 100 °C of about 2 to about 3 cSt, and a Noack volatility of less than about 40 %, such as less than about 30 %, by weight.

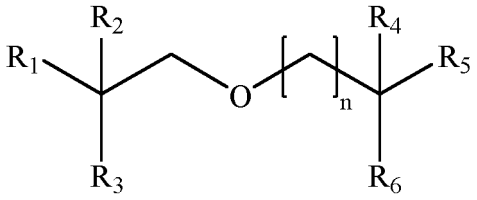
[0052] The unclaimed ether compounds of formula (A) or formula (1) are particularly suited for blending into a lubricant composition. In particular, the compounds are miscible with conventional base stocks, including hydrocarbon base stocks, as well as with conventional lubricant additives. Moreover, the compounds may be used in a lubricant composition in a relatively high amount (for example, in an amount of greater than about 10 % by weight, such as greater than about 20 % by weight or greater than about 30 % by weight) whilst meeting elastomer compatibility requirements for lubricant compositions.

[0053] The unclaimed compounds of formula (A) and formula (1) may be prepared from a wide range of commercially available feedstocks.

[0054] In some embodiments, the compounds are prepared from bio-derived feedstocks. For instance, the compounds may contain greater than about 50 %, such as greater than about 70 %, or greater than about 80 % by weight of biobased carbon. The biobased carbon content of the compounds may be measured according to ASTM D6866.

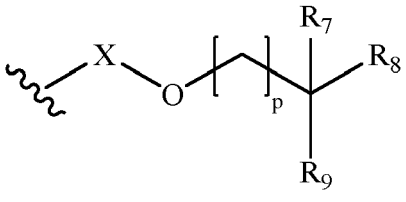
Guerbet-derived base stocks

[0055] As disclosed herein, but not encompassed within the scope of the present invention, the compounds of formula (1) may be derived from β-alkylated alcohols. In these examples, the compound may have the formula (2):



(2)

where: R_1 and R_2 are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_3 and R_5 are H or alkyl;
R_4 is alkyl;
R_6 is alkyl or



;

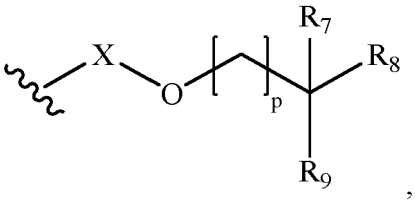
where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent; and
p is 0, 1, 2 or 3; and
n is 0, 1, 2 or 3.

[0056] In some unclaimed examples, R_1 and R_2 are C_{1-15} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_1 and R_2 are C_{1-15} alkyl, such as C_{2-12} alkyl.

[0057] In some unclaimed examples, R_3 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_3 and R_5 are H.

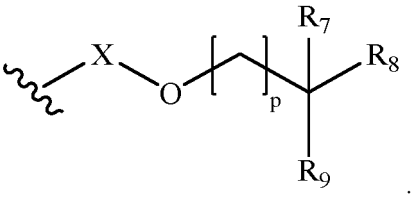
[0058] In some unclaimed examples, R_4 is C_{1-15} alkyl, such as C_{2-12} alkyl.

[0059] In some unclaimed examples, R_6 is C_{1-15} alkyl or



,

such as C_{1-12} alkyl or



.

[0060] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

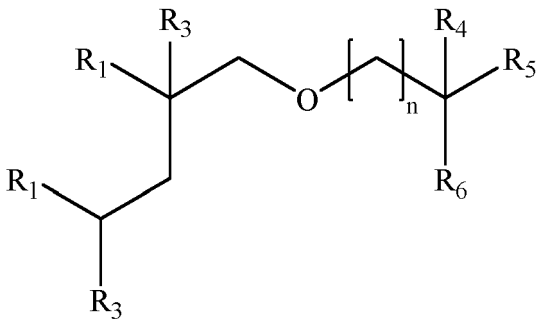
[0061] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

[0062] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0063] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

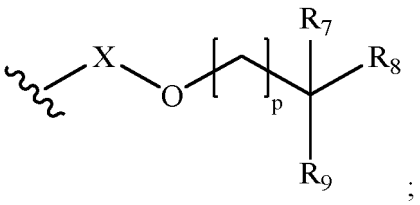
[0064] In some unclaimed examples, n is 0, 1 or 2, such as 0 or 1.

[0065] Where the compound is derived from a β-alkylated alcohol, it is preferably derived, at least in part, from a Guerbet alcohol. Compounds which are derived, at least in part, from Guerbet alcohols may have the formula (3):



(3)

where: R_1 is alkyl;
R_3 and R_5 are H or alkyl;
R_4 is alkyl;
R_6 is alkyl or



;

where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent; and
p is 0, 1, 2 or 3; and
n is 0, 1, 2 or 3.

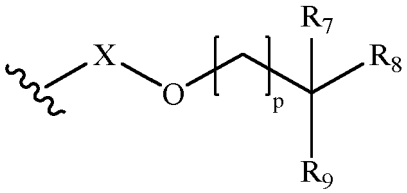
[0066] In some unclaimed examples, R_1 is C_{1-12} alkyl, such as C_{2-10} alkyl.

[0067] In some unclaimed examples, R_3 is H or C_{1-12} alkyl, such as H or C_{2-10} alkyl. Preferably, R_3 is H.

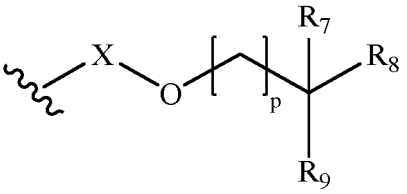
[0068] In some unclaimed examples, R_4 is C_{1-15} alkyl, such as C_{2-12} alkyl.

[0069] In some unclaimed examples, R_5 is H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_5 is H.

[0070] In some unclaimed examples, R_6 is C_{1-15} alkyl or



, such as C_{1-12} alkyl or



Preferably, R_6 is C_{1-15} alkyl, such as C_{1-12} alkyl.

[0071] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

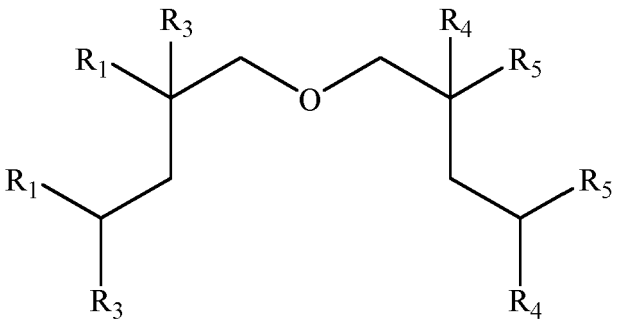
[0072] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

[0073] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0074] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

[0075] In some unclaimed examples, n is 0, 1 or 2, such as 0 or 1.

[0076] One portion of the compound of formula (3) has a structure which may be derived from a Guerbet alcohol (*i.e.* the portion containing R_1 and R_3), whereas the other portion need not be derived from a Guerbet alcohol (*i.e.* the portion containing R_4, R_5 and R_6). However, in preferred embodiments, the compound may be derived from a combination of two Guerbet alcohols. In accordance with the present invnetion, the ether base stock has the formula (4):



(4)

where: R_1 and R_4 are alkyl;
R_3 and R_5 are H or alkyl.

[0077] In some embodiments, R_1 and R_4 are C_{1-12} alkyl, such as C_{2-10} alkyl.

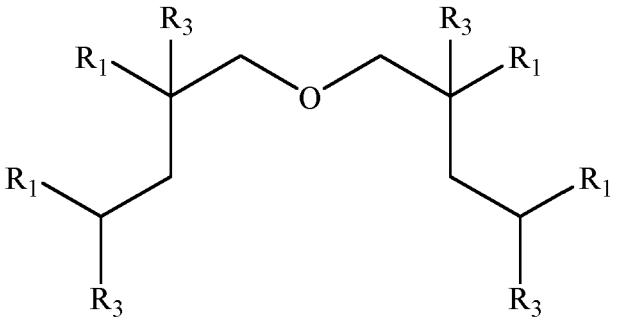
[0078] In some embodiments, R_3 and R_5 are H or C_{1-12} alkyl, such as H or C_{2-10} alkyl. Preferably, R_3 and R_5 are H.

[0079] In particular embodiments: R_1 is C_{4-12} alkyl, such as C_{6-10} alkyl;

R_3 is H;
R_4 is C_{1-10} alkyl, such as C_{2-8} alkyl; and
R_5 is H.

[0080] Two different Guerbet alcohols may be combined to form compounds of formula (4), in which case R_1 and R_4 may be different. Alternatively, R_3 and R_5 may be different. In some embodiments, R_1 and R_4 are different and R_3 and R_5 are also different.

[0081] However, in some embodiments, the compound may be derived from a reaction in which the same Guerbet alcohols are combined. A compound prepared in this way may have the formula (5):



(5)

where: R_1 is alkyl; and
R_3 is H or alkyl.

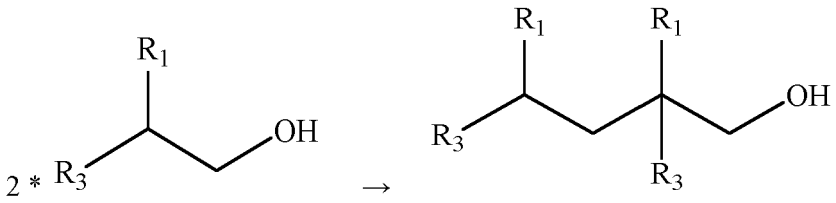
[0082] In some embodiments, R_1 is C_{1-10} alkyl, such as C_{2-9} alkyl.

[0083] In some embodiments, R_3 is H or C_{1-9} alkyl, such as H or C_{2-8} alkyl. Preferably, R_3 is H.

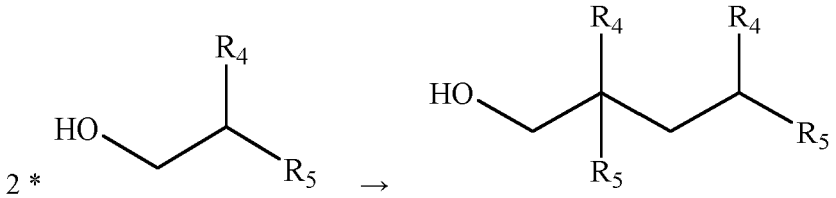
[0084] In particular embodiments: R_1 is C_{3-10} alkyl, such as C_{4-8} alkyl; and
R_3 is H.

[0085] Compounds that are derived from Guerbet alcohols include compounds GE1-GE3, GE5, GE7-GE9, SE1, SE2 and TE1 as shown in Table 2. Base stocks GE1, GE3, GE7, GE18, GE22 and GE23 shown in Table 2 fall within formula (4) as defined above.

[0086] Guerbet alcohols may be prepared, for example, by dimerising primary alcohols to form a β-alkylated alcohol product in a Guerbet reaction:



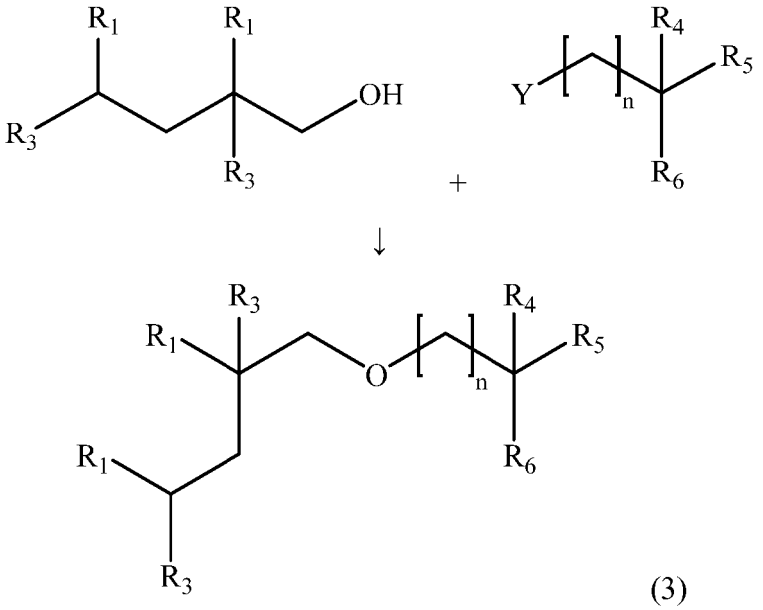
where R_1 and R_3 are as defined previously;
and/or:



where R_4 and R_5 are as defined previously.

[0087] Guerbet reactions are well-known to the skilled person. The reactions are typically carried out at elevated temperatures in the presence of a catalyst.

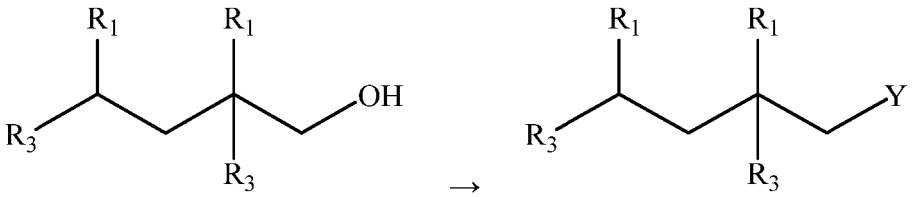
[0088] The compound may be prepared from the Guerbet alcohol, for example, according to the following reaction:



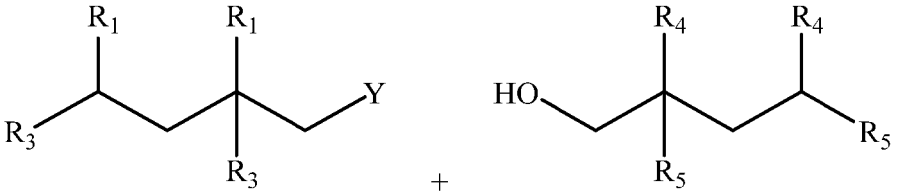
(3)

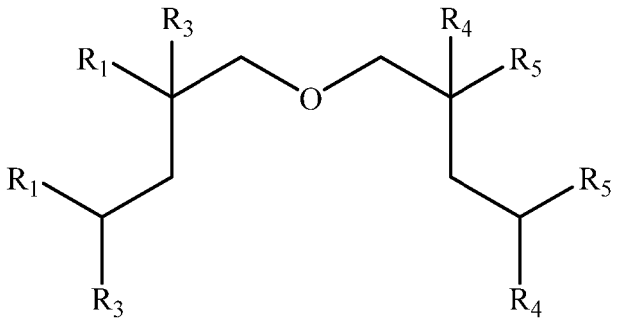
where: Y is a leaving group; and
R_1, R_3, R_4, R_5, R_6 and n are as defined previously for the compound of formula (3).

[0089] Where two Guerbet alcohols are combined to form a compound, one of the Guerbet alcohols may first be modified so that it contains a leaving group, Y, and the compound then prepared:



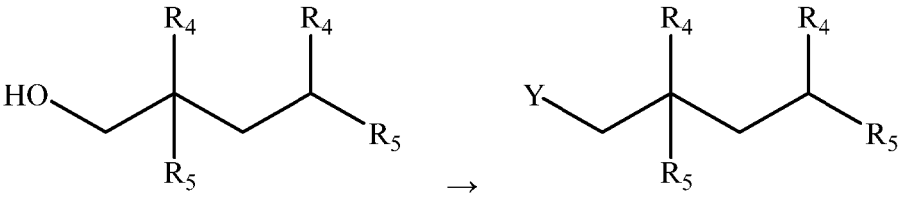
then:



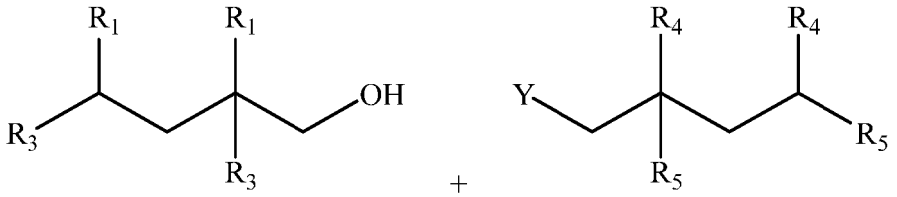


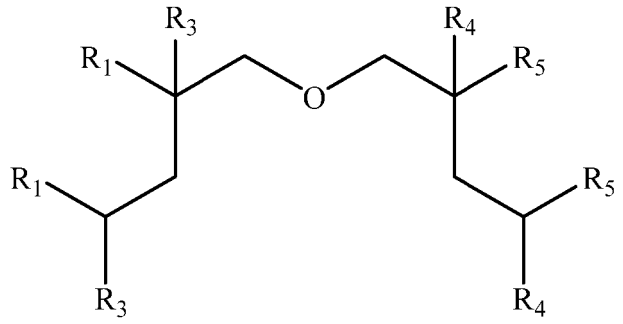
(4);

or:



then:

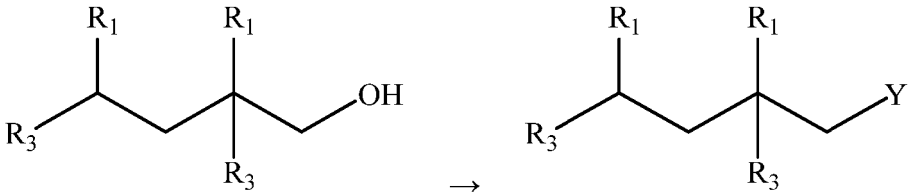




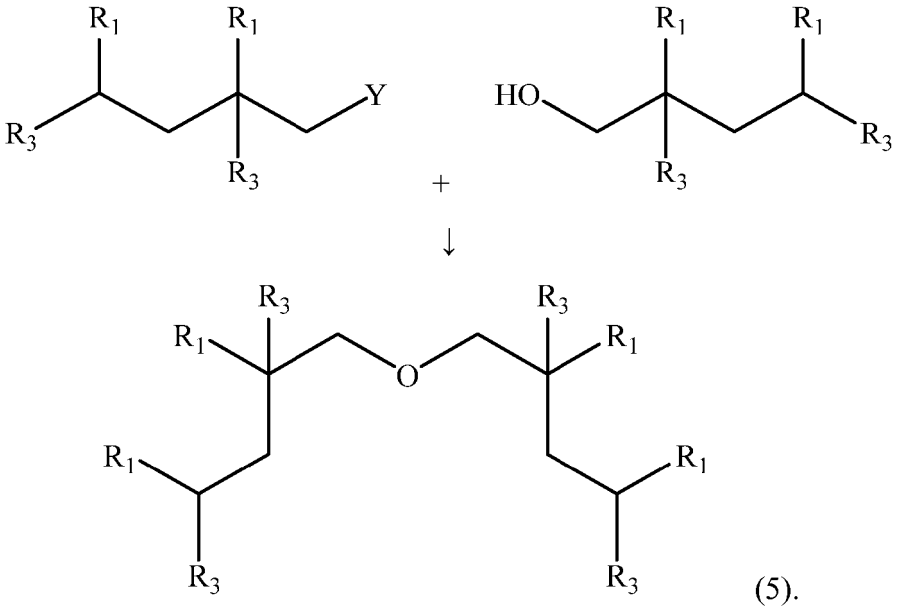
(4).

where: Y is a leaving group; and
R_1, R_3, R_4 and R_5 are as defined previously for the compound of formula (4).

[0090] Where the same Guerbet alcohols are combined to form a compound, they may be combined, for example, according to the following reactions:



then:



(5).

where: Y is a leaving group; and
R_1 and R_3 are as defined previously for the compound of formula (5).

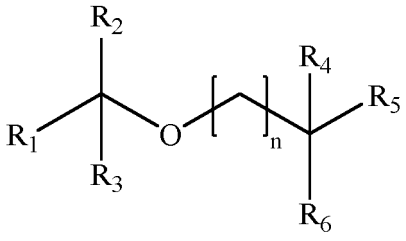
[0091] Methods and reaction conditions for modifying a Guerbet alcohol so that it contains a leaving group, Y, are known to the skilled person. For instance, a mesylate group may be introduced by reacting the Guerbet alcohol with mesyl chloride in the presence of triethylamine. A bromide group may be introduced by reacting the Guerbet alcohol with N-bromosuccinimide and triphenyl phosphine.

[0092] Methods and reaction conditions for carrying out etherification reactions are known to the skilled person. A base (for example potassium hydroxide or potassium tert-butoxide), a catalyst (for example Starks' catalyst: *N*-Methyl-*N,N,N*-trioctyloctan-1-ammonium chloride) or both may be used in the abovementioned compound forming reactions, *i.e.* the etherification reactions.

[0093] In the abovementioned compound forming reactions, Y may be any suitable leaving group, such as a halogen (for example bromine, chlorine or iodine) or a sulfonate ester (for example mesylate ortosylate).

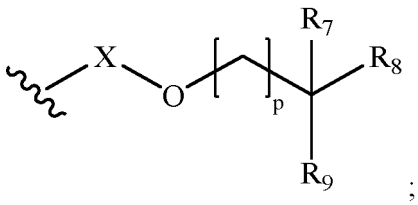
Secondary and tertiary ether base stocks

[0094] In examples disclosed herein, but not encompassed within the scope of the present invention, the compounds of formula (1) are secondary or tertiary ether compounds. In these examples, the compound may have the formula (6):



(6)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;
R_3, R_4 and R_5 are H or alkyl;
R_6 is alkyl or



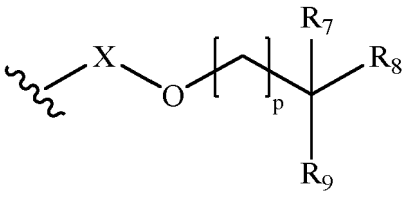
;

where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent; and
p is 0, 1, 2 or 3; and
n is 0, 1, 2 or 3.

[0095] For example, R_1 and R_2 may be $C_{1\text{-}15}$ alkyl or, together with the carbon atom to which they are attached, $C_{5\text{-}30}$ cycloalkyl, such as $C_{2\text{-}12}$ alkyl or, together with the carbon atom to which they are attached, $C_{5\text{-}25}$ cycloalkyl. Preferably, R_1 and R_2 are $C_{1\text{-}15}$ alkyl, such as $C_{2\text{-}12}$ alkyl.

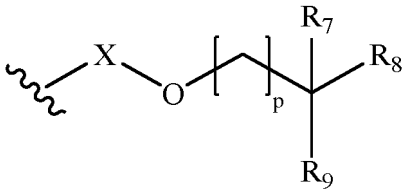
[0096] In some unclaimed examples, R_3, R_4 and R_5 are H or $C_{1\text{-}15}$ alkyl, such as H or $C_{2\text{-}12}$ alkyl. Preferably, R_5 is H.

[0097] In some unclaimed examples, R_6 is $C_{1\text{-}20}$ alkyl or



,

such as $C_{1\text{-}16}$ alkyl or



.

[0098] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

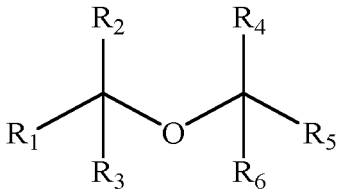
[0099] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

[0100] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0101] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

[0102] In some unclaimed examples, n is 0, 1 or 2, such as 0 or 1.

[0103] Secondary and tertiary ether compounds may have the formula (7):



(7)

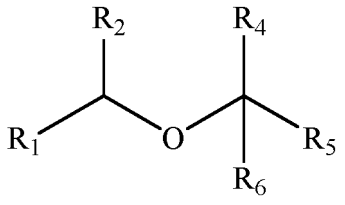
where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;
R_3, R_4 and R_5 are H or alkyl; and
R_6 is alkyl.

[0104] In some unclaimed examples, R_1 and R_2 are C_{1-15} alkyl or, together with the carbon to which they are attached, C_{5-30} cycloalkyl, such as C_{2-12} alkyl or, together with the carbon to which they are attached, C_{5-25} cycloalkyl.

[0105] In some unclaimed examples, R_3, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_5 is H.

[0106] In some unclaimed examples, R_6 is C_{1-20} alkyl, such as C_{1-16} alkyl.

[0107] The compounds may be secondary ether compounds of formula (8):



(8)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;
R_4 and R_5 are H or alkyl; and
R_6 is alkyl.

[0108] In some unclaimed examples, R_1 and R_2 are C_{1-15} alkyl, such as C_{2-12} alkyl.

[0109] In other unclaimed examples, the secondary ether may be obtained from a cyclic compound. In this case, R_1 and R_2, together with the carbon to which they are attached, form a cycloalkyl group, such as a C_{5-30} cycloalkyl or a C_{5-25} cycloalkyl. The cycloalkyl group may contain a cyclopentyl, cyclohexyl or cycloheptyl group optionally having one or more alkyl groups, such as C_{1-12} alkyl or C_{1-8} alkyl, attached thereto.

[0110] In some unclaimed examples, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_5 is H.

[0111] In some unclaimed examples, R_6 is C_{1-20} alkyl, such as C_{1-16} alkyl.

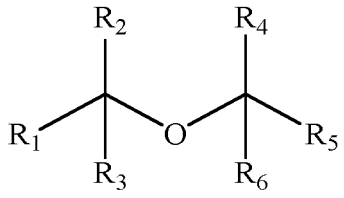
[0112] In particular examples:

R_1 and R_2 are C_{3-12} alkyl, such as C_{5-10} alkyl;
R_4 and R_5 are H; and
R_6 is C_{4-20} alkyl, such as C_{6-15} alkyl.

[0113] In other particular examples:

R_1 and R_2 are C_{3-12} alkyl, such as C_{5-10} alkyl;
R_4 is C_{3-12} alkyl, such as C_{5-10} alkyl;
R_5 is H; and
R_6 is C_{3-12} alkyl, such as C_{5-10} alkyl.

[0114] The compounds may be tertiary ether compounds of formula (9):



(9)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;
R_3 is alkyl;
R_4 and R_5 are H or alkyl; and
R_6 is alkyl.

[0115] In some unclaimed examples, R_1 and R_2 are C_{1-15} alkyl or, together with the carbon to which they are attached, C_{5-30} cycloalkyl, such as C_{2-12} alkyl or, together with the carbon to which they are attached, C_{5-25} cycloalkyl. Preferably, R_1 and R_2 are C_{1-15} alkyl, such as C_{2-12} alkyl.

[0116] In some unclaimed examples, R_3 is C_{1-12} alkyl, such as C_{1-10} alkyl.

[0117] In some unclaimed examples, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl.

[0118] In some unclaimed examples, R_6 is C_{1-20} alkyl, such as C_{1-16} alkyl.

[0119] In particular examples:

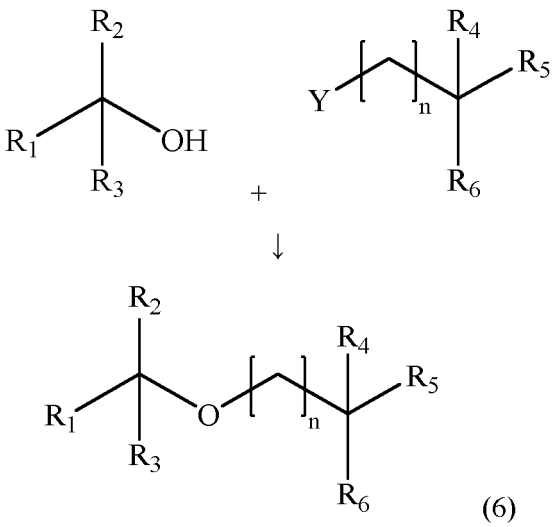
R_1 and R_2 are C_{2-12} alkyl, such as C_{4-10} alkyl;
R_3 is C_{1-10} alkyl, such as C_{1-8} alkyl;
R_4 and R_5 are H; and
R_6 is C_{4-20} alkyl, such as C_{6-15} alkyl.

[0120] In other particular examples:

R_1, R_2 and R_3 are C_{2-12} alkyl, such as C_{4-10} alkyl;
R_3 is C_{1-10} alkyl, such as C_{1-8} alkyl;
R_4 is C_{3-12} alkyl, such as C_{5-10} alkyl;
R_5 is H; and
R_6 is C_{3-12} alkyl, such as C_{5-10} alkyl.

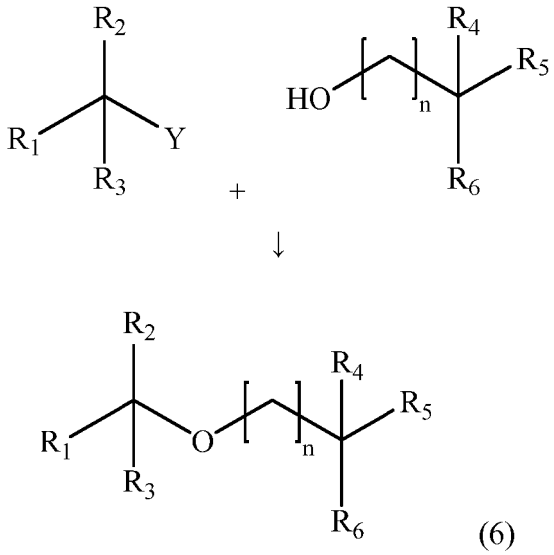
[0121] Examples of secondary and tertiary ether compounds include SE1, SE2 and TE1 as shown in Table 2.

[0122] The secondary and tertiary ether compounds may be prepared according to the following reactions:



(6)

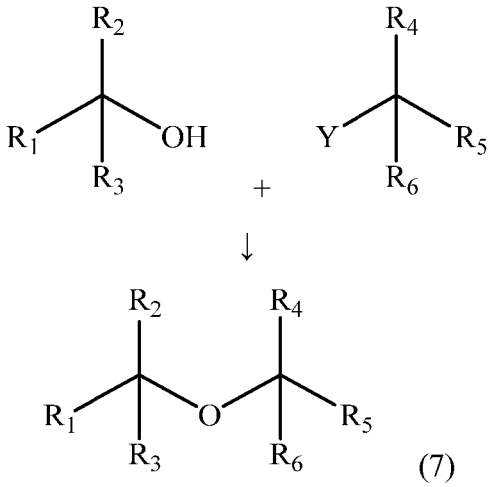
or:



(6)

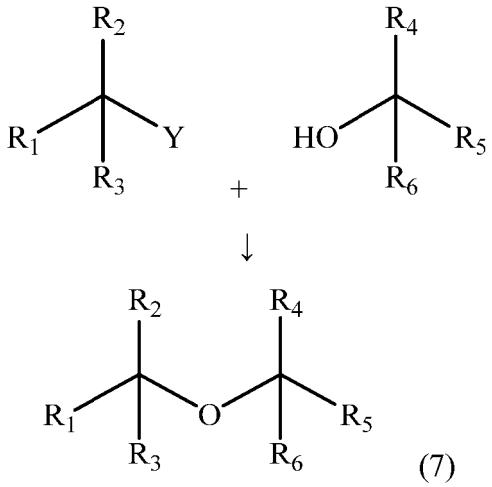
where: Y is a leaving group; and
R_1, R_2, R_3, R_4, R_5, R_6 and n are as defined previously for the compound of formula (6).

[0123] Similarly:



(7)

or:



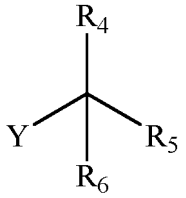
(7)

where: Y is a leaving group; and
R_1, R_2, R_3, R_4, Rs and R_6 are as defined previously for the compound of formula (7).

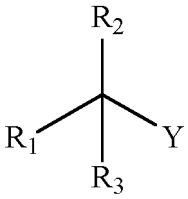
[0124] The skilled person will be aware of methods and reaction conditions for carrying out these etherification reactions. For instance, the reaction may be carried out in the presence of magnesium sulfate, sulfuric acid and dichloromethane.

[0125] Secondary and tertiary alcohol starting materials for use in etherification reactions will generally be commercially available, or they may be obtained from commercially available ketones.

[0126] The groups



and

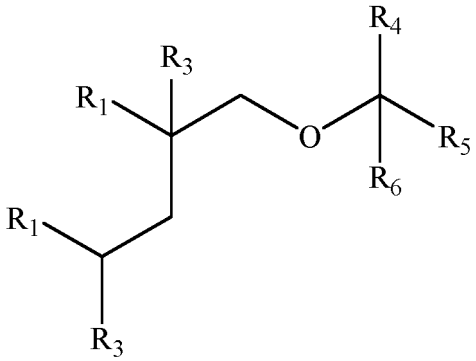


may be prepared by introducing a leaving group, Y, into the alcohol starting materials. Methods and reaction conditions for introducing the leaving group into alcohol are known to the skilled person.

[0127] In the abovementioned secondary and tertiary ether compound forming reactions, Y may be any suitable leaving group, such as a halogen (for example bromine, chlorine or iodine) or a sulfonate ester (for example mesylate or tosylate).

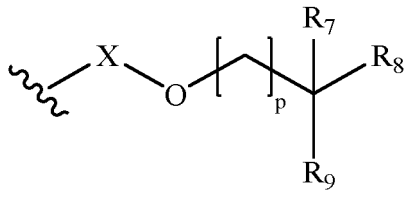
Secondary or tertiary ethers derived from a Guerbet alcohol

[0128] In some examples disclosed herein, but not encompassed within the present invention, the compound may comprise an ether which is derived on one side from a secondary or tertiary alcohol and is derived on the other side from a Guerbet alcohol. In these embodiments, the compound may have the formula (10):



(10)

where: R_1 and R_4 are alkyl;
R_3 and R_5 are H or alkyl;
R_6 is alkyl or



;

where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent; and
and p is 0, 1, 2 or 3.

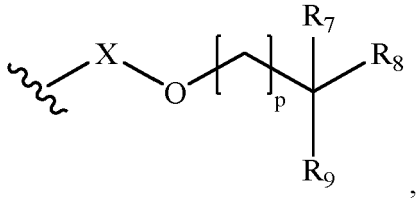
[0129] For example, R_1 may be C_{1-12} alkyl, such as C_{2-10} alkyl.

[0130] In some unclaimed examples, R_3 is H or C_{1-12} alkyl, such as H or C_{2-10} alkyl. Preferably, R_3 is H.

[0131] In some unclaimed examples, R_4 is C_{1-15} alkyl, such as C_{2-12} alkyl.

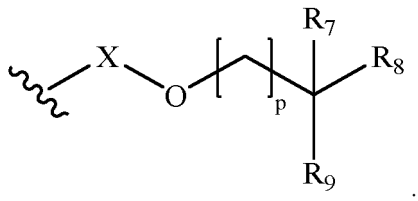
[0132] In some unclaimed examples, R_5 is H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_5 is H.

[0133] In some unclaimed examples, R_6 is C_{1-15} alkyl or



,

such as C_{1-12} alkyl or



.

[0134] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

[0135] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

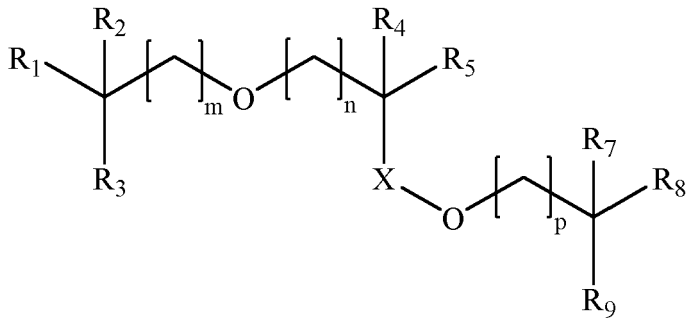
[0136] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0137] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

[0138] Examples of secondary and tertiary ether compounds derived from a Guerbet-alcohol include compounds SE1, SE2 and TE1 as shown in Table 2.

Di-ether base stocks

[0139] It is generally preferred that the compounds of formula (1) are monoethers. However, in some examples which are disclosed herein but do not fall within the present invention, the compound is a diether compound. Such compounds may have the formula (11):



(11)

where: R_1 and R_2 are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_3, R_4 and R_5 are H or alkyl;
R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent;
p is 0, 1, 2 or 3; and
m and n are 0, 1, 2 or 3.

[0140] In some unclaimed examples, R_1 and R_2 are C_{1-15} alkyl or, together with the carbon to which they are attached, C_{5-30} cycloalkyl, such as C_{2-12} alkyl or, together with the carbon to which they are attached, C_{5-25} cycloalkyl. Preferably, R_1 and R_2 are C_{1-15} alkyl, such as C_{2-12} alkyl.

[0141] In some unclaimed examples, R_3, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_3 and R_5 are H.

[0142] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

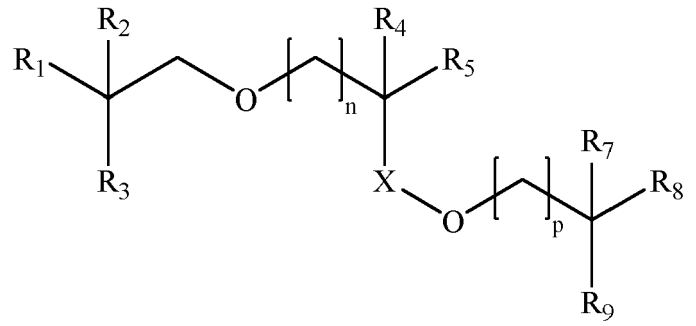
[0143] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

[0144] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0145] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

[0146] In some unclaimed examples, m and n are 0, 1 or 2, such as 0 or 1.

[0147] In some unclaimed examples, the diether compound may contain two ether groups, at least one of which is derived from a β-alkylated alcohol. In such examples, the compound may have the formula (12):



(12)

where: R_1 and R_2 are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_3, R_4 and R_5 are H or alkyl;
R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;
R_9 is H or alkyl;
X is alkylene or is absent;
p is 0, 1, 2 or 3; and
n is 0, 1, 2 or 3.

[0148] In some unclaimed examples, R_1 and R_2 are C_{1-15} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_1 and R_2 are C_{1-15} alkyl, such as C_{2-12} alkyl.

[0149] In some unclaimed examples, R_3, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_3 and R_5 are H. Preferably, R_4 is C_{1-15} alkyl, such as C_{2-12} alkyl

[0150] In some unclaimed examples, R_7 and R_8 are H, C_{1-20} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as H, C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_7 and R_8 are C_{1-20} alkyl, such as C_{2-12} alkyl.

[0151] In some unclaimed examples, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

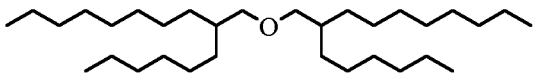
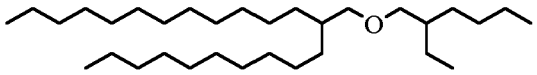
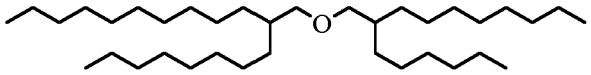
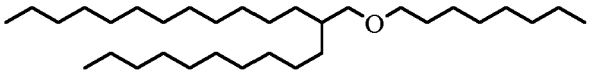
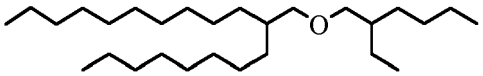
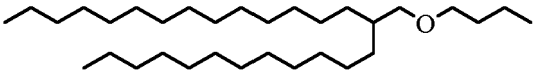
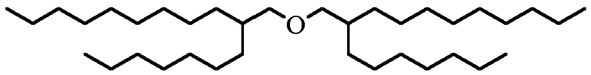
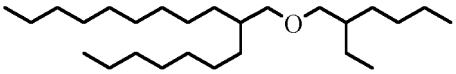
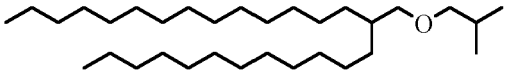
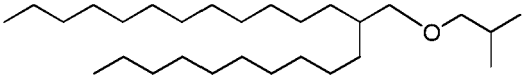
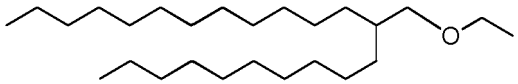
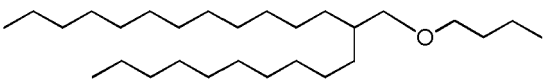
[0152] In some unclaimed examples, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

[0153] In some unclaimed examples, p is 0, 1 or 2, such as 0 or 1.

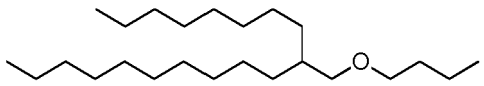
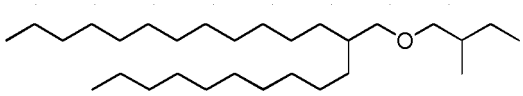
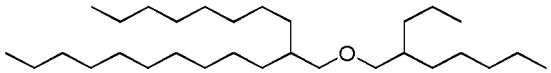
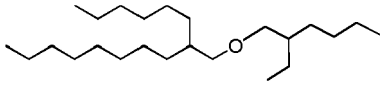
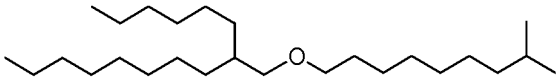
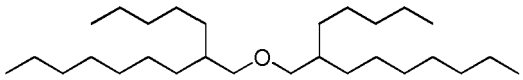
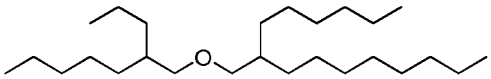
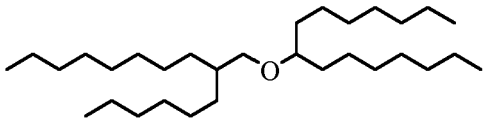
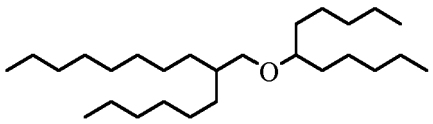
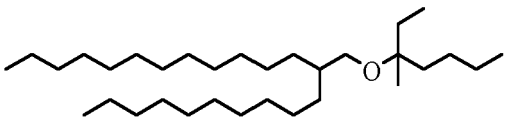
[0154] In some unclaimed examples, n is 0, 1 or 2, such as 0 or 1.

[0155] Examples of Guerbet-derived base stocks GE1- GE9, secondary ether base stocks SE1 and SE2, and tertiary ether base stock TE1 of formula (1), are shown in Table 2. Base stocks GE1, GE3, GE7, GE18, GE22 and GE23 shown in Table 2 fall within formula (4) as defined above.

Table 2

	Molecular Weight	Chemical Formula	Structure
GE1	466.87	$C_{32}H_{66}O$	
GE2	466.87	$C_{32}H_{66}O$	
GE3	522.97	$C_{36}H_{74}O$	
GE4	466.87	$C_{32}H_{66}O$	
GE5	410.76	$C_{28}H_{58}O$	
GE6	466.87	$C_{32}H_{66}O$	
GE7	522.57	$C_{36}H_{74}O$	
GE8	382.42	$C_{26}H_{54}O$	
GE9	466.51	$C_{32}H_{66}O$	
GE10	410.76	$C_{28}H_{58}O$	
GE12	382.71	$C_{26}H_{54}O$	
GE14	410.76	$C_{28}H_{58}O$	

(continued)

	Molecular Weight	Chemical Formula	Structure
GE15	354.65	$C_{24}H_{50}O$	
GE16	424.79	$C_{29}H_{60}O$	
GE18	438.81	$C_{30}H_{62}O$	
GE20	354.65	$C_{24}H_{50}O$	
GE21	382.71	$C_{26}H_{54}O$	
GE22	410.76	$C_{28}H_{58}O$	
GE23	382.71	$C_{26}H_{54}O$	
SE1	452.84	$C_{31}H_{64}O$	
SE2	396.43	$C_{27}H_{56}O$	
TE1	466.87	$C_{32}H_{66}O$	

Base oils and lubricant compositions

[0156] As disclosed herein, but not encompassed within the claimed invention the ether compounds of formula (A), or the subset thereof of formula (1), may be used as part of a base oil.

[0157] The base oils may contain an amount of compound of formula (A), or a compound of the subset thereof of formula (1), which is sufficient to impart beneficial properties of the compound onto the base oil.

[0158] In some unclaimed examples, the base oil comprises greater than about 5 %, such as greater than about 25 %, or greater than about 40 % by weight of ether compound of formula (A), or the subset thereof of formula (1). The base oil may comprise up to about 100 %, such as up to about 90 % of compound of formula (A), or of the subset thereof of formula (1). The compound of formula (A), or of the subset thereof of formula (1), in the base oil may be composed of a single compound or a combination of compounds of formula (A), or of the subset thereof of formula (1).

[0159] The remainder of the base oil may be made up with base stocks which are not compounds of formula (A) and formula (1). Base stocks other than those of formula (A) and formula (1) which are suitable for use in the base oil include non-aqueous base stocks, such as Group I, Group II, Group III, Group IV and Group V base stocks. The remainder of the base oil may comprise a single base stock or a combination of base stocks other than those of formula (A) and

formula (1).

[0160] The base oils are used as part of the lubricant composition in accordance with the present invention.

[0161] The lubricant compositions may contain an amount of base oil which is sufficient to impart beneficial properties of the compound of formula (A), or a compound of the subset thereof of formula (1), onto the lubricating composition.

[0162] In some embodiments, the lubricant composition comprises greater than about 50 %, such as greater than about 65 %, or greater than about 80 % by weight of base oil. In some examples disclosed herein but not encompassed within the present invention, the base oil may be composed of a single base oil or a combination of base oils comprising compound of formula (A), or of the subset thereof of formula (1).

[0163] The lubricant composition comprises at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant, wherein the total combined amount of aminic and phenolic antioxidant is no more than 4 %, by weight of the lubricant composition. In preferred embodiments, the lubricant compositions have a total combined amount of aminic and phenolic anti-oxidant in the lubricant composition of not more than 3.0 %, not more than 2.5 %, or not more than 2.0 %, by weight of the lubricant composition. In preferred embodiments, the lubricant compositions have a total combined amount of aminic and phenolic anti-oxidant in the lubricant composition of at least 0.25 %, at least 0.5 %, or at least 1.0 %, by weight of the lubricant composition.

[0164] Any total combined amount of aminic and phenolic anti-oxidant may be present in the lubricant composition of the invention provided it does not exceed 4 %, by weight of the lubricant composition. Thus, any sub-range of anti-oxidant concentration which lies within the above range may be used in accordance with the invention. For example, all sub-ranges formed from the combination of a lower weight percentage limit of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5 together with an upper weight percentage limit of 4.0, 3.9, 3.8, 3.7, 3.6, 3.5, 3.4, 3.3, 3.2, 3.1, 3.0, 2.9, 2.8, 2.7, 2.6, 2.5, 2.4, 2.3, 2.2, 2.1 or 2.0 may be utilized in accordance with the present invention.

[0165] A particular advantage of the unclaimed lubricant compositions relates to the oxidative stability conferred to the lubricant composition by the presence of ether compounds of formula (A), or of the subset thereof of formula (1). This allows desirable oxidative stability properties to be attained in the composition without the need for the same total concentration of aminic and/or phenolic antioxidants as would usually be required in a comparable lubricant composition which is formulated without any ether compounds of formula (A) or formula (1). A total combined aminic and/or phenolic antioxidant level representative of a high performance engine oil may exceed 5 %, by weight of the lubricant composition. The present invention enables the use of much lower concentrations of total combined aminic and/or phenolic antioxidants to achieve the same or better oxidative stability properties, both before and during use, for instance, in an internal combustion engine, compared to conventional lubricant compositions which comprise the same aminic and/or phenolic antioxidants but in higher concentration. This is of particular benefit from a cost perspective as well as from a lubricant composition lifetime, fuel economy and piston cleanliness perspective. A reduction in aminic anti-oxidant in a lubricant composition for an internal combustion engine has a particular benefit in reducing turbocharger deposits as well as a reduction in copper corrosion and an increase in elastomer compatibility. Meanwhile, a reduction in phenolic antioxidant leads to an improvement in environmental toxicity of the lubricant compositions.

[0166] It is common to add one or more anti-wear additives to a lubricant composition, examples of which include zinc dihydrocarbyl dithiophosphates (ZDDP). In addition, it has also been found that some of the beneficial effects of the invention are not impacted by the presence of ZDDP as, in contrast, is observed to be the case with non-ether based lubricant compositions. Surprisingly, some of the beneficial effects of the invention are even enhanced by the presence of ZDDP in the lubricant compositions. For instance, the presence of ZDDP has been observed to exacerbate oxidative thickening in CEC-L-109 tests relating to non-ether based compositions comprising aminic and/or phenolic antioxidants. In contrast, the presence of ZDDP, together with aminic and phenolic antioxidants in the ether-based compositions of the invention gives surprisingly high oxidative stability and resistance to oxidative thickening in the CEC-L-109 tests, which are indicative of a synergy between the ether base stock in the lubricant composition and the ZDDP and antioxidant components. Consequently, an additional benefit of the present invention is that greater amounts of ZDDP can be used with the ether compositions of the invention without significantly impacting upon the oxidative stability of the composition, such that the full anti-wear benefit of ZDDP can be realized.

[0167] Further still, it has also been found that some of the beneficial effects of the invention are not impacted by the presence of significant amounts of boron or magnesium in the lubricant compositions, for instance in the form of borated dispersants or magnesium detergents as, in contrast, is observed to be the case with non-ether based lubricant compositions. The presence of borated dispersant and/or other boron containing additives or magnesium gives rise to a substantial increase in percentage change in Kinematic Viscosity at 100 °C for non-ether based lubricant compositions in CEC-L-109 tests. In contrast, the presence of boron and/or magnesium in ether-based compositions according to the invention is well tolerated without significant increases in oxidative thickening. This is of particular benefit since an increase in boron in the lubricant compositions leads to increased elastomer compatibility and reduced corrosion of the lubricated surfaces, whilst magnesium reduces the occurrence of low-speed pre-ignition.

[0168] In some embodiments, the lubricant compositions of the invention may comprise both aminic anti-oxidant and phenolic anti-oxidant.

[0169] In some embodiments, the lubricant compositions of the invention may comprise aminic anti-oxidant or phenolic anti-oxidant and not both.

[0170] The aminic and/or phenolic antioxidants present in the compositions of the invention are not particularly limited, provided that they are suitable for use in a lubricant composition intended for use in an internal combustion engine, for instance an internal combustion engine of an automotive vehicle.

[0171] In some embodiments, the phenolic anti-oxidant is selected from alkylated monophenols, alkylated hydroquinones, hydroxylated thiodiphenyl ethers, alkylidenebisphenols, acylaminophenols, and sulphurised alkyl phenols and alkali and alkaline earth metal salts thereof. In preferred embodiments, the phenolic anti-oxidant is selected from 2-t-butyl-4-heptyl phenol, 2-t-butyl-4-octyl phenol, 2-t-butyl-4-dodecyl phenol, 2,6-di-t-butyl-4-methylphenol, 2,6-di-t-butyl-4-heptylphenol, 2,6-di-t-butyl-4-dodecylphenol, 2-methyl-6-t-butyl-4-heptylphenol, 2-methyl-6-t-butyl-4-dodecylphenol, 4,4'-methylenebis(2,6-di-t-butylphenol), 2'-bis(4-heptyl-6-t-butylphenol), 2,2'-bis(4-octyl-6-t-butylphenol), 2,2'-bis(4-dodecyl-6-t-butylphenol), 4,4'-bis(2,6-di-t-butylphenol) and 4,4'-methylene-bis(2,6-di-t-butylphenol) and derivatives thereof.

[0172] In some embodiments, the aminic anti-oxidant is selected from alkylated and non-alkylated aromatic amines, alkylated diphenylamines, N-alkylated phenylenediamines, phenyl-α-naphthylamine, and alkylated phenyl-α-naphthylamines. In preferred embodiments, the aminic anti-oxidant is selected from p,p-dioctylphenylamine, t-octylphenyl-α-naphthylamine, p-octylphenyl-α-naphthylamine, monooctyldiphenylamine, N,N-di(2-naphthyl)-p-phenylenediamine, phenyl-1-naphthylamine, phenyl-2-naphthylamine, an alkylphenyl-1-naphthylamine and an alkylphenyl-2-naphthylamine and derivatives thereof.

[0173] The lubricant composition may also comprise other antioxidants which are not aminic or phenolic in nature. For example, the lubricant compositions of the invention may additionally comprise antioxidants selected from hydroxylated thiodiphenyl ethers, thiopropionates, metallic dithiocarbamates, 1,3,4-dimercaptothiadiazole and derivatives, oil soluble copper compounds (for example, copper dihydrocarbyl thio- or thio-phosphate, copper salts of a synthetic or natural carboxylic acids, for example a C_8 to C_{18} fatty acid, an unsaturated acid or a branched carboxylic acid, for example basic, neutral or acidic Cu(I) and/or Cu(II) salts derived from alkenyl succinic acids or anhydrides), alkaline earth metal salts of alkylphenolthioesters, suitably containing C_5 to C_{12} alkyl side chains, barium t-octylphenyl sulphide, phosphosulphised or sulphurised hydrocarbons, oil soluble phenates, oil soluble sulphurised phenates, phosphosulphurised hydrocarbons, sulphurised hydrocarbons, phosphorus esters, low sulphur peroxide decomposers and the like.

[0174] As will be appreciated, it is preferred that non-aminic and non-phenolic antioxidants are used in minimal amounts where they are present. In some embodiments, the total amount of non-aminic and non-phenolic antioxidant in the lubricant compositions is not more than 1.0 %, not more than 0.75 %, or not more than 0.5 %, by weight of the lubricant composition. In some embodiments, the antioxidant present in the lubricant compositions consists, or consists essentially of, aminic and/or phenolic antioxidant.

[0175] The lubricant composition may also comprise other lubricant additives, in addition to antioxidants. The additional lubricant additives will typically be present in the lubricant composition in an amount of from about 2 % to about 40 % by weight, such as about 3 % to about 30 % by weight.

[0176] Suitable additional lubricant additives include detergents (including metallic and non-metallic detergents), friction modifiers, viscosity modifiers, dispersants (including metallic and non-metallic dispersants), dispersant viscosity modifiers, viscosity index improvers, pour point depressants, anti-wear additives, rust inhibitors, corrosion inhibitors, antioxidants (sometimes also called oxidation inhibitors), anti-foams (sometimes also called anti-foaming agents), seal swell agents (sometimes also called seal compatibility agents), extreme pressure additives (including metallic, non-metallic, phosphorus containing, non-phosphorus containing, sulphur containing and non-sulphur containing extreme pressure additives), surfactants, demulsifiers, anti-seizure agents, wax modifiers, lubricity agents, anti-staining agents, chromophoric agents, metal deactivators, and mixtures of two or more thereof.

[0177] In some embodiments, the lubricant composition comprises a detergent. Examples of detergents include ashless detergents (that is, non-metal containing detergents) and metal-containing detergents. Suitable non-metallic detergents are described for example in US 7,622,431. Metal-containing detergents comprise at least one metal salt of at least one organic acid, which is called soap or surfactant. Suitable organic acids include for example, sulphonic acids, phenols (suitably sulphurised and including for example, phenols with more than one hydroxyl group, phenols with fused aromatic rings, phenols which have been modified for example, alkylene bridged phenols, and Mannich base-condensed phenols and saligenin-type phenols, produced for example by reaction of phenol and an aldehyde under basic conditions) and sulphurised derivatives thereof, and carboxylic acids including for example, aromatic carboxylic acids (for example hydrocarbyl-substituted salicylic acids and derivatives thereof, for example hydrocarbyl substituted salicylic acids and sulphurised derivatives thereof).

[0178] Advantageously, magnesium detergents may also be used in the lubricant compositions of the present invention without negatively impacting oxidative stability. In some embodiments, the amount of magnesium contained in the lubricant composition is from 0.025 wt.% to 0.5 wt. %, preferably from 0.05 wt.% to 0.4 wt.%, more preferably from 0.08 wt.% to 0.35 wt.%, even more preferably from 0.1 wt.% to 0.25 wt.%. This level of elemental magnesium may be derived

from the use of magnesium detergents and/or other magnesium-containing additives or otherwise.

[0179] In some embodiments, the lubricant composition comprises a friction modifier. Suitable friction modifiers include for example, ash-producing additives and ashless additives. Examples of suitable friction modifiers include fatty acid derivatives including for example, fatty acid esters, amides, amines, and ethoxylated amines. Examples of suitable ester friction modifiers include esters of glycerol for example, mono-, di-, and trioleates, mono-palmitates and mono-myristates. A particularly suitable fatty acid ester friction modifier is glycerol monooleate. Examples of suitable friction modifiers also include molybdenum compounds for example, organo molybdenum compounds, molybdenum dialkyldithiocarbamates, molybdenum dialkylthiophosphates, molybdenum disulphide, tri-molybdenum cluster dialkyldithiocarbamates, non-sulphur molybdenum compounds and the like. Suitable molybdenum-containing compounds are described for example, in EP 1533362 A1 for example in paragraphs [0101] to [0117].

[0180] In some embodiments, the lubricant composition comprises a dispersant. Examples of suitable ashless dispersants include oil soluble salts, esters, amino-esters, amides, imides and oxazolines of long chain hydrocarbon-substituted mono- and polycarboxylic acids or anhydrides thereof; thiocarboxylate derivatives of long chain hydrocarbons; long chain aliphatic hydrocarbons containing polyamine moieties attached directly thereto; Mannich condensation products formed by condensing a long chain substituted phenol with formaldehyde and polyalkylene polyamine; Koch reaction products and the like. Particularly preferred dispersants for use in the present invention are long chain aliphatic hydrocarbons containing polyamine moieties attached directly thereto such as polyisobutylene succinyl anhydride-polyamines (PIBSA-PAM).

[0181] Advantageously, borated dispersants may also be used in the lubricant compositions of the present invention without negatively impacting oxidative stability. In some embodiments, the lubricant composition may contain boron in an amount from 0.005 wt.% to 0.05 wt.%, preferably from 0.0075 wt.% to 0.035 wt.%. This level of elemental boron may be derived from the use of a borated dispersants and/or boron-containing anti-wear additives or otherwise.

[0182] In some embodiments, the lubricant composition comprises a dispersant viscosity modifier. Examples of suitable dispersant viscosity modifiers and methods of making them are described in WO 99/21902, WO 2003/099890 and WO 2006/099250.

[0183] In some embodiments, the lubricant composition comprises a viscosity index improver. Examples of suitable viscosity modifiers include high molecular weight hydrocarbon polymers (for example polyisobutylene, copolymers of ethylene and propylene and higher alpha-olefins); polyesters (for example polymethacrylates); hydrogenated poly(styrene-co-butadiene or isoprene) polymers and modifications (for example star polymers); and esterified poly(styrene-co-maleic anhydride) polymers. Oil-soluble viscosity modifying polymers generally exhibit number average molecular weights of at least about 15,000 to about 1,000,000, such as about 20,000 to about 600,000 as determined by gel permeation chromatography or light scattering methods.

[0184] In some embodiments, the lubricant composition comprises a pour point depressant. Examples of suitable pour point depressants include Cg to C_{18} dialkyl fumarate/vinyl acetate copolymers, methacrylates, polyacrylates, polyarylamides, polymethacrylates, polyalkyl methacrylates, vinyl fumarates, styrene esters, condensation products of haloparaffin waxes and aromatic compounds, vinyl carboxylate polymers, terpolymers of dialkyfumarates, vinyl esters of fatty acids and allyl vinyl ethers, wax naphthalene and the like.

[0185] In some embodiments, the lubricant composition comprises at least one anti-wear additive. Examples of suitable anti-wear additives include non-phosphorus containing additives for example, sulphurised olefins. Examples of suitable anti-wear additives also include phosphorus-containing anti-wear additives. Examples of suitable ashless phosphorus-containing anti-wear additives include trilauryl phosphite and triphenylphosphorothionate and those disclosed in paragraph [0036] of US 2005/0198894. Examples of suitable ash-forming, phosphorus-containing anti-wear additives include dihydrocarbyl dithiophosphate metal salts. Examples of suitable metals of the dihydrocarbyl dithiophosphate metal salts include alkali and alkaline earth metals, aluminium, lead, tin, molybdenum, manganese, nickel, copper and zinc. Particularly suitable dihydrocarbyl dithiophosphate metal salts are zinc dihydrocarbyl dithiophosphates (ZDDP).

[0186] In some embodiments, the amount of phosphorus contained in the lubricant composition is less than 0.5 wt.%, preferably from 0.001 to 0.3 wt.%, more preferably from 0.025 to 0.2 wt.%, and even more preferably from 0.04 to 0.12 wt.%, based on the total weight of the lubricant composition.

[0187] Since ZDDP is particularly well tolerated in terms of oxidative stability of the lubricant compositions of the invention, and appears also to confer synergistic effects when used in combination with the ether base stock and antioxidants, the use of ZDDP in the compositions of the present invention is particularly beneficial to the overall properties of the lubricant composition, particularly from an anti-wear perspective. Thus, in some embodiments, the amount of dihydrocarbyl dithiophosphate metal salts, preferably in the form of zinc dihydrocarbyl dithiophosphates (ZDDP), in the lubricant composition is from 0.01 wt.% to 10.0 wt.%, preferably from 0.1 wt.% to 5 wt.%, more preferably from 0.2 wt.% to 2.5 wt.% and even more preferably from 0.3 wt.% to 1.0 wt.%.

[0188] In some embodiments, the lubricant composition comprises a rust inhibitor. Examples of suitable rust inhibitors include non-ionic polyoxyalkylene polyols and esters thereof, polyoxyalkylene phenols, polyoxyalkylene polyols, anionic alky sulphonic acids, zinc dithiophosphates, metal phenolates, basic metal sulphonates, fatty acids and amines.

[0189] In some embodiments, the lubricant composition comprises a corrosion inhibitor. Examples of suitable corrosion inhibitors include phosphosulphurised hydrocarbons and the products obtained by the reaction of phosphosulphurised hydrocarbon with an alkaline earth metal oxide or hydroxide, non-ionic polyoxyalkylene polyols and esters thereof, polyoxyalkylene phenols, thiadiazoles, triazoles and anionic alkyl sulphonic acids. Examples of suitable epoxidised ester corrosion inhibitors are described in US 2006/0090393.

[0190] In some embodiments, the lubricant composition comprises an antifoam agent. Examples of suitable anti-foam agents include silicones, organic polymers, siloxanes (including poly siloxanes and (poly) dimethyl siloxanes, phenyl methyl siloxanes), acrylates and the like.

[0191] In some embodiments, the lubricant composition comprises a seal swell agent. Examples of suitable seal swell agents include long chain organic acids, organic phosphates, aromatic esters, aromatic hydrocarbons, esters (for example butylbenzyl phthalate) and polybutenyl succinic anhydride.

[0192] The lubricant composition may comprise lubricant additives in the amounts shown in Table 3.

Table 3

	Lubricant composition	
Additive type	Suitable amount (actives) if present by weight	Preferred amount (actives) if present by weight
Phosphorus-containing anti-wear additives	Corresponding to about 10 to about 6000 ppm P	Corresponding to about 10 to about 1000 ppm P
Molybdenum-containing anti-wear additives	Corresponding to about 10 to about 1000 ppm Mo	Corresponding to about 40 to about 600 ppm Mo
Boron-containing anti-wear additives	Corresponding to about 10 to about 500 ppm B	Corresponding to about 50 to about 350 ppm B
Friction modifiers	About 0.01 to about 5 %	About 0.01 to about 1.5 %
Molybdenum-containing friction modifiers	Corresponding to about 10 to about 1000 ppm Mo	Corresponding to about 400 to about 600 ppm Mo
Molybdenum-containing additives (e.g. both anti-wear additives and friction modifiers)	Corresponding to about 10 to about 2000 ppm Mo	Corresponding to about 40 to about 1200 ppm Mo
Dispersants	About 0.1 to about 20 %	About 0.1 to about 8 %
Detergents	About 0.01 to about 6 %	About 0.01 to about 4 %
Viscosity index improvers	About 0.01 to about 20 %	About 0.01 to about 15 %
Pour point depressants	About 0.01 to about 5 %	About 0.01 to about 1.5 %
Corrosion and/or rust inhibitors	About 0.01 to about 5 %	About 0.01 to about 1.5 %
Antifoams containing	Corresponding to about 1 to	Corresponding to about 1 to
silicon	about 20 ppm Si	about 10 ppm Si

[0193] The lubricant compositions may have a kinematic viscosity at 40 °C of less than about 60 cSt, such as less than about 55 cSt, or less than about 50 cSt. The lubricant compositions may have a kinematic viscosity at 100 °C of less than about 12 cSt, such as less than about 10 cSt, or less than about 9.5 cSt. The lubricant compositions may have a viscosity index of greater than about 100, such as greater than about 110, or greater than about 120. The kinematic viscosity at 40 °C and the kinematic viscosity at 100 °C may be measured according to ASTM D445. The viscosity index may be calculated according to ASTM D2270.

[0194] The lubricant compositions may have a Noack volatility of less than about 25 %, such as less than about 15 %, or less than about 10 % by weight. Noack volatility may be measured according to CEC-L-40-A-93.

[0195] The lubricant compositions may have a viscosity at 150 °C and a shear rate of 10^6 s^{-1} of no greater than 3 cP, such as no greater than 2.8 cP. This high temperature high shear viscosity may be measured according to CEC-L-36-A-90.

[0196] The lubricant composition may have at least one of:

an oxidative stability performance on a CEC-L-088-02 test indicated by an absolute viscosity increase at 40 °C of no more than 45 cSt, such as no more than 35 cSt or no more than 25 cSt; a fuel economy performance on a CEC-L-054-96 test of at least 2.5 %, such as at least 3 %; a piston cleanliness performance on a CEC-L-088-02 test indicated by an

overall piston merit of at least 8.5, such as 9; and an oxidative stability performance on a CEC-L-109-14 test indicated by an increase in kinematic viscosity at 100 °C of less than 200 %, preferably less than 150 %, at 216 hours and/or less than 200 %, preferably less than 150 %, at 168 hours.

[0197] The lubricant compositions may have a cold-crankcase simulator performance at -30 °C of less than about 3000, such as less than about 2800, or less than about 2750, for example as measured according to ASTM D5293.

[0198] Preferred lubricant compositions meet the requirements set out in SAE J300.

[0199] As disclosed herein but not encompassed within the present invention, the lubricant compositions may be used in a method of lubricating a surface.

[0200] Suitable surfaces include those in power transmission systems for example drive lines and gear boxes for example for vehicles including for example passenger vehicles and heavy duty vehicles; and those in internal combustion engines, for example the crankcases of internal combustion engines. Suitable surfaces also include those in turbine bearings for example in water turbine bearings.

[0201] Suitable internal combustion engines include, for example, engines used in automotive applications, engines used in marine applications and engines used in land- based power generation plants. The lubricant compositions are particularly suited to use in an automotive internal combustion engine.

[0202] The lubricant compositions may be used to improve the fuel economy and/or piston cleanliness performance of an internal combustion engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine. Accordingly, disclosed herein but not encompassed within the claimed invention are methods of improving the fuel economy and/or piston cleanliness performance of an internal combustion engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine, comprising the step of providing or supplying to the engine and/or vehicle at least one of the lubricant compositions.

[0203] The invention will now be described with reference to the accompanying figure and examples, which are not limiting in nature, in which:

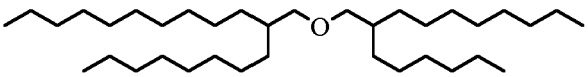
Fig. 1 is a graph of percentage increase in Kinematic Viscosity at 100 °C against time corresponding to results of CEC-L-109 testing of blended compositions containing Guerbet-derived base stock (GE3) and/or a Group III base stock (Yubase 4) together with varying amounts of aminic oxidant and/or phenolic oxidant as well as other lubricant additives.

Examples

Example 1 - Properties of ether base stocks

[0204] Guerbet-derived base stock GE3 of formula (1) was prepared, the structure of which is shown in Table 4.

Table 4

	Molecular Weight	Chemical Formula	Structure
GE3	522.97	$C_{36}H_{74}O$	

[0205] The following properties of the base stock were tested:

Kinematic viscosity at 100 °C (KV100) and kinematic viscosity at 40 °C (KV40) were tested according to ASTM D7279.
Viscosity index (VI) was calculated according to ASTM D2270.
Pour point was determined according to ASTM D7346.

[0206] Differential scanning calorimetry (DSC) oxidation onset temperature was tested using a method which was based on ASTM E2009 (method B). According to the method, the base stocks were heated from 50 °C to 300 °C, at a rate of 50 °C / minute, under a pressure of 500 psi in an aluminium SFI pan. The temperature at which an exotherm was observed was recorded.

[0207] Noack volatility was measured using a method which was based on IP 393 and was considered similar to CEC-L-40-A-93. According to the method, reference oils of known Noack volatility were heated from 40 °C to 550 °C to determine the temperature at which the Noack volatility weight loss of each of the reference oils was reached. The base stocks were subjected to the same process as the reference oils. The Noack weight of the base stocks could be determined based on the results obtained from the reference oils.

[0208] The results of the tests are summarized in Table 5, together with results obtained from a conventional base stock (Yubase 4, a group III base stock) provided as a comparative example.

Table 5

	KV100 (cSt)	KV40 (cSt)	VI	Pour Point (°C)	DSC Oxidation Onset T (°C)	Noack volatility (% by weight)
GE3	3.9	16.0	143	-42	202.89	2.4
Yubase 4	4.2	19.2	126	-12	220.00	11.7

[0209] It can be seen that the Guerbet-derived base stock ether has a lower volatility, lower pour point and lower kinematic viscosity as compared to the conventional base oil.

Example 2: Properties of lubricant compositions containing ether base stocks

[0210] Guerbet-derived ether base stock GE3 was blended with conventional base oil additives (additive A, a commercially available additive package providing a dispersant level representative of high performance engine oil between 7 and 10 wt% based on the total weight of the lubricant composition; additive B, a cold-flow improver; additive C, an oxidation inhibitor; and additive D, a viscosity index improver) and conventional base oils (Yubase 4, a group III base oil; and Yubase 6, a group III base oil) to form a lubricant blend. A Baseline blend was also prepared. Yubase 4 was chosen as the main component of the Baseline blend, since it exhibits a similar KV100 to Guerbet-derived ether base stock, GE3. The Baseline blend was believed to be a stringent baseline for comparison, since it is a 5W-30 formulation which meets certain specifications (ACEA A5/B5, API-SN/GF-4). The details of the blended compositions are shown in Table 6 in % by weight

Table 6

	Baseline blend	GE3 blend
Additive A	16.4	16.4
Additive B	0.15	0.15
Additive C	0.1	0.1
Additive D	4	4
Yubase 4	67.45	17.45
Yubase 6	11.9	11.9
GE3	0	50

[0211] No problems with miscibility were encountered during preparation of the blended compositions.

[0212] The blended compositions were tested to see whether the advantageous properties of the base stocks would be reflected in a fully formulated lubricant composition. The following properties were tested:

Kinematic viscosity at 100 °C (KV100) and kinematic viscosity at 40 °C (KV40) were tested according to ASTM D445 (part of SAE J300).
Viscosity index (VI) was calculated according to ASTM D2270.
Cold-cranking simulator (CCS) analysis was carried out at -30 °C according to ASTM D5293 (part of SAE J300).
High temperature high shear (HTHS) analysis was carried out according to CEC-L-36-A-90.
Total base number (TBN) was determined according to ASTM D2896.
Noack volatility was tested according to CEC-L-40-A-93.
Sulphated ash content was measured according to IP 163.

[0213] The results of the tests are summarized in Table 7.

Table 7

	Baseline blend	GE3 blend
KV40 (cSt)	53.59	44.63
KV100 (cSt)	9.542	8.688
VI	164	177

(continued)

	Baseline blend	GE3 blend
CCS -30 °C (cP)	4656	2702
HTHS (cP)	2.98	2.75
TBN (mg KOH/g)	11.66	11.44
NOACK (% by weight)	11.2	9.7
Sulphated ash (%)	1.22	1.27

[0214] It can be seen that the properties of the Guerbet-derived base stock are also exhibited in the blended composition. In particular, beneficial viscosity, volatility and cold-flow properties are observed. The Guerbet-derived base stock also exhibited similar HTHS measurements, TBNs and sulphated ash contents to the Baseline blend.

Example 3: CEC-L-85-99 test

[0215] Blended compositions comprising Guerbet-derived base stock (GE3), a group III base stock (Yubase 4) or a group IV base stock (PAO 4) together with varying amounts of aminic oxidant (a diphenylamine) and/or phenolic oxidant (a substituted phenol) were subjected to the CEC-L-85-99 test, which measures DSC oxidation onset temperature and DSC oxidation induction time of the tested blends. Results obtained from the CEC-L-85-99 testing are shown in Table 8 (compositional data shown in % by weight). Blends A to J are provided as comparaitve examples.

Table 8

Blend	A	B	C	D	E	F	G	H	J	K	L	M
Yubase 4	100	99.5	99.5	99								
PAO 4					100	99.5	99.5	99				
GE3 ether									100	99.5	99.5	99
Aminic AO			0.5	0.5			0.5	0.5			0.5	0.5
Phenolic AO		0.5		0.5		0.5		0.5		0.5		0.5
DSC oxidation onset temperature (°C)	221	246	246	254	222	245	249	258	209	236	241	252
DSC oxidation induction time (mins)	<3.0	7.5	4.1	20.0	<3.0	10.4	6.0	20.8	<3.0	4.2	3.1	27.8

[0216] The results in Table 8 demonstrate that both the oxidation onset temperature and oxidation induction time is increased, indicating increased oxidative stability, in the ether blends when either phenolic anti-oxidant (Blend K) or aminic anti-oxidant (Blend L) are present (compared against Blend J). Additionally, a substantial increase in oxidation onset temperature and oxidation induction time is observed when both aminic and phenolic antioxidants are added (Blend M). Notably, when non-ether blends are compared (Blends B to D and F to H) there is clearly only modest increase in oxidation onset temperature and oxidation induction time when both aminic and phenolic anti-oxidants are present (Blends D and H) compared to when they are present singly (Blends B, C, F and G). This indicates that there are synergistic effects associated with the ether base stock with aminic and phenolic anti-oxidants, which are not observed with the non-ether base stocks. This can be readily seen when comparing the tested blends comprising both aminic and phenolic antioxidants present (Blends D, H and M), where moving to the ether based system (Blend M) results in over a 25 % increase in oxidation induction time over the group III and IV based systems (Blends D and H).

Example 4: CEC-L-85-99 test - fully formulated lubricant compositions

[0217] Fully formulated lubricant compositions comprising Guerbet-derived base stock (GE3) and a group III base stock (Yubase 4) together with varying amounts of aminic oxidant and/or phenolic oxidant as well as other lubricant additives including (non-borated) dispersant, detergents, viscosity index modifier (VIM) and secondary ZDDP, were

subjected to the CEC-L-85-99 test. Results obtained from the CEC-L-85-99 testing are shown in Table 9 (compositional data shown in % by weight). Lubricant compositions 1 to 8 are provided as comparative examples.

[0218] The results in Table 9 demonstrate that both the oxidation onset temperature and oxidation induction time is increased, indicating increased oxidative stability, when the level of phenolic antioxidant and aminic anti-oxidant is increased in the ether based compositions. Additionally, a substantial increase in oxidation onset temperature and oxidation induction time is observed when both aminic and phenolic anti-oxidants are each added at a level of 0.5 wt.% (Compositions 12 and 16) compared to when one of the aminic or phenolic anti-oxidant is present at a lower concentration of 0.1 wt% (Compositions 10, 11, 14 and 15).

Table 9

Lubricant Composition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Yubase 4	84.62	84.22	84.22	83.82	84.085	83.685	83.685	83.285	34.62	34.22	34.22	33.82	34.085	33.685	33.685	33.285
GE3 ether									50	50	50	50	50	50	50	50
Phenolic AO	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5
Aminic AO	0.1	0.1	0.5	0.5	0.1	0.1	0.5	0.5	0.1	0.1	0.5	0.5	0.1	0.1	0.5	0.5
Detergents	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18
Dispersant	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
ZDDP					0.535	0.535	0.535	0.535					0.535	0.535	0.535	0.535
VM	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
DSC oxidation onset temperature (°C)	262	261	266	269	267	267	271	266	258	258	262	266	261	259	269	267
DSC oxidation induction time (mins)	19.2	29.0	36.1	47.2	43.9	40.0	56.3	45.0	17.2	21.8	30.2	44.6	43.0	41.5	45.2	61.6

[0219] Notably, the presence of ZDDP, in addition to aminic or phenolic anti-oxidants, also surprisingly confers a substantial increase in oxidative stability as shown by the corresponding increases in oxidation onset temperature and oxidation induction time (Compositions 13 to 16 compared to Compositions 9 to 12). Furthermore, this effect is particularly pronounced where aminic and phenolic antioxidants are present in equal amounts of 0.5 wt.% in the ether-based composition (Composition 16). This pronounced effect is not, however, observed in the corresponding non-ether-based system (Composition 8), indicating that there are synergistic effects associated with the combination of an ether base stock together with aminic and phenolic anti-oxidants and ZDDP. The presence of ZDDP therefore offers a further improvement in oxidative stability in the compositions of the invention whilst also contributing to improved anti-wear performance of the lubricant composition.

Example 5: CEC-L-109 tests

[0220] Fully formulated lubricant compositions comprising Guerbet-derived base stock (GE3) and a group III base stock (Yubase 4) together with varying amounts of aminic oxidant and/or phenolic oxidant, as well as other lubricant additives including (non-borated) dispersant, borated dispersant, detergents, viscosity modifier (VM) and secondary ZDDP, were subjected to the CEC-L-109 test. The CEC-L-109 test is a high temperature oxidation test designed to determine the oxidative stability of an engine lubricant, via the measurement of percentage increase in Kinematic Viscosity at 100 °C ("KV 100 % change"), with lower percentage changes indicative of higher oxidative stability. Results obtained from the CEC-L-109 testing are shown in Table 10 (compositional data shown in % by weight). Lubricant compositions a to e, g and i are provided as comparative examples.

Table 10

Lubricant Composition	a	b	c	d	e	f	g	h	i	**j**
Yubase 4	84.618	83.818	84.083	83.283	82.484	32.484	82.484	32.484	82.484	32.484
GE3 ether						50		50		50
Phenolic AO	0.1	0.5	0.1	0.5	1	1	1	1	1	1
Aminic AO	0.1	0.5	0.1	0.5	1	1	1	1	1	1
Calcium containing detergents	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	1.32	1.32
Magnesium containing detergent									0.86	0.86
Dispersant	6	6	6	6	6	6			6	6
Borated dispersant							6	6		
ZDDP			0.535	0.535	0.334	0.334	0.334	0.334	0.334	0.334
VM	7	7	7	7	7	7	7	7	7	7
Antifoam	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Average KV100 change (%)	76.0	64.3	561	too viscous to measure	227	40.7	too viscous to measure	84.4	Too viscous to measure	76.1

[0221] The CEC-L-109 test results, in the form of average percentage increase in Kinematic Viscosity at 100 °C from duplicate runs, illustrate the benefit of increasing the total antioxidant concentration (compare the result for Composition b with that of Composition a) as well as the negative impact of the presence of ZDDP on oxidative stability of the non-ether based lubricant compositions in this test (compare results for Compositions a and b with those of Compositions c and d).

[0222] However, it is apparent from the results for Composition f that the oxidative stability of the ether-based compositions as measured by the CEC-L-109 test is not significantly impacted by the presence of ZDDP, where this is clearly not the case for the corresponding non-ether based Composition e, which has the same levels of ZDDP and antioxidants as Composition f (40.7 % change for Composition f versus 227 % change for Composition e). These results are indicative of synergy between the ether base stock in the lubricant composition and the ZDDP and antioxidant components. This therefore means that greater amounts of ZDDP can be used with the ether compositions of the invention without significantly impacting upon the oxidative stability of the composition, such that the full anti-wear benefit of ZDDP can be realized.

[0223] For lubricant compositions g and h, the presence of 6 wt.% borated dispersant provides approximately 0.021 wt.% of boron (on an elemental basis) to the lubricant compositions. The presence of the borated dispersant and associated boron gives rise to a substantial increase in percentage change in Kinematic Viscosity at 100 °C for the non-ether based Composition g (too viscous to measure). In contrast, the presence of borated dispersant in the ether-based Composition h is well tolerated with only a moderate average percentage increase in Kinematic Viscosity at 100 °C (84.4 %). These results demonstrate that oxidative stability of the ether compositions of the invention is substantially maintained despite increases in boron content. This is of particular benefit since an increase in boron in the lubricant composition leads to increased elastomer compatibility and reduced corrosion.

[0224] For lubricant compositions i and j, the presence of 0.86 wt.% magnesium-containing detergent provides approximately 0.072 wt.% magnesium (on an elemental basis) to the lubricant compositions. The presence of the magnesium-containing detergent gives rise to a substantial increase in percentage change in Kinematic Viscosity at 100 °C for the non-ether based Composition i (too viscous to measure). In contrast, the presence of magnesium-containing detergent in the ether-based Composition j is well tolerated with only a moderate average percentage increase in Kinematic Viscosity at 100 °C (76.1%). These results demonstrate that oxidative stability of the ether compositions of the invention is substantially maintained despite increases in magnesium content. This is of particular benefit since an increase in magnesium-containing detergents in the lubricant composition provides reduced sulphated ash level for the same total base number (acid neutralisation capability) compared to calcium-containing detergents.

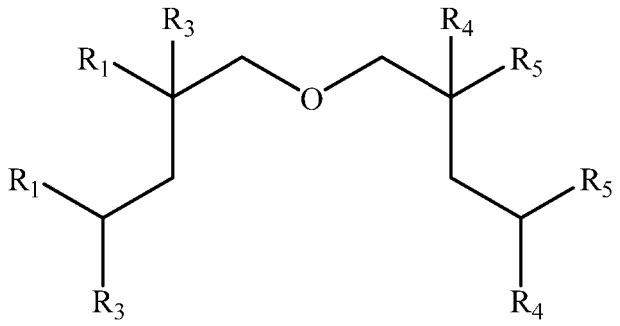
[0225] The effect of the presence of ZDDP and/or borated dispersant in compositions of the invention (Compositions f and h) compared to conventional non-ether based compositions (Compositions e and g) as discussed above are also illustrated in Figure 1.

[0226] The results in the above examples demonstrate the benefit of the ether base stocks together with aminic and/or phenolic antioxidants for improving oxidative stability, as well as the additional benefits resulting from a synergy with ZDDP. These results demonstrate that aminic and/or phenolic antioxidants can be used in lower amounts in lubricant compositions comprising ether base stocks in accordance with the invention and achieve similar or better oxidative stability in comparison to conventional non-ether based lubricant compositions. A reduction in aminic anti-oxidant in a lubricant composition for an internal combustion engine has a particular benefit in reducing turbocharger deposits as well as a reduction in copper corrosion and an increase in elastomer compatibility. Meanwhile, a reduction in phenolic antioxidant leads to an improvement in environmental toxicity of the lubricant compositions.

[0227] The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document disclosed herein, the meaning or definition assigned to that term in this document shall govern.

Claims

1. A lubricant composition for an internal combustion engine comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (4):



(4)

where: R_1 and R_4 are alkyl;
R_3 and R_5 are H or alkyl;
the lubricant composition further comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant; and
wherein the total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is not more than 4.0 % by weight of the lubricant composition and wherein the base oil of the lubricant composition comprises greater than 10 % by weight of the ether base stock.

2. The lubricant composition of Claim 1, wherein

R_1 is $C_{4\text{-}12}$ alkyl, such as $C_{6\text{-}10}$ alkyl;
R_3 is H;
R_4 is $C_{1\text{-}10}$ alkyl, such as $C_{2\text{-}8}$ alkyl; and
R_5 is H.

3. The lubricant composition of Claim 1 or Claim 2, wherein the ether base stock contains a total number of carbons atoms of from 20 to 50, such as from 25 to 45, such as from 28 to 40 or from 28 to 36.

4. The lubricant composition of any of Claims 1 to 3, wherein the ether base stock is prepared from bio-derived feedstock; preferably wherein the ether base stock contains greater than 50 %, such as greater than 70 %, or greater than 80 % by weight of biobased carbon.

5. The lubricant composition of any of Claims 1 to 4, wherein the base oil of the lubricant composition comprises greater than 25 %, or greater than 40 % by weight of the ether base stock and/or wherein the lubricant composition comprises greater than 50 %, such as greater than 65 %, or greater than 80 % by weight of the base oil.

6. The lubricant composition of any of Claims 1 to 5, wherein the lubricant composition has at least one of:

a kinematic viscosity at 40 °C of less than 60 cSt, such as less than 55 cSt, or less than 50 cSt;
a kinematic viscosity at 100 °C of less than 12 cSt, such as less than 10 cSt, or less than 9.5 cSt;
a viscosity index of greater than 100, such as greater than 110, or greater than 120;
a viscosity at 150 °C and a shear rate of 10^6 s^{-1} of no greater than 3 cP, such as no greater than 2.8 cP; and
a Noack volatility of less than 25 %, such as no more than 20%, less than 15 %, or less than 10 % by weight; and/or

wherein the lubricant composition has at least one of:

an oxidative stability performance on a CEC-L-088-02 test indicated by an absolute viscosity increase at 40 °C of no more than 45 cSt, such as no more than 35 cSt or no more than 25 cSt;
an oxidative stability performance on a CEC-L-109-14 test indicated by an increase in kinematic viscosity at 100 °C of less than 200 %, preferably less than 150 %, at 216 hours and/or less than 200 %, preferably less than 150 %, at 168 hours;
a fuel economy performance on a CEC-L-054-96 test of at least 2.5 %, such as at least 3 %; and
a piston cleanliness performance on a CEC-L-088-02 test indicated by an overall piston merit of at least 8.5, such as 9.

7. The lubricant composition of any of Claims 1 to 6, wherein the total combined amount of aminic and phenolic anti-

oxidant in the lubricant composition is not more than 3.0 %, not more than 2.5 %, or not more than 2.0 %, by weight of the lubricant composition; and/or wherein the total combined amount of aminic and phenolic anti-oxidant in the lubricant composition is at least 0.25 %, at least 0.5 %, or at least 1.0 %, by weight of the lubricant composition; and/or wherein the total amount of non-aminic and non-phenolic antioxidant in the lubricant composition is not more than 1.0 %, not more than 0.75 %, or not more than 0.5 %, by weight of the lubricant composition.

8. The lubricant composition of any of Claims 1 to 7, wherein the lubricant composition comprises aminic anti-oxidant or phenolic anti-oxidant but not both aminic anti-oxidant and phenolic anti-oxidant.

9. The lubricant composition of any of Claims 1 to 8, wherein the at least one phenolic anti-oxidant is selected from alkylated mono-phenols, alkylated hydroquinones, hydroxylated thiodiphenyl ethers, alkylidenebisphenols, acylaminophenols, and sulphurised alkyl phenols and alkali and alkaline earth metal salts thereof.

10. The lubricant composition of any of Claims 1 to 9, wherein the at least one aminic anti-oxidant is selected from alkylated and non-alkylated aromatic amines, alkylated diphenylamines, N-alkylated phenylenediamines, phenyl-α-naphthylamine, and alkylated phenyl-α-naphthylamines.

11. The lubricant composition of any of Claims 1 to 10, wherein the amount of phosphorus contained in the lubricant composition is less than 0.5 wt.%, preferably from 0.001 to 0.3 wt.%, more preferably from 0.025 to 0.2 wt.%, and even more preferably from 0.04 to 0.12 wt.%, based on the total weight of the lubricant composition; and/or wherein the amount of boron contained in the lubricant composition is from 0.005 wt.% to 0.05 wt.%, preferably from 0.0075 wt.% to 0.035 wt.%; and/or wherein the amount of magnesium contained in the lubricant composition is from 0.025 wt.% to 0.5 wt. %, preferably from 0.05 wt.% to 0.4 wt.%, more preferably from 0.08 wt.% to 0.35 wt.%, most preferably from 0.1 wt.% to 0.25 wt.%.

12. The lubricant composition of any of Claims 1 to 11, wherein the lubricant composition comprises one or more dihydrocarbyl dithiophosphate metal salts, preferably in the form of zinc dihydrocarbyl dithiophosphates (ZDDP), in an amount of from 0.01 wt.% to 10.0 wt.%, preferably from 0.1 wt.% to 5 wt.%, more preferably from 0.2 wt.% to 2.5 wt.% and even more preferably from 0.3 wt.% to 1.0 wt.% .

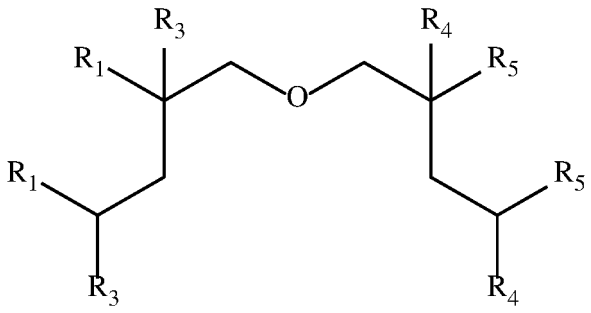
13. Use of a lubricant composition according to any of Claims 1 to 12 for lubricating a surface, such as wherein the lubricant composition is used for lubricating a surface in an internal combustion engine.

14. Use of an ether base stock as defined in any of Claims 1 to 3, for reducing the total amount of anti-oxidant additive required in a lubricant composition, the lubricant composition comprising at least one aminic anti-oxidant and/or at least one phenolic anti-oxidant, in order for the lubricant composition to achieve a particular level of oxidative stability performance.

15. Use of a lubricant composition according to any of claims 1 to 12 to improve the fuel economy performance and/or piston cleanliness performance of an engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine.

Patentansprüche

1. Schmiermittelzusammensetzung für einen Verbrennungsmotor, die ein Basisöl mit Schmierviskosität umfasst, wobei das Basisöl ein Etherbasismaterial von Formel (4) umfasst:



(4)

wobei: R_1 und R_4 Alkyl sind;
R_3 und R_5 H oder Alkyl sind;
wobei die Schmiermittelzusammensetzung ferner wenigstens ein aminisches Antioxidationsmittel und/oder wenigstens ein phenolisches Antioxidationsmittel umfasst; und
wobei die kombinierte Gesamtmenge an aminischem und phenolischem Antioxidationsmittel in der Schmiermittelzusammensetzung nicht mehr als 4,0 % bezogen auf das Gewicht der Schmiermittelzusammensetzung beträgt und wobei das Basisöl der Schmiermittelzusammensetzung mehr als 10 Gew.-% des Etherbasismaterials umfasst.

2. Schmiermittelzusammensetzung nach Anspruch 1, wobei

R_1 C_{4-12}-Alkyl wie C_{6-10}-Alkyl ist;
R_3 H ist;
R_4 C_{1-10}-Alkyl wie C_{2-8}-Alkyl ist; und
R_5 H ist.

3. Schmiermittelzusammensetzung nach Anspruch 1 oder 2, wobei das Etherbasismaterial eine Gesamtzahl an Kohlenstoffatomen von 20 bis 50, wie z.B. von 25 bis 45, wie z.B. von 28 bis 40 oder von 28 bis 36 enthält.

4. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 3, wobei das Etherbasismaterial aus biologisch gewonnenem Ausgangsmaterial hergestellt ist; wobei das Etherbasismaterial vorzugsweise mehr als 50 Gew.-%, wie z.B. mehr als 70 Gew.-% oder mehr als 80 Gew.-% biobasierten Kohlenstoff enthält.

5. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 4, wobei das Basisöl der Schmiermittelzusammensetzung mehr als 25 Gew.-% oder mehr als 40 Gew.-% des Etherbasismaterials umfasst und/oder wobei die Schmiermittelzusammensetzung mehr als 50 Gew.-%, wie z.B. mehr als 65 Gew.-% oder mehr als 80 Gew.-% des Basisöls umfasst.

6. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 5, wobei die Schmiermittelzusammensetzung wenigstens eines der Folgenden aufweist:

eine kinematische Viskosität bei 40°C von weniger als 60 cSt, wie z.B. weniger als 55 cSt oder weniger als 50 cSt;
eine kinematische Viskosität bei 100°C von weniger als 12 cSt, wie z.B. weniger als 10 cSt oder weniger als 9,5 cSt;
einen Viskositätsindex von mehr als 100, wie z.B. mehr als 110 oder mehr als 120;
eine Viskosität bei 150°C und einer Scherrate von 10^6 s^{-1} von nicht mehr als 3 cP, wie z.B. nicht mehr als 2,8 cP; und
eine Noack-Flüchtigkeit von weniger als 25 %, wie z.B. nicht mehr als 20 Gew.- %, weniger als 15 Gew.-% oder weniger als 10 Gew.-%; und/oder
wobei die Schmiermittelzusammensetzung wenigstens eines der Folgenden aufweist:

eine Oxidationsstabilitätsleistung bei einem CEC-L-088-02-Test, angegeben durch einen absoluten Viskositätsanstieg bei 40°C von nicht mehr als 45 cSt, wie z.B. nicht mehr als 35 cSt oder nicht mehr als 25 cSt;
eine Oxidationsstabilitätsleistung bei einem CEC-L-109-14-Test, angegeben durch einen Anstieg der kinematischen Viskosität bei 100°C von weniger als 200 %, vorzugsweise weniger als 150 %, nach 216 Stunden und/oder weniger als 200 %, vorzugsweise weniger als 150 %, nach 168 Stunden;

eine Kraftstoffeinsparungsleistung bei einem CEC-L-054-96-Test von wenigstens 2,5 %, wie z.B. wenigstens 3 %, und
eine Kolbensauberkeitsleistung bei einem CEC-L-088-02-Test, angegeben durch eine Gesamtkolbenleistung von wenigstens 8,5, wie z.B. 9.

7. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 6, wobei die kombinierte Gesamtmenge an aminischem und phenolischem Antioxidationsmittel in der Schmiermittelzusammensetzung nicht mehr als 3,0 %, nicht mehr als 2,5 % oder nicht mehr als 2,0 % bezogen auf die Schmiermittelzusammensetzung beträgt; und/oder wobei die kombinierte Gesamtmenge an aminischem und phenolischem Antioxidationsmittel in der Schmiermittelzusammensetzung wenigstens 0,25 %, wenigstens 0,5 % oder wenigstens 1,0 % bezogen auf das Gewicht der Schmiermittelzusammensetzung beträgt; und/oder wobei die Gesamtmenge an nicht aminischem und nicht phenolischem Antioxidationsmittel in der Schmiermittelzusammensetzung nicht mehr als 1,0 %, nicht mehr als 0,75 % oder nicht mehr als 0,5 % bezogen auf das Gewicht der Schmiermittelzusammensetzung beträgt.

8. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 7, wobei die Schmiermittelzusammensetzung ein aminisches Antioxidationsmittel oder ein phenolisches Antioxidationsmittel, aber nicht sowohl ein aminisches Antioxidationsmittel als auch ein phenolisches Antioxidationsmittel umfasst.

9. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 8, wobei das wenigstens eine phenolische Antioxidationsmittel ausgewählt ist aus alkylierten Monophenolen, alkylierten Hydrochinonen, hydroxylierten Thiodiphenylethern, Alkylidenbisphenolen, Acylaminophenolen und geschwefelten Alkylphenolen sowie Alkali- und Erdalkalimetallsalzen davon.

10. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 9, wobei das wenigstens eine aminische Antioxidationsmittel ausgewählt ist aus alkylierten und nicht alkylierten aromatischen Aminen, alkylierten Diphenylaminen, N-alkylierten Phenylendiaminen, Phenyl-α-naphthylamin und alkylierten Phenyl-α-naphthylaminen.

11. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 10, wobei die Menge an in der Schmiermittelzusammensetzung enthaltenem Phosphor weniger als 0,5 %, vorzugsweise 0,001 bis 0,3 %, bevorzugter 0,025 bis 0,2 % und noch bevorzugter 0,04 bis 0,12 % bezogen auf das Gesamtgewicht der Schmiermittelzusammensetzung beträgt; und/oder wobei die Menge an in der Schmiermittelzusammensetzung enthaltenem Bor 0,005 Gew.-% bis 0,05 Gew.-%, vorzugsweise 0,0075 Gew.-% bis 0,035 Gew.-% beträgt; und/oder wobei die Menge an in der Schmiermittelzusammensetzung enthaltenem Magnesium 0,025 Gew.-% bis 0,5 Gew.-%, vorzugsweise 0,05 Gew.-% bis 0,4 Gew.-%, bevorzugter 0,08 Gew.-% bis 0,35 Gew.-%, am meisten bevorzugt 0,1 Gew.-% bis 0,25 Gew.-% beträgt.

12. Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 11, wobei die Schmiermittelzusammensetzung ein oder mehrere Dihydrocarbyldithiophosphatmetallsalze, vorzugsweise in Form von Zinkdihydrocarbyldithiophosphaten (ZDDP), in einer Menge von 0,01 Gew.-% bis 10,0 Gew.-%, vorzugsweise 0,1 Gew.-% bis 5 Gew.-%, bevorzugter 0,2 Gew.-% bis 2,5 Gew.-% und noch bevorzugter 0,3 Gew.-% bis 1,0 Gew.-% umfasst.

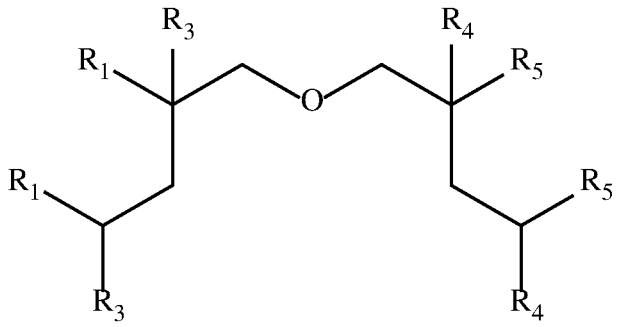
13. Verwendung einer Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 12 zum Schmieren einer Oberfläche, wobei die Schmiermittelzusammensetzung beispielsweise zum Schmieren einer Oberfläche in einem Verbrennungsmotor verwendet wird.

14. Verwendung eines Etherbasismaterials nach einem der Ansprüche 1 bis 3 zum Verringern der Gesamtmenge an in einer Schmiermittelzusammensetzung erforderlichem antioxidativem Additiv, wobei die Schmiermittelzusammensetzung wenigstens ein aminisches Antioxidationsmittel und/oder wenigstens ein phenolisches Antioxidationsmittel umfasst, damit die Schmiermittelzusammensetzung ein bestimmtes Niveau an oxidativer Stabilitätsleistung erreicht.

15. Verwendung einer Schmiermittelzusammensetzung nach einem der Ansprüche 1 bis 12 zum Verbessern der Kraftstoffeinsparungsleistung und/oder der Kolbensauberkeitsleistung eines Motors und/oder eines Fahrzeugs, wie z.B. ein Kraftfahrzeug, das mit einem Verbrennungsmotor assoziiert ist.

Revendications

1. Composition de lubrifiant pour un moteur à combustion interne comprenant une huile de base de viscosité lubrifiante, dans laquelle l'huile de base comprend une huile de base à base d'éther de formule (4) :



(4)

où : R_1 et R_4 sont un alkyle ;
R_3 et R_5 sont H ou un alkyle ;
la composition de lubrifiant comprenant en outre au moins un antioxydant aminique et/ou au moins un antioxydant phénolique ; et
dans laquelle la quantité combinée totale d'antioxydants aminique et phénolique dans la composition de lubrifiant n'est pas supérieure à 4,0 % en poids de la composition de lubrifiant et dans laquelle l'huile de base de la composition de lubrifiant comprend plus de 10 % en poids de l'huile de base à base d'éther.

2. Composition de lubrifiant selon la revendication 1, dans laquelle

R_1 est un alkyle en C_{4-12}, tel qu'un alkyle en C_{6-10} ;
R_3 est H ;
R_4 est un alkyle en C_{1-10}, tel qu'un alkyle en C_{2-8} ; et
R_5 est H.

3. Composition de lubrifiant selon la revendication 1 ou la revendication 2, dans laquelle l'huile de base à base d'éther contient un nombre total d'atomes de carbone allant de 20 à 50, tel que de 25 à 45, tel que de 28 à 40 ou de 28 à 36.

4. Composition de lubrifiant selon l'une quelconque des revendications 1 à 3, dans laquelle l'huile de base à base d'éther est préparée à partir d'une charge d'alimentation d'origine biologique ; préférablement dans laquelle l'huile de base à base d'éther contient plus de 50 %, tel que plus de 70 %, ou plus de 80 % en poids de carbone de source biologique.

5. Composition de lubrifiant selon l'une quelconque des revendications 1 à 4, dans laquelle l'huile de base de la composition de lubrifiant comprend plus de 25 %, ou plus de 40 % en poids de l'huile de base à base d'éther et/ou dans laquelle la composition de lubrifiant comprend plus de 50 %, tel que plus de 65 %, ou plus de 80 % en poids de l'huile de base.

6. Composition de lubrifiant selon l'une quelconque des revendications 1 à 5, dans laquelle la composition de lubrifiant a au moins un élément parmi :

une viscosité cinématique à 40 °C inférieure à 60 cSt, telle qu'inférieure à 55 cSt, ou inférieure à 50 cSt ;
une viscosité cinématique à 100 °C inférieure à 12 cSt, telle qu'inférieure à 10 cSt, ou inférieure à 9,5 cSt ;
un indice de viscosité supérieur à 100, tel que supérieur à 110, ou supérieur à 120 ;
une viscosité à 150 °C et un taux de cisaillement de 10^6 s^{-1} inférieure ou égale à 3 cP, telle qu'inférieure ou égale 2,8 cP ; et
une volatilité de Noack inférieure à 25 %, telle qu'inférieure ou égale à 20 %, inférieure à 15 %, ou inférieure à 10 % en poids ; et/ou dans laquelle la composition de lubrifiant a au moins un élément parmi :

une performance de stabilité à l'oxydation sur un essai CEC-L-088-02 indiquée par une augmentation de viscosité absolue à 40 °C inférieure ou égale à 45 cSt, telle qu'inférieure ou égale à 35 cSt ou inférieure ou égale à 25 cSt ;
une performance de stabilité à l'oxydation sur un essai CEC-L-109-14 indiquée par une augmentation de viscosité cinématique à 100 °C inférieure à 200 %, préférablement inférieure à 150 %, à 216 heures et/ou inférieure à 200 %, préférablement inférieure à 150 %, à 168 heures ;
une performance d'économie de carburant sur un essai CEC-L-054-96 d'au moins 2,5 %, telle qu'au moins

3 % ; et
une performance de propreté de pistons sur un essai CEC-L-088-02 indiquée par un mérite global de pistons d'au moins 8,5, tel que 9.

7. Composition de lubrifiant selon l'une quelconque des revendications 1 à 6, dans laquelle la quantité combinée totale d'antioxydants aminique et phénolique dans la composition de lubrifiant est inférieure ou égale à 3,0 %, inférieure ou égale à 2,5 %, ou inférieure ou égale à 2,0 %, en poids de la composition de lubrifiant ; et/ou dans laquelle la quantité combinée totale d'antioxydants aminique et phénolique dans la composition de lubrifiant est d'au moins 0,25 %, d'au moins 0,5 %, ou d'au moins 1,0 %, en poids de la composition de lubrifiant ; et/ou dans laquelle la quantité totale d'antioxydants non aminique et non phénolique dans la composition de lubrifiant est inférieure ou égale à 1,0 %, inférieure ou égale à 0,75 %, inférieure ou égale à 0,5 %, en poids de la composition de lubrifiant.

8. Composition de lubrifiant selon l'une quelconque des revendications 1 à 7, dans laquelle la composition de lubrifiant comprend un antioxydant aminique ou un antioxydant phénolique mais pas un antioxydant aminique et un antioxydant phénolique à la fois.

9. Composition de lubrifiant selon l'une quelconque des revendications 1 à 8, dans laquelle l'au moins un antioxydant phénolique est choisi parmi des mono-phénols alkylés, des hydroquinones alkylées, des éthers thiodiphényliques hydroxylés, des alkylidènebisphénols, des acylaminophénols, et des alkylphénols sulfurisés et des sels de métaux alcalins et alcalino-terreux de ceux-ci.

10. Composition de lubrifiant selon l'une quelconque des revendications 1 à 9, dans laquelle l'au moins un antioxydant aminique est choisi parmi des amines aromatiques alkylées et non alkylées, des diphénylamines alkylées, des phénylènediamines N-alkylées, une phényl-α-naphtylamine, et des phényl-α-naphtylamines alkylées.

11. Composition de lubrifiant selon l'une quelconque des revendications 1 à 10, dans laquelle la quantité de phosphore contenue dans la composition de lubrifiant est inférieure à 0,5 % en poids, préférablement de 0,001 à 0,3 % en poids, plus préférablement de 0,025 à 0,2 % en poids, et de manière encore plus préférée de 0,04 à 0,12 % en poids, sur la base du poids total de la composition de lubrifiant ; et/ou dans laquelle la quantité de bore contenue dans la composition de lubrifiant est de 0,005 % en poids à 0,05 % en poids, préférablement de 0,0075 % en poids à 0,035 % en poids ; et/ou dans laquelle la quantité de magnésium contenue dans la composition de lubrifiant est de 0,025 % en poids à 0,5 % en poids, préférablement de 0,05 % en poids à 0,4 % en poids, plus préférablement de 0,08 % en poids à 0,35 % en poids, de manière plus préférée entre toutes de 0,1 % en poids à 0,25 % en poids.

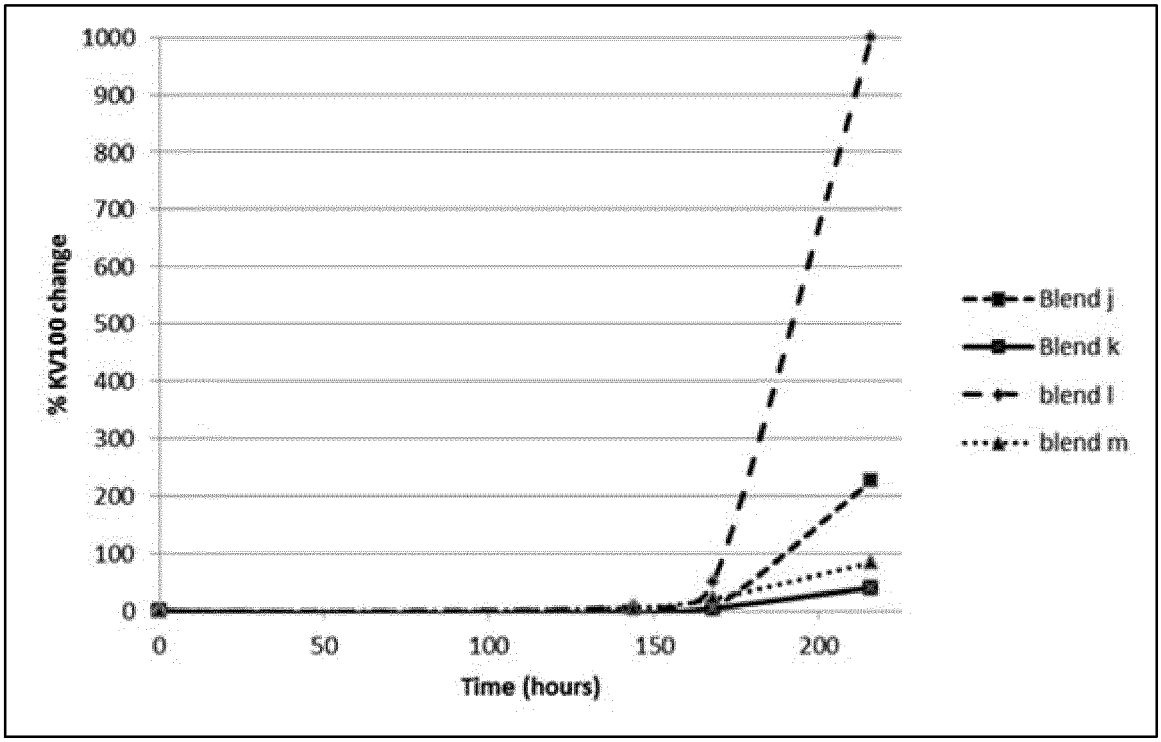
12. Composition de lubrifiant selon l'une quelconque des revendications 1 à 11, dans laquelle la composition de lubrifiant comprend un ou plusieurs sels métalliques dithiophosphate de dihydrocarbyle, préférablement sous la forme de dithiophosphates de dihydrocarbyle de zinc (ZDDP), dans une quantité allant de 0,01 % en poids à 10,0 % en poids, préférablement de 0,1 % en poids à 5 % en poids, plus préférablement de 0,2 % en poids à 2,5 % en poids et de manière encore plus préférée de 0,3 % en poids à 1,0 % en poids .

13. Utilisation d'une composition de lubrifiant selon l'une quelconque des revendications 1 à 12 destinée à lubrifier une surface, telle que dans laquelle la composition de lubrifiant est utilisée pour lubrifier une surface dans un moteur à combustion interne.

14. Utilisation d'une huile de base à base d'éther telle que définie dans l'une quelconque des revendications 1 à 3, destinée à réduire la quantité totale d'additif antioxydant requise dans une composition de lubrifiant, la composition de lubrifiant comprenant au moins un antioxydant aminique et/ou au moins un antioxydant phénolique, afin que la composition de lubrifiant atteigne un niveau particulier de performance de stabilité à l'oxydation.

15. Utilisation d'une composition de lubrifiant selon l'une quelconque des revendications 1 à 12 pour améliorer la performance d'économie de carburant et/ou la performance de propreté des pistons d'un moteur et/ou d'un véhicule, tel qu'un véhicule automobile associé à un moteur à combustion interne.

Figure 1:


1000
900
800
700
600
500
400
300
200
100
0
% KV100 change
0
50
100
150
200
Time (hours)
Blend j
Blend k
blend l
blend m

REFERENCES CITED IN THE DESCRIPTION

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