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

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(57) **ABSTRACT**

The present invention provides a lubricant composition comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (A) where:  $R_a$  and  $R_b$  are aliphatic hydrocarbonyl groups and may be the different; the lubricant composition further comprising from 0.5 to 7% of total dispersant additive, by weight of the lubricant composition. In some embodiments, the ether base stock has the formula (1) where:  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$  and  $R_6$  are as defined herein. The lubricant composition may be used for lubricating a surface in an internal combustion engine as well as for 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.

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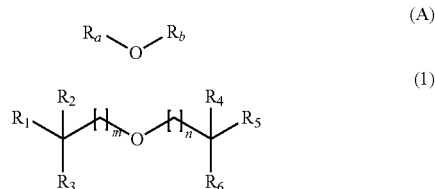


FIGURE 1:

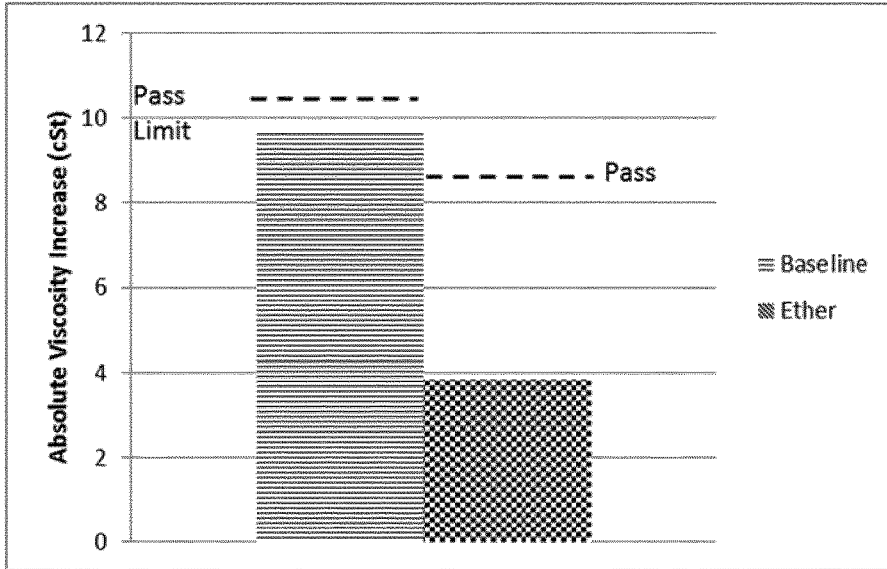


FIGURE 2:

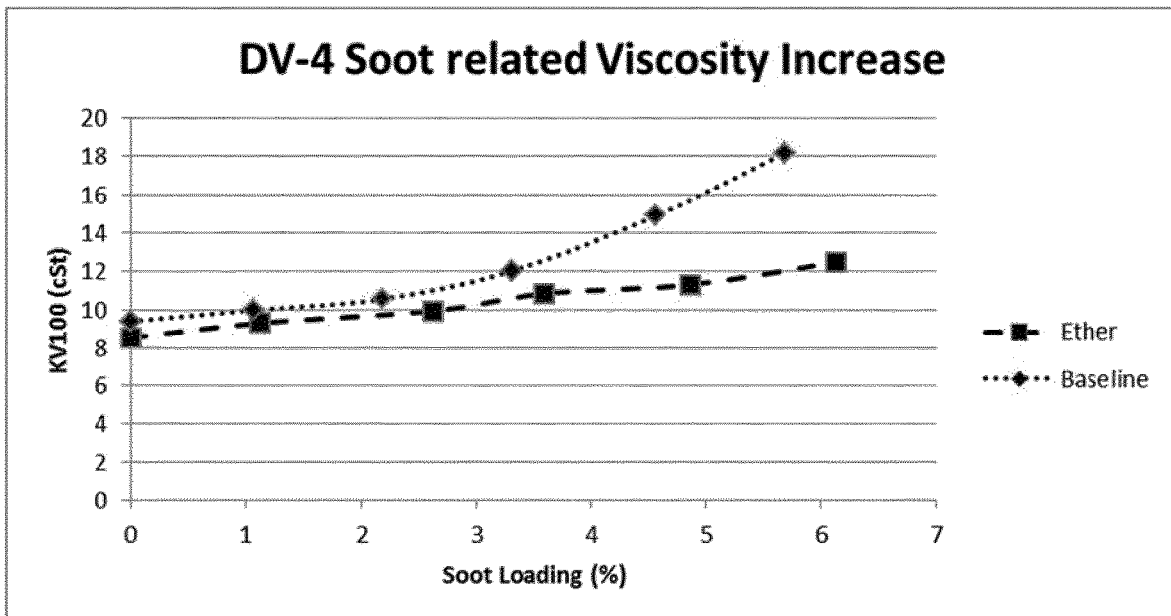


FIGURE 3:

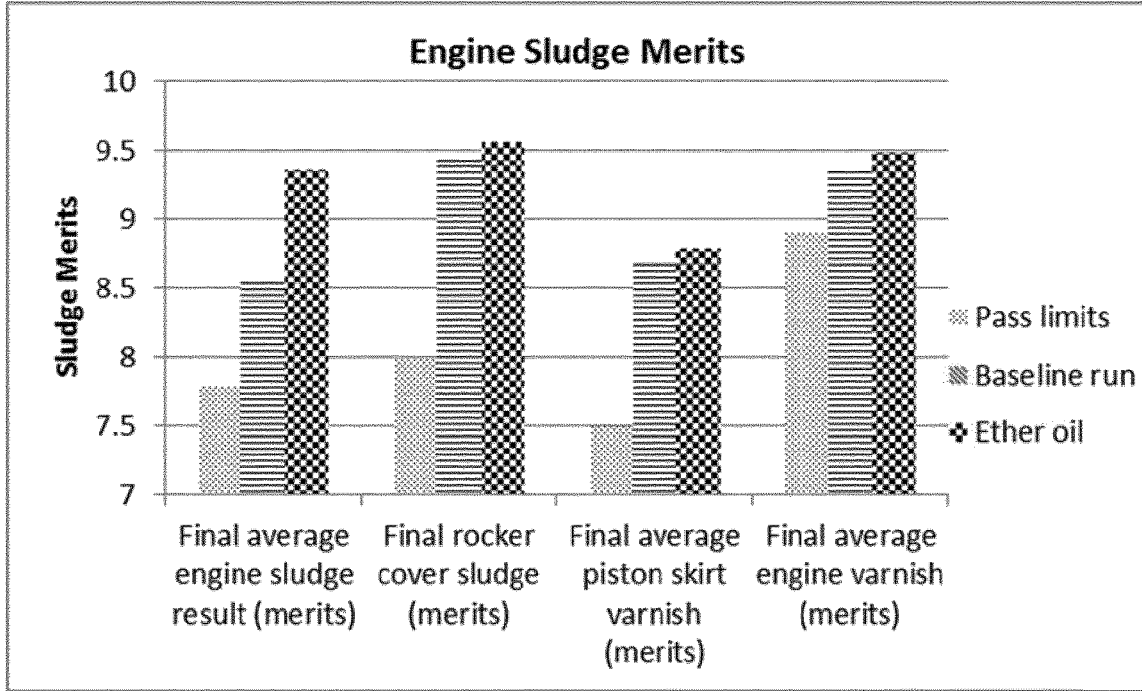
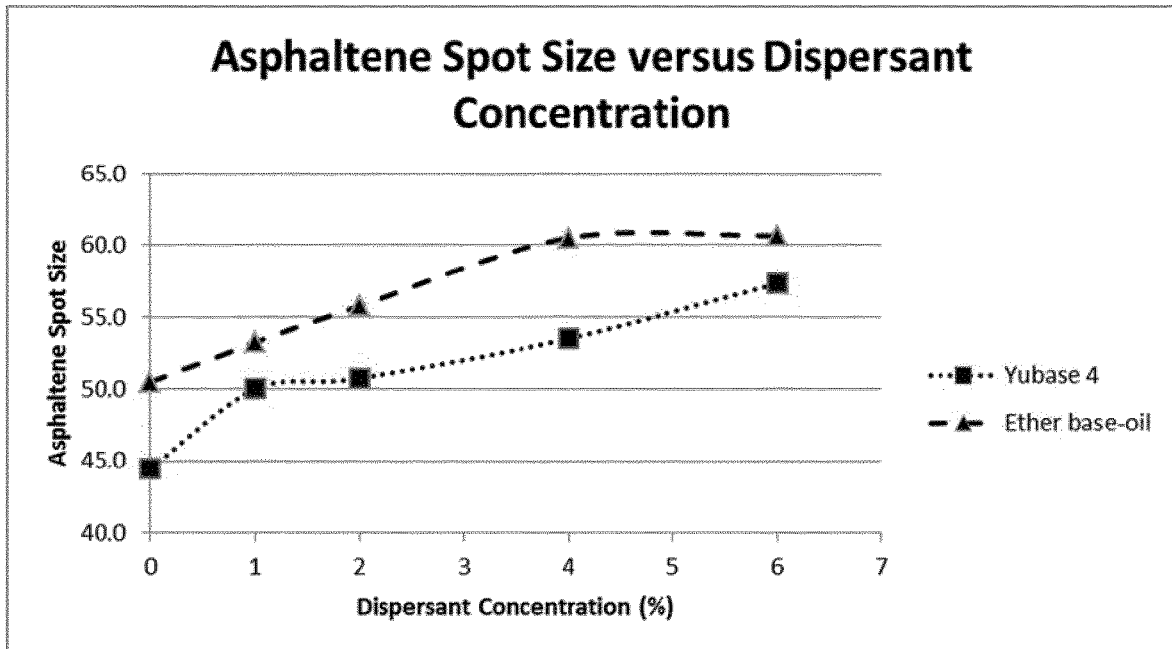


FIGURE 4:



## ETHER-BASED LUBRICANT COMPOSITIONS, METHODS AND USES

**[0001]** The present invention relates to lubricant compositions containing base oils comprising certain ether base stocks which are suitable for use in a lubricant composition intended for use in an internal combustion engine. Also provided are methods and 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", 17<sup>th</sup> Edition, Annex E (October 2013 with Errata March 2015), as set out in Table 1.

TABLE 1

Group	Saturated hydrocarbon content	Sulphur content		Viscosity Index
	(% by weight) ASTM D2007	(% by weight) ASTM D2622, D4294, D4927, D3120 or D1552		
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 dispersancy properties and tolerance to soot and sludge, to which a lubricant composition employed in an internal combustion engine is inevitably exposed during its lifetime. Good dispersancy properties can extend the useful lifetime of a lubricant composition, for instance, by reducing soot-induced lubricant composition thickening, or by reducing sludge build-up in the lubricant composition, which can otherwise rapidly lead to a loss of fuel economy. Typically, dispersancy properties of a lubricant composition are improved by the addition of dispersants. A dispersant level representative of a high performance engine oil typically lies between 7 and 10%, by weight of the lubricant composition. Thus, a significant proportion of the composition of the lubricant may be made up of dispersants and therefore these represent a significant cost component of the lubricant composition. Moreover, dispersants can themselves contribute to oil thickening and therefore gains in dispersancy properties of the composition may have to be balanced with losses as far as lubricant viscosity properties are concerned.

**[0008]** Accordingly, there is a need in the art for a lubricant composition having a desirable viscosity profile, including good low-temperature viscosity characteristics, but which also exhibits low volatility. There is also a need for a lubricant composition which exhibits good dispersancy properties without requiring a high dispersant treat rate, as is typically associated with a high performance engine oil.

**[0009]** Problems may also be encountered when a lubricating composition is used in an engine. For instance, poor miscibility of a base stock with lubricant additives or other base stocks may lead to problems in the engine, for instance with piston cleanliness. 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. Lubricant compositions may also undergo oxidative degradation at the high temperatures encountered in an engine.

**[0010]** Accordingly, there is a need for a lubricant composition having low volatility for a given viscosity profile, but which is also suitable for use, for example, in an internal combustion engine.

### SUMMARY

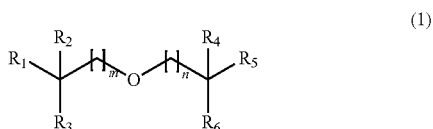
**[0011]** Accordingly, in a first aspect a lubricant composition is provided comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (A):



where:  $\text{R}_a$  and  $\text{R}_b$  are aliphatic hydrocarbyl groups and may be the same or different;

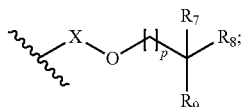
the lubricant composition further comprising from 0.5 to 7% of total dispersant additive, by weight of the lubricant composition.

[0012] In a particularly preferred embodiment, the ether base stock of the lubricant composition is selected from a subset of the compounds of formula (A), namely a compound of formula (1):



[0013] where:  $\text{R}_1$  and  $\text{R}_2$  are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0014]  $\text{R}_3$ ,  $\text{R}_4$  and  $\text{R}_5$  are H or alkyl;



[0015]  $\text{R}_6$  is alkyl or

[0016] where:  $\text{R}_7$  and  $\text{R}_8$  are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0017]  $\text{R}_9$  is H or alkyl;

[0018] X is alkylene or is absent; and

[0019] p is 0, 1, 2 or 3; and

[0020] m and n are 0, 1, 2 or 3 provided that m is 0 when  $\text{R}_4$  and  $\text{R}_5$  are H.

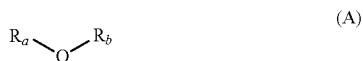
[0021] Also provided are methods of preparing lubricant compositions.

[0022] Also provided is a method for lubricating a surface using a lubricant composition, as well as the use of a lubricant composition for lubricating a surface.

[0023] Also provided are methods and uses of improving the dispersancy properties and/or viscosity profile 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

[0024] A lubricant composition is provided comprising a base oil of lubricating viscosity, wherein the base oil comprises an ether base stock of formula (A):



where:  $\text{R}_a$  and  $\text{R}_b$  are aliphatic hydrocarbyl groups and may be the same or different;

the lubricant composition further comprising from 0.5 to 7% of total dispersant additive, by weight of the lubricant composition.

[0025] For the purposes of the present invention, the following terms as used herein shall, unless otherwise indicated, be understood to have the following meanings:

[0026] 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—, or from 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—.

[0027] 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).

[0028] 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.

[0029] 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.

[0030] 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



be H and another subset of R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> may be alkyl. Where R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub>, or a subset thereof, are alkyl, each of R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> may be the same alkyl group or they may be different alkyl groups. In contrast, where R<sub>1</sub> (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.

**[0057]** In each of the embodiments disclosed herein, the ether compounds of the lubricant compositions may contain a total number of carbon 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.

**[0058]** As indicated previously, the alkyl and alkylene groups mentioned herein, i.e. those that may be represented by R<sub>a</sub>, R<sub>b</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, R<sub>6</sub>, R<sub>7</sub>, R<sub>8</sub>, R<sub>9</sub> and X, may be straight chain alkyl or alkylene groups, though they may also be branched. In some embodiments, 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<sub>a</sub> and R<sub>b</sub> are both alkyl groups, it is preferred that at least one of these alkyl groups is branched, preferably both. In some embodiments, for instance with respect to R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, R<sub>6</sub>, R<sub>7</sub>, R<sub>8</sub>, R<sub>9</sub> 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.

**[0059]** The 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 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.

**[0060]** The 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.

**[0061]** The compounds may have a viscosity at 150° C. and a shear rate of 10<sup>6</sup> s<sup>-1</sup> 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.

**[0062]** The ether compounds described herein may be used to improve the dispersancy properties and/or viscosity profile of a lubricant composition, such as a lubricant composition for an internal combustion engine, preferably associated with an automotive vehicle. Preferably, the lubricant compositions for improving through the use of the ether compounds described herein have a total dispersant additive concentration of from 0.5 to 7.0%, from 1.0 to 7.0%, from 1.0 to 6.5%, from 2.0 to 6.0%, or from 3.0 to 5.0%, by weight of the fully formulated lubricant composition. Accordingly, there is also provided a method of improving the dispersancy properties and/or viscosity profile of a lubricant composition, such as a lubricant composition for an internal combustion engine, preferably associated with an automotive vehicle, comprising the step of providing or supplying to the lubricant composition at least one of the

ether compounds described herein. Preferably, the lubricant compositions for improving have a total dispersant additive concentration of from 0.5 to 7.0%, from 1.0 to 7.0%, from 1.0 to 6.5%, from 2.0 to 6.0%, or from 3.0 to 5.0%, by weight of the fully formulated lubricant composition.

**[0063]** 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, there is provided 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.

**[0064]** 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.

**[0065]** 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.

**[0066]** 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).

**[0067]** In particular embodiments, the 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.

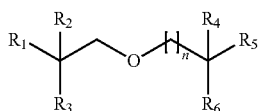
**[0068]** The ether compounds of formula (A) or formula (1) are particularly suited for blending into a lubricant composition. In particular, the compounds are miscible with conventional base stocks, including hydrocarbon base stocks, as well as with conventional lubricant additives. Moreover, the compounds 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.

**[0069]** The compounds of formula (A) and formula (1) may be prepared from a wide range of commercially available feedstocks.

**[0070]** 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

**[0071]** In preferred embodiments, the compounds of formula (1) are derived from β-alkylated alcohols. In these embodiments, the compound may have the formula (2):



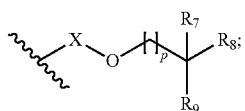
(2)

[0072] where:  $R_1$  and  $R_2$  are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0073]  $R_3$  and  $R_5$  are H or alkyl;

[0074]  $R_4$  is alkyl;

[0075]  $R_6$  is alkyl or



[0076] where:  $R_7$  and  $R_8$  are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0077]  $R_9$  is H or alkyl;

[0078] X is alkylene or is absent; and

[0079] p is 0, 1, 2 or 3; and

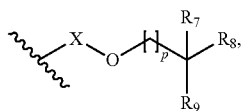
[0080] n is 0, 1, 2 or 3.

[0081] In some embodiments,  $R_1$  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.

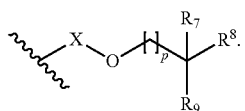
[0082] In some embodiments,  $R_3$  and  $R_5$  are H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_3$  and  $R_5$  are H.

[0083] In some embodiments,  $R_4$  is  $C_{1-15}$  alkyl, such as  $C_{2-12}$  alkyl.

[0084] In some embodiments,  $R_6$  is  $C_{1-15}$  alkyl or



such as  $C_{1-12}$  alkyl or



[0085] In some embodiments,  $R_7$  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.

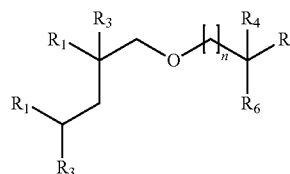
[0086] In some embodiments,  $R_9$  is H or  $C_{1-20}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_9$  is H.

[0087] In some embodiments, X is  $C_{1-20}$  alkylene, such as  $C_{3-15}$  alkylene.

[0088] In some embodiments, p is 0, 1 or 2, such as 0 or 1.

[0089] In some embodiments, n is 0, 1 or 2, such as 0 or 1.

[0090] Where the compound is derived from a  $\beta$ -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):



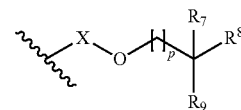
(3)

[0091] where:  $R_1$  is alkyl;

[0092]  $R_3$  and  $R_5$  are H or alkyl;

[0093]  $R_4$  is alkyl;

[0094]  $R_6$  is alkyl or



[0095] where:  $R_7$  and  $R_8$  are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0096]  $R_9$  is H or alkyl;

[0097] X is alkylene or is absent; and

[0098] p is 0, 1, 2 or 3; and

[0099] n is 0, 1, 2 or 3.

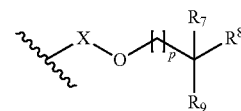
[0100] In some embodiments,  $R_1$  is  $C_{1-12}$  alkyl, such as  $C_{2-10}$  alkyl.

[0101] In some embodiments,  $R_3$  is H or  $C_{1-12}$  alkyl, such as H or  $C_{2-10}$  alkyl. Preferably,  $R_3$  is H.

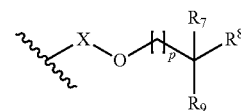
[0102] In some embodiments,  $R_4$  is  $C_{1-15}$  alkyl, such as  $C_{2-12}$  alkyl.

[0103] In some embodiments,  $R_5$  is H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_5$  is H.

[0104] In some embodiments,  $R_6$  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.

[0105] In some embodiments,  $R_7$  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<sub>5-25</sub> cycloalkyl. Preferably, R<sub>7</sub> and R<sub>8</sub> are C<sub>1-20</sub> alkyl, such as C<sub>2-12</sub> alkyl.

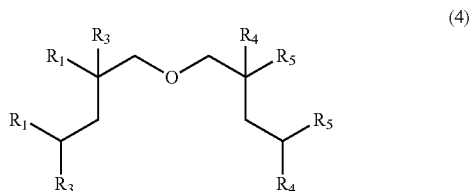
[0106] In some embodiments, R<sub>9</sub> is H or C<sub>1-20</sub> alkyl, such as H or C<sub>2-12</sub> alkyl. Preferably, R<sub>9</sub> is H.

[0107] In some embodiments, X is C<sub>1-20</sub> alkylene, such as C<sub>3-15</sub> alkylene.

[0108] In some embodiments, p is 0, 1 or 2, such as 0 or 1.

[0109] In some embodiments, n is 0, 1 or 2, such as 0 or 1.

[0110] 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<sub>1</sub> and R<sub>3</sub>), whereas the other portion need not be derived from a Guerbet alcohol (i.e. the portion containing R<sub>4</sub>, R<sub>5</sub> and R<sub>6</sub>). However, in preferred embodiments, the compound may be derived from a combination of two Guerbet alcohols. A compound prepared in this way may have the formula (4):



[0111] where: R<sub>1</sub> and R<sub>4</sub> are alkyl;

[0112] R<sub>3</sub> and R<sub>5</sub> are H or alkyl.

[0113] In some embodiments, R<sub>1</sub> and R<sub>4</sub> are C<sub>1-12</sub> alkyl, such as C<sub>2-10</sub> alkyl.

[0114] In some embodiments, R<sub>3</sub> and R<sub>5</sub> are H or C<sub>1-12</sub> alkyl, such as H or C<sub>2-10</sub> alkyl. Preferably, R<sub>3</sub> and R<sub>5</sub> are H.

[0115] In particular embodiments: R<sub>1</sub> is C<sub>4-12</sub> alkyl, such as C<sub>6-10</sub> alkyl;

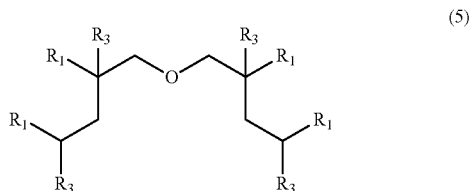
[0116] R<sub>3</sub> is H;

[0117] R<sub>4</sub> is C<sub>1-10</sub> alkyl, such as C<sub>2-8</sub> alkyl; and

[0118] R<sub>5</sub> is H.

[0119] Two different Guerbet alcohols may be combined to form compounds of formula (4), in which case R<sub>1</sub> and R<sub>4</sub> may be different. Alternatively, R<sub>3</sub> and R<sub>5</sub> may be different. In some embodiments, R<sub>1</sub> and R<sub>4</sub> are different and R<sub>3</sub> and R<sub>5</sub> are also different.

[0120] 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):



[0121] where: R<sub>1</sub> is alkyl; and

[0122] R<sub>3</sub> is H or alkyl.

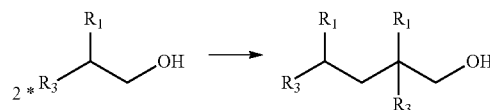
[0123] In some embodiments, R<sub>1</sub> is C<sub>1-10</sub> alkyl, such as C<sub>2-9</sub> alkyl.

[0124] In some embodiments, R<sub>3</sub> is H or C<sub>1-9</sub> alkyl, such as H or C<sub>2-8</sub> alkyl. Preferably, R<sub>3</sub> is H.

[0125] In particular embodiments: R<sub>1</sub> is C<sub>3-10</sub> alkyl, such as C<sub>4-8</sub> alkyl; and R<sub>3</sub> is H.

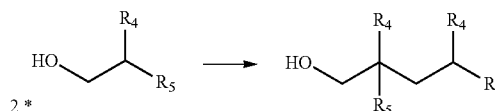
[0126] Compounds that are derived from Guerbet alcohols include compounds GE1-GE3, GES, GE7-GE9, SE1, SE2 and TE1 as shown in Table 2.

[0127] Guerbet alcohols may be prepared, for example, by dimerising primary alcohols to form a β-alkylated alcohol product in a Guerbet reaction:



[0128] where R<sub>1</sub> and R<sub>3</sub> are as defined previously;

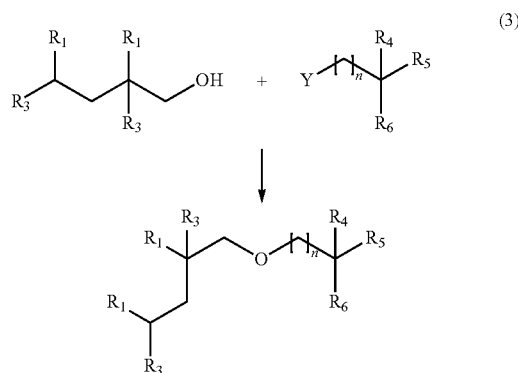
[0129] and/or:



[0130] where R<sub>4</sub> and R<sub>5</sub> are as defined previously.

[0131] Guerbet reactions are well-known to the skilled person. The reactions are typically carried out at elevated temperatures in the presence of a catalyst.

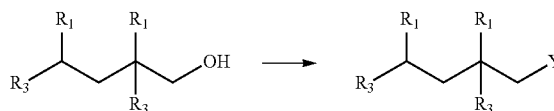
[0132] The compound may be prepared from the Guerbet alcohol, for example, according to the following reaction:



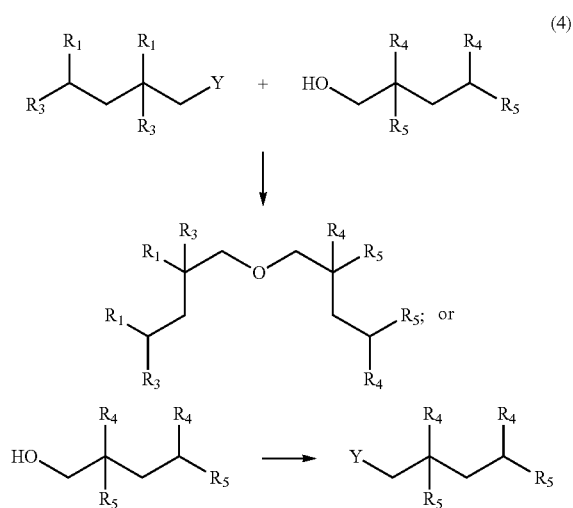
[0133] where: Y is a leaving group; and

[0134] R<sub>1</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, R<sub>6</sub> and n are as defined previously for the compound of formula (3).

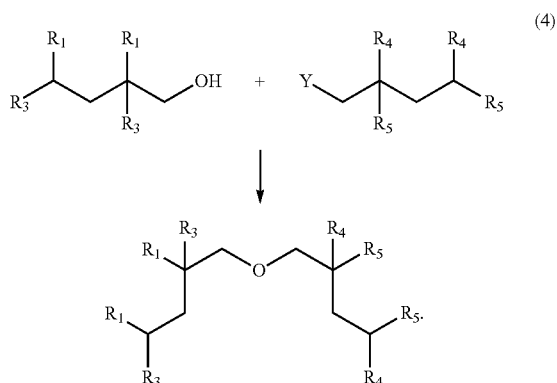
[0135] Where two Guerbet alcohols are combined to form a compound, one of the Guerbet alcohols may first be modified so that it contains a leaving group, Y, and the compound then prepared:



then:



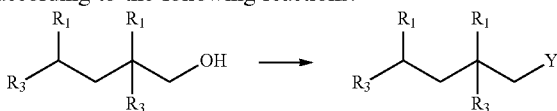
then:



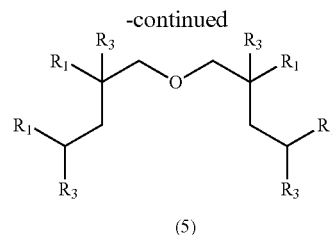
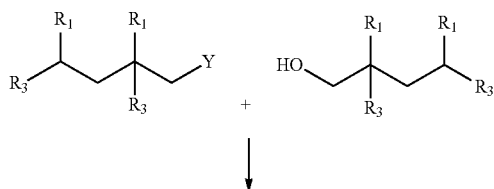
[0136] where: Y is a leaving group; and

[0137] R<sub>1</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> are as defined previously for the compound of formula (4).

[0138] Where the same Guerbet alcohols are combined to form a compound, they may be combined, for example, according to the following reactions:



then:



[0139] where: Y is a leaving group; and

[0140] R<sub>1</sub> and R<sub>3</sub> are as defined previously for the compound of formula (5).

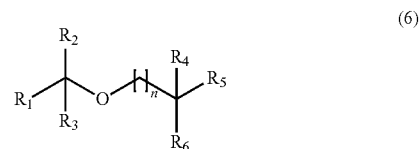
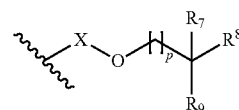
[0141] Methods and reaction conditions for modifying a Guerbet alcohol so that it contains a leaving group, Y, are known to the skilled person. For instance, a mesylate group may be introduced by reacting the Guerbet alcohol with mesyl chloride in the presence of triethylamine. A bromide group may be introduced by reacting the Guerbet alcohol with N-bromosuccinimide and triphenyl phosphine.

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.

[0142] 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 or tosylate).

Secondary and Tertiary Ether Base Stocks

[0143] In some preferred embodiments, the compounds of formula (1) are secondary or tertiary ether compounds. In these embodiments, the compound may have the formula (6):

[0144] where: R<sub>1</sub> and R<sub>2</sub> are alkyl or, together with the carbon to which they are attached, cycloalkyl;[0145] R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> are H or alkyl;[0146] R<sub>6</sub> is alkyl or[0147] where: R<sub>7</sub> and R<sub>8</sub> are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;[0148] R<sub>9</sub> is H or alkyl;

[0149] X is alkylene or is absent; and

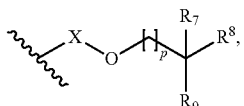
[0150] p is 0, 1, 2 or 3; and

[0151] n is 0, 1, 2 or 3.

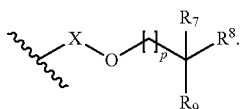
**[0152]** In some embodiments,  $R_1$  and  $R_2$  are  $C_{1-15}$  alkyl or, together with the carbon atom to which they are attached,  $C_{5-30}$  cycloalkyl, such as  $C_{2-12}$  alkyl or, together with the carbon atom to which they are attached,  $C_{5-25}$  cycloalkyl. Preferably,  $R_1$  and  $R_2$  are  $C_{1-15}$  alkyl, such as  $C_{2-12}$  alkyl.

**[0153]** In some embodiments,  $R_3$ ,  $R_4$  and  $R_5$  are H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_5$  is H.

**[0154]** In some embodiments,  $R_6$  is  $C_{1-20}$  alkyl or



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



**[0155]** In some embodiments,  $R_7$  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.

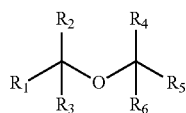
**[0156]** In some embodiments,  $R_9$  is H or  $C_{1-20}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_9$  is H.

**[0157]** In some embodiments, X is  $C_{1-20}$  alkylene, such as  $C_{3-15}$  alkylene.

**[0158]** In some embodiments, p is 0, 1 or 2, such as 0 or 1.

**[0159]** In some embodiments, n is 0, 1 or 2, such as 0 or 1.

**[0160]** Secondary and tertiary ether compounds may have the formula (7):



(7)

**[0161]** where:  $R_1$  and  $R_2$  are alkyl or, together with the carbon to which they are attached, cycloalkyl;

**[0162]**  $R_3$ ,  $R_4$  and  $R_5$  are H or alkyl; and

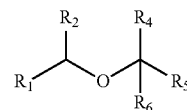
**[0163]**  $R_6$  is alkyl.

**[0164]** In some embodiments,  $R_1$  and  $R_2$  are  $C_{1-15}$  alkyl or, together with the carbon to which they are attached,  $C_{5-39}$  cycloalkyl, such as  $C_{2-12}$  alkyl or, together with the carbon to which they are attached,  $C_{5-25}$  cycloalkyl.

**[0165]** In some embodiments,  $R_3$ ,  $R_4$  and  $R_5$  are H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_5$  is H.

**[0166]** In some embodiments,  $R_6$  is  $C_{1-20}$  alkyl, such as  $C_{1-16}$  alkyl.

**[0167]** The compounds may be secondary ether compounds of formula (8):



(8)

**[0168]** where:  $R_1$  and  $R_2$  are alkyl or, together with the carbon to which they are attached, cycloalkyl;

**[0169]**  $R_4$  and  $R_5$  are H or alkyl; and

**[0170]**  $R_6$  is alkyl.

**[0171]** In some embodiments,  $R_1$  and  $R_2$  are  $C_{1-15}$  alkyl, such as  $C_{2-12}$  alkyl.

**[0172]** In other embodiments, 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.

**[0173]** In some embodiments,  $R_4$  and  $R_5$  are H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_5$  is H.

**[0174]** In some embodiments,  $R_6$  is  $C_{1-20}$  alkyl, such as  $C_{1-16}$  alkyl.

**[0175]** In particular embodiments:  $R_1$  and  $R_2$  are  $C_{3-12}$  alkyl, such as  $C_{5-10}$  alkyl;

**[0176]**  $R_4$  and  $R_5$  are H; and

**[0177]**  $R_6$  is  $C_{4-20}$  alkyl, such as  $C_{6-15}$  alkyl.

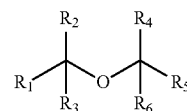
**[0178]** In other particular embodiments:  $R_1$  and  $R_2$  are  $C_{3-12}$  alkyl, such as  $C_{5-10}$  alkyl;

**[0179]**  $R_4$  is  $C_{3-12}$  alkyl, such as  $C_{5-10}$  alkyl;

**[0180]**  $R_5$  is H; and

**[0181]**  $R_6$  is  $C_{3-12}$  alkyl, such as  $C_{5-10}$  alkyl.

**[0182]** The compounds may be tertiary ether compounds of formula (9):



(9)

**[0183]** where:  $R_1$  and  $R_2$  are alkyl or, together with the carbon to which they are attached, cycloalkyl;

**[0184]**  $R_3$  is alkyl;

**[0185]**  $R_4$  and  $R_5$  are H or alkyl; and

**[0186]**  $R_6$  is alkyl.

**[0187]** In some embodiments,  $R_1$  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.

**[0188]** In some embodiments,  $R_3$  is  $C_{1-12}$  alkyl, such as  $C_{1-10}$  alkyl.

**[0189]** In some embodiments,  $R_4$  and  $R_5$  are H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. In some embodiments,  $R_6$  is  $C_{1-20}$  alkyl, such as  $C_{1-16}$  alkyl.

**[0190]** In particular embodiments:  $R_1$  and  $R_2$  are  $C_{2-12}$  alkyl, such as  $C_{4-10}$  alkyl;

**[0191]**  $R_3$  is  $C_{1-10}$  alkyl, such as  $C_{1-8}$  alkyl;

**[0192]**  $R_4$  and  $R_5$  are H; and

[0193]  $R_6$  is  $C_{4-20}$  alkyl, such as  $C_{6-15}$  alkyl.

[0194] In other particular embodiments:  $R_1$ ,  $R_2$  and  $R_3$  are  $C_{2-12}$  alkyl, such as  $C_{4-10}$  alkyl;

[0195]  $R_3$  is  $C_{1-10}$  alkyl, such as  $C_{1-8}$  alkyl;

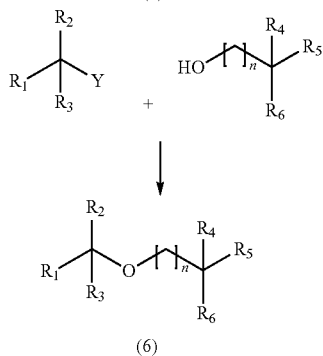
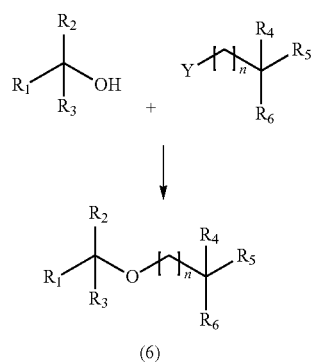
[0196]  $R_4$  is  $C_{3-12}$  alkyl, such as  $C_{5-10}$  alkyl;

[0197]  $R_5$  is H; and

[0198]  $R_6$  is  $C_{3-12}$  alkyl, such as  $C_{5-10}$  alkyl.

[0199] Examples of secondary and tertiary ether compounds include SE1, SE2 and TE1 as shown in Table 2.

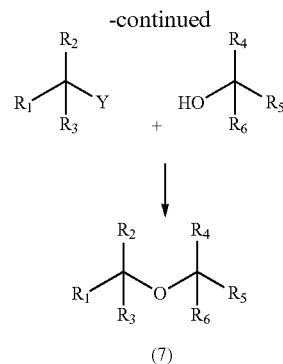
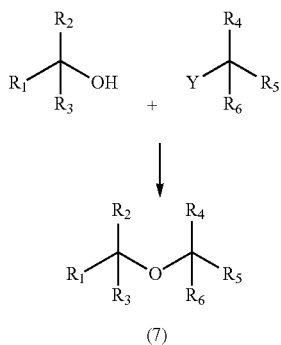
[0200] The secondary and tertiary ether compounds may be prepared according to the following reactions:



[0201] where: Y is a leaving group; and

[0202]  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$  and  $n$  are as defined previously for the compound of formula (6).

[0203] Similarly:



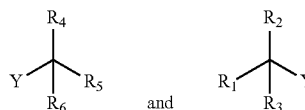
[0204] where: Y is a leaving group; and

[0205]  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$  and  $R_6$  are as defined previously for the compound of formula (7).

[0206] 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.

[0207] 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.

[0208] The groups

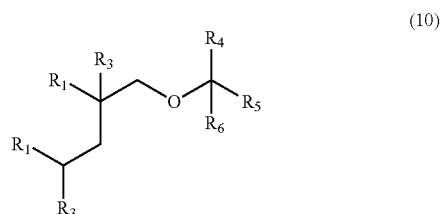


may be prepared by introducing a leaving group, Y, into the alcohol starting materials. Methods and reaction conditions for introducing the leaving group into alcohol are known to the skilled person.

[0209] 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

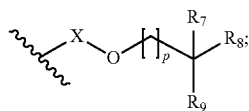
[0210] In some embodiments, the compound may comprise an ether which is derived on one side from a secondary or tertiary alcohol and is derived on the other side from a Guerbet alcohol. In these embodiments, the compound may have the formula (10):



[0211] where:  $R_1$  and  $R_4$  are alkyl;

[0212]  $R_3$  and  $R_5$  are H or alkyl;

[0213]  $R_6$  is alkyl or



(11)

[0214] where:  $R_7$  and  $R_8$  are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0215]  $R_9$  is H or alkyl;

[0216] X is alkylene or is absent; and

[0217] and p is 0, 1, 2 or 3.

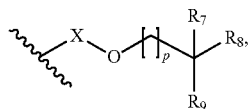
[0218] In some embodiments,  $R_1$  is  $C_{1-12}$  alkyl, such as  $C_{2-10}$  alkyl.

[0219] In some embodiments,  $R_3$  is H or  $C_{1-12}$  alkyl, such as H or  $C_{2-10}$  alkyl. Preferably,  $R_3$  is H.

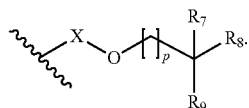
[0220] In some embodiments,  $R_4$  is  $C_{1-15}$  alkyl, such as  $C_{2-12}$  alkyl.

[0221] In some embodiments,  $R_5$  is H or  $C_{1-15}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_5$  is H.

[0222] In some embodiments,  $R_6$  is  $C_{1-15}$  alkyl or



such as  $C_{1-12}$  alkyl or



[0223] In some embodiments,  $R_7$  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.

[0224] In some embodiments,  $R_9$  is H or  $C_{1-20}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_9$  is H.

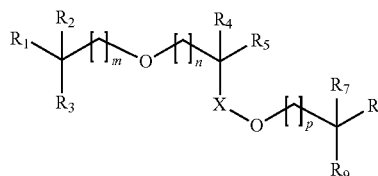
[0225] In some embodiments, X is  $C_{1-20}$  alkylene, such as  $C_{3-15}$  alkylene.

[0226] In some embodiments, p is 0, 1 or 2, such as 0 or 1.

[0227] 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

[0228] It is generally preferred that the compounds of formula (1) are monoethers. However, in some embodiments, the compound is a diether compound. Such compounds may have the formula (11):



[0229] where:  $R_1$  and  $R_2$  are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0230]  $R_3$ ,  $R_4$  and  $R_5$  are H or alkyl;

[0231]  $R_7$  and  $R_8$  are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0232]  $R_9$  is H or alkyl;

[0233] X is alkylene or is absent;

[0234] p is 0, 1, 2 or 3; and

[0235] m and n are 0, 1, 2 or 3.

[0236] In some embodiments,  $R_1$  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.

[0237] In some embodiments,  $R_3$ ,  $R_4$  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.

[0238] In some embodiments,  $R_7$  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.

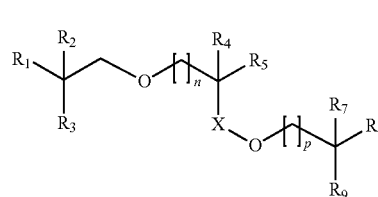
[0239] In some embodiments,  $R_9$  is H or  $C_{1-20}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_9$  is H.

[0240] In some embodiments, X is  $C_{1-20}$  alkylene, such as  $C_{3-15}$  alkylene.

[0241] In some embodiments, p is 0, 1 or 2, such as 0 or 1.

[0242] In some embodiments, m and n are 0, 1 or 2, such as 0 or 1.

[0243] In some embodiments, the diether compound may contain two ether groups, at least one of which is derived from a  $\beta$ -alkylated alcohol. In such embodiments, the compound may have the formula (12):



(12)

[0244] where:  $R_1$  and  $R_2$  are alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0245]  $R_3$ ,  $R_4$  and  $R_5$  are H or alkyl;

[0246]  $R_7$  and  $R_8$  are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

[0247]  $R_9$  is H or alkyl;

[0248] X is alkylene or is absent;

[0249] p is 0, 1, 2 or 3; and

[0250] n is 0, 1, 2 or 3.

**[0251]** In some embodiments,  $R_1$  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.

**[0252]** In some embodiments,  $R_3$ ,  $R_4$  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.

**[0253]** In some embodiments,  $R_7$  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.

**[0254]** In some embodiments,  $R_9$  is H or  $C_{1-20}$  alkyl, such as H or  $C_{2-12}$  alkyl. Preferably,  $R_9$  is H.

**[0255]** In some embodiments, X is  $C_{1-20}$  alkylene, such as  $C_{3-15}$  alkylene.

**[0256]** In some embodiments, p is 0, 1 or 2, such as 0 or 1.

**[0257]** In some embodiments, n is 0, 1 or 2, such as 0 or 1.

**[0258]** Examples of Guerbet-derived base stocks GE1-GE9, secondary ether base stocks SE1 and SE2, and tertiary ether base stock TE1 of formula (1), which may preferably be used in connection with the present application, are shown in Table 2.

TABLE 2

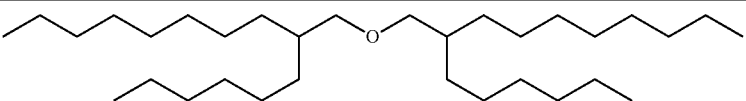
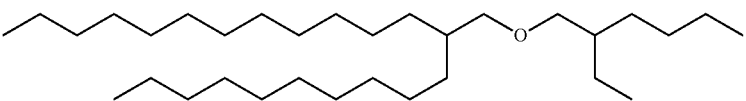
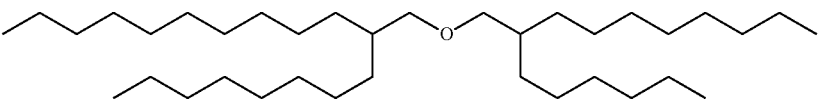
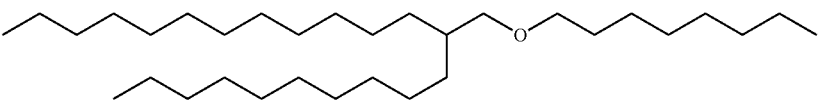
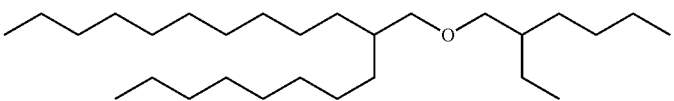
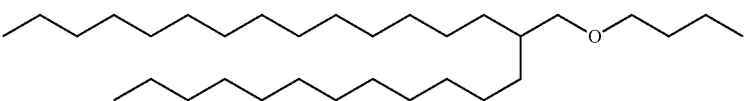
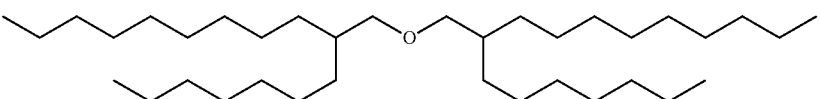
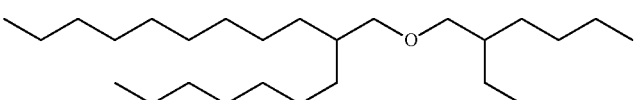
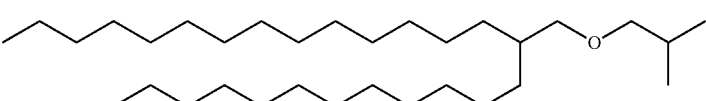
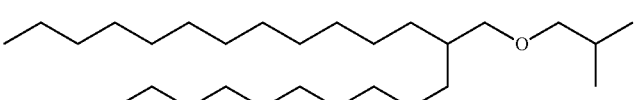
	Molecular Weight	Chemical Formula	Structure
GE1	466.87	$C_{32}H_{66}O$	
GE2	466.87	$C_{32}H_{66}O$	
GE3	522.97	$C_{36}H_{74}O$	
GE4	466.87	$C_{32}H_{66}O$	
GE5	410.76	$C_{28}H_{58}O$	
GE6	466.87	$C_{32}H_{66}O$	
GE7	522.57	$C_{36}H_{74}O$	
GE8	382.42	$C_{26}H_{54}O$	
GE9	466.51	$C_{32}H_{66}O$	
GE10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

TABLE 2-continued

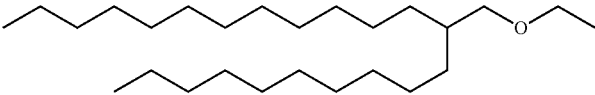
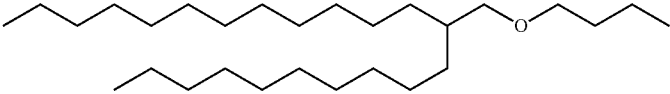
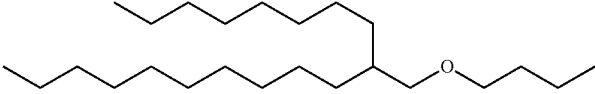
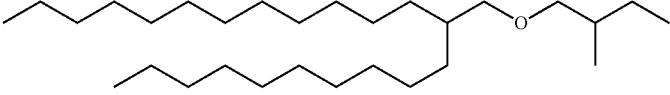
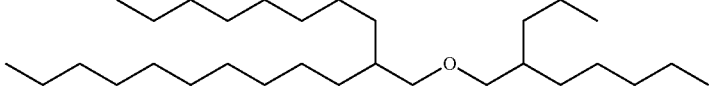
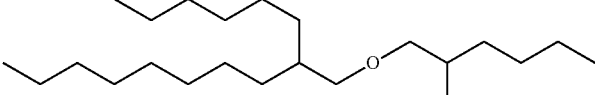
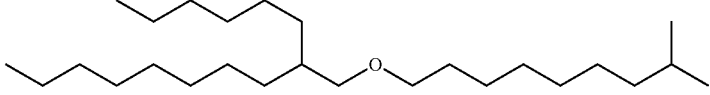
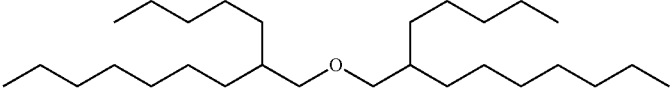
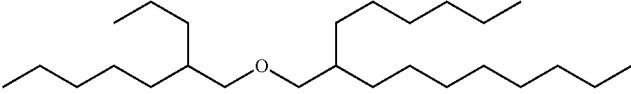
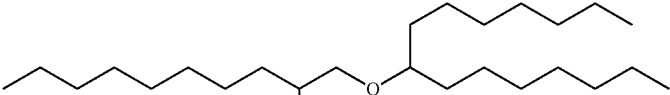
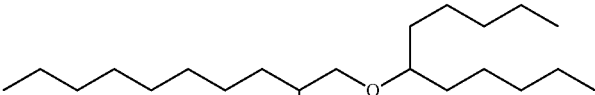
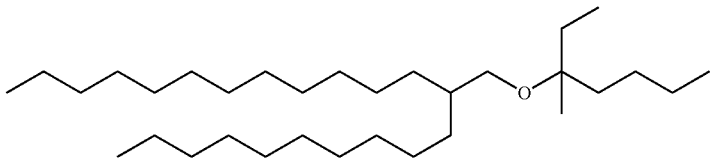
	Molecular Weight	Chemical Formula	Structure
GE12	382.71	C <sub>26</sub> H <sub>54</sub> O	
GE14	410.76	C <sub>28</sub> H <sub>58</sub> O	
GE15	354.65	C <sub>24</sub> H <sub>50</sub> O	
GE16	424.79	C <sub>29</sub> H <sub>60</sub> O	
GE18	438.81	C <sub>30</sub> H <sub>62</sub> O	
GE20	354.65	C <sub>24</sub> H <sub>50</sub> O	
GE21	382.71	C <sub>26</sub> H <sub>54</sub> O	
GE22	410.76	C <sub>28</sub> H <sub>58</sub> O	
GE23	382.71	C <sub>26</sub> H <sub>54</sub> O	
SE1	452.84	C <sub>31</sub> H <sub>64</sub> O	
SE2	396.43	C <sub>27</sub> H <sub>56</sub> O	

TABLE 2-continued

	Molecular Weight	Chemical Formula	Structure
TE1	466.87	C <sub>32</sub> H <sub>66</sub> O	

#### Base Oils and Lubricant Compositions

**[0259]** The ether compounds of formula (A), or the subset thereof of formula (1), are used as part of a base oil in accordance with the present invention.

**[0260]** 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.

**[0261]** In some embodiments, 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).

**[0262]** 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).

**[0263]** The base oils are used as part of the lubricant composition in accordance with the present invention.

**[0264]** 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.

**[0265]** 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. 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).

**[0266]** The lubricant composition comprises a dispersant in an amount of from 0.5 to 7%, by weight of the lubricant composition. As the skilled person will appreciate, dispersants may be added to a base oil composition in preparation of the lubricant composition in an isolated form or diluted in oil. Reference herein to an amount of dispersant included in the lubricant composition is to be understood as referring to the weight of dispersant species employed itself, without any dilution. Any amount of dispersant may be present in the lubricant composition of the invention provided it lies within the range of 0.5 to 7%, by weight of the lubricant compo-

sition. Similarly any sub-range of dispersant concentration which lies within the range of 0.5 to 7%, by weight of the lubricant composition may be used in accordance with the invention. For example, all sub-ranges formed from the combination of a lower weight percentage limit of 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9 or 3.0 together with an upper weight percentage limit of 7.0, 6.9, 6.8, 6.7, 6.6, 6.5, 6.4, 6.3, 6.2, 6.1, 6.0, 5.9, 5.8, 5.7, 5.6, 5.5, 5.4, 5.3, 5.2, 5.1 or 5.0 may be utilized in accordance with the present invention.

**[0267]** In preferred embodiments, the total amount of dispersant additive present in the lubricant composition is from 1.0 to 7.0%. In other preferred embodiments, the total amount of dispersant additive present in the lubricant composition is from 1.0 to 6.5%, by weight of the lubricant composition. In other preferred embodiments, the total amount of dispersant additive present in the lubricant composition is from 2.0 to 6.0%, by weight of the lubricant composition. In other preferred embodiments, the total amount of dispersant additive present in the lubricant composition is from 3.0 to 5.0%, by weight of the lubricant composition.

**[0268]** A particular advantage of the present invention relates to the dispersancy properties conferred to the lubricant composition by the presence of ether compounds of formula (A), or of the subset thereof of formula (1). This allows a desirable lubricant viscosity profile and dispersancy properties to be attained without the need for the same concentration of dispersants as would usually be required in a comparable lubricant composition which is formulated without any ether compounds of formula (A) or formula (1). A dispersant level representative of a high performance engine oil typically lies between 7 and 10%, by weight of the lubricant composition. The present invention enables the use of much lower concentrations of dispersants to achieve the same or better dispersancy properties and viscosity profile, both before and during use, for instance, in an internal combustion engine, compared to conventional lubricant compositions, which do not contain any ether compounds of formula (A) or formula (1), and which comprise the same dispersants but in higher concentration. This is of particular benefit from a cost perspective as well as from a lubricant composition lifetime, fuel economy, elastomer compatibility and piston and engine cleanliness perspective.

**[0269]** Dispersants of use in connection with the present invention include both metallic and non-metallic dispersants. 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 such as polyisobutylene succinyl anhydride-polyamines (PIBSA-PAM); 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).

[0270] The dispersants for use in connection with the present invention suitably have a molecular weight of less than 20,000 g/mol, preferably less than 15,000 g/mol, such as less than 12,000 g/mol or less than 10,000 g/mol. In preferred embodiments, the dispersants for use in connection with the present invention have a molecular weight of from 500 to 20,000 g/mol, 500 to 15,000 g/mol, 800 to 10,000 g/mol or 1,200 to 7,500 g/mol. Molecular weight of the dispersants may readily be determined, for instance, by gel permeation chromatography or light scattering methods. As will be appreciated by the skilled person, dispersants for use in connection with the present invention do not encompass polymeric dispersant viscosity modifiers, whose molecular weights lie above 20,000 g/mole, such as between 25,000 and 500,000 g/mol.

[0271] In preferred embodiments, the dispersant for use in connection with the present invention is a nitrogen-containing dispersant. In particularly preferred embodiments, the nitrogen-containing dispersant has a molecular weight of from 500 to 20,000 g/mol, 500 to 15,000 g/mol, 800 to 10,000 g/mol or 1,200 to 7,500 g/mol.

[0272] In other embodiments, the dispersant for use in connection with the present invention is a non-nitrogen-containing dispersant. The non-nitrogen-containing dispersant may in some embodiments have a molecular weight of from 500 to 20,000 g/mol, 500 to 15,000 g/mol, 800 to 10,000 g/mol or 1,200 to 7,500 g/mol.

[0273] The lubricant composition may also comprise other lubricant additives, in addition to the dispersant additive. 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, such as about 4% to about 15% by weight.

[0274] Suitable additional lubricant additives include detergents (including metallic and non-metallic detergents), friction modifiers, viscosity modifiers, 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.

[0275] 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 U.S. Pat. No. 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).

[0276] 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 tri-oleates, 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].

[0277] 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.

[0278] 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.

[0279] In some embodiments, the lubricant composition comprises a pour point depressant. Examples of suitable pour point depressants include C<sub>8</sub> to C<sub>18</sub> 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 dialkylfumarates, vinyl esters of fatty acids and allyl vinyl ethers, wax naphthalene and the like.

[0280] 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 triauryl 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).

**[0281]** 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. %, based on the total weight of the lubricant composition.

**[0282]** 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.

**[0283]** 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.

**[0284]** In some embodiments, the lubricant composition comprises an antioxidant. Examples of suitable antioxidants include alkylated diphenylamines, N-alkylated phenylene-

diamines, phenyl-a-naphthylamine, alkylated phenyl-a-naphthylamines, dimethylquinolines, trimethyldihydroquinolines and oligomeric compositions derived therefrom, hindered phenolics (including ashless (metal-free) phenolic compounds and neutral and basic metal salts of certain phenolic compounds), aromatic amines (including alkylated and non-alkylated aromatic amines), sulphurised alkyl phenols and alkali and alkaline earth metal salts thereof, alkylated hydroquinones, hydroxylated thiodiphenyl ethers, alkylidenebisphenols, 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<sub>8</sub> to C<sub>18</sub> 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<sub>5</sub> to C<sub>12</sub> alkyl side chains, calcium nonylphenol sulphide, barium t-octylphenyl sulphide, dioctylphenylamine, phosphosulphurised or sulphurised hydrocarbons, oil soluble phenates, oil soluble sulphurised phenates, calcium dodecylphenol sulphide, phosphosulphurised hydrocarbons, sulphurised hydrocarbons, phosphorus esters, low sulphur peroxide decomposers and the like.

**[0285]** In some embodiments, the lubricant composition comprises an antifoam agent. Examples of suitable antifoam agents include silicones, organic polymers, siloxanes (including poly siloxanes and (poly) dimethyl siloxanes, phenyl methyl siloxanes), acrylates and the like.

**[0286]** 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.

**[0287]** The lubricant composition may comprise lubricant additives in the amounts shown in Table 3.

TABLE 3

Additive type	Lubricant composition	
	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 100 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
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%
Anti-oxidants	About 0.01 to about 10%	About 0.5 to about 5%
Antifoams containing silicon	Corresponding to about 1 to about 20 ppm Si	Corresponding to about 1 to about 10 ppm Si

**[0288]** 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.

**[0289]** 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.

**[0290]** The lubricant compositions may have a viscosity at 150° C. and a shear rate of  $10^6 \text{ s}^{-1}$  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.

**[0291]** The lubricant composition may have at least one of:

**[0292]** 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%; 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.

**[0293]** 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.

**[0294]** Preferred lubricant compositions meet the requirements set out in SAE J300.

performance of an internal combustion engine and/or a vehicle, such as an automotive vehicle associated with an internal combustion engine. Accordingly, there are provided 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.

**[0299]** The invention will now be described with reference to the accompanying figures and examples, which are not limiting in nature, in which:

**[0300]** FIG. 1 is a graph of absolute viscosity increase at 100° C. and 5% soot for blended compositions containing Guerbet-derived base stock (GE3) and a Baseline composition;

**[0301]** FIG. 2 is a graph of kinematic viscosity at 100° C. against soot loading percentage for a blend containing Guerbet-derived base stock and a Baseline composition;

**[0302]** FIG. 3 is a graph showing engine sludge and varnish merits achieved in a Sequence VG Engine test of blended compositions containing Guerbet-derived base stock (GE3) and a Baseline composition; and

**[0303]** FIG. 4 is a graph of central spot area of total (%) against dispersant concentration (%) relating to a Soot Blotter Test performed for compositions of the invention and non-ether based lubricant compositions.

## EXAMPLES

### Example 1—Properties of Ether Base Stocks

**[0304]** 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	$\text{C}_{36}\text{H}_{74}\text{O}$	

**[0295]** The lubricant compositions may be used in a method of lubricating a surface.

**[0296]** 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.

**[0297]** 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.

**[0298]** The lubricant compositions may be used to improve the fuel economy and/or piston cleanliness perfor-

**[0305]** The following properties of the base stock were tested:

**[0306]** Kinematic viscosity at 100° C. (KV100) and kinematic viscosity at 40° C. (KV40) were tested according to ASTM D7279.

**[0307]** Viscosity index (VI) was calculated according to ASTM D2270.

**[0308]** Pour point was determined according to ASTM D7346.

**[0309]** 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.

**[0310]** 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.

**[0311]** 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).

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

**[0312]** 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

**[0313]** 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

**[0314]** No problems with miscibility were encountered during preparation of the blended compositions.

**[0315]** 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:

**[0316]** Kinematic viscosity at 100° C. (KV100) and kinematic viscosity at 40° C. (KV40) were tested according to ASTM D445 (part of SAE J300).

**[0317]** Viscosity index (VI) was calculated according to ASTM D2270.

**[0318]** Cold-cranking simulator (CCS) analysis was carried out at -30° C. according to ASTM D5293 (part of SAE J300).

**[0319]** High temperature high shear (HTHS) analysis was carried out according to CEC-L-36-A-90.

**[0320]** Total base number (TBN) was determined according to ASTM D2896.

**[0321]** Noack volatility was tested according to CEC-L-40-A-93.

**[0322]** Sulphated ash content was measured according to IP 163.

**[0323]** 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
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

**[0324]** 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: DV-4 Soot Handling Test

**[0325]** The blended compositions from Example 2 were subjected to a DV-4 soot handling test in accordance with CEC-L-93-04 in order to determine the ability of the compositions to handle an increase in soot loading. Results for absolute viscosity increase at 100° C. and 5% soot, as well as kinematic viscosity increase at 100° C. with increasing soot level from 0 to 6%, obtained from the DV-4 testing are shown in Table 8. The pass limit for a particular sample is set in accordance with a reference oil RL223, tested shortly prior to the sample. As will be appreciated, experimental variation between reference runs may therefore influence the pass limit, so in order to ensure consistency over time, a passing limit is less than or equal to 60% of the KV100 viscosity increase of reference oil RL223 at 6% soot loading.

TABLE 8

	Baseline blend	GE3 blend	Limits
Absolute viscosity increase at 100° C. and 5% soot (mm <sup>2</sup> /s)	9.72	3.83	≤8.6 (GE3) ≤10.3 (baseline)
Soot content/ Kinematic Viscosity at 100° C. (mm <sup>2</sup> /s) - 0 hours	0/9.39	0/8.53	

TABLE 8-continued

	Baseline blend	GE3 blend	Limits
Soot content/ Kinematic Viscosity at 100° C. (mm <sup>2</sup> /s) - 24 hours	1.07/9.96	1.12/9.29	
Soot content/ Kinematic Viscosity at 100° C. (mm <sup>2</sup> /s) - 48 hours	2.19/10.55	2.63/9.93	
Soot content/ Kinematic Viscosity at 100° C. (mm <sup>2</sup> /s) 72 hours	3.31/12.03	3.59/10.84	
Soot content/ Kinematic Viscosity at 100° C. (mm <sup>2</sup> /s) - 96 hours	4.56/14.89	4.86/11.31	
Soot content/ Kinematic Viscosity at 100° C. (mm <sup>2</sup> /s) - 120 hours	5.68/18.17	6.13/12.48	

[0326] The lubricant composition containing the Guerbet-derived base stock passed all aspects of the DV-4 test.

[0327] A graph of the results from Table 8 of absolute viscosity increase at 100° C. and 5% soot for the blended compositions tested is shown in FIG. 1, illustrating the substantially lower viscosity increase observed with the blend containing Guerbet-derived base stock (GE3) as opposed to the Baseline composition.

[0328] Similarly, a graph of the results of kinematic viscosity at 100° C. against soot loading percentage from Table 8 is shown in FIG. 2 for the blend compositions, illustrating a substantially lower rate of viscosity increase in the blend containing Guerbet-derived base stock with increasing soot loading compared with the Baseline composition.

[0329] The graphs of FIGS. 1 and 2 demonstrate that a blend containing an ether base stock, preferably a Guerbet-derived base stock, is more resilient to viscosity increase when subjected to soot than a blend formulated with a conventional base stock.

Example 4: Sequence VG Engine Test

[0330] The blended compositions from Example 2 were subjected to a Sequence VG Engine Test according to ASTM D6593. This test method is used to evaluate an automotive engine oil's control of engine sludge and deposits under operating conditions deliberately selected to accelerate sludge and deposit formation. Cleanliness of the engine is measured via sludge and varnish merits, whereby a higher score demonstrates increased engine cleanliness. Results for the different blended compositions are provided in Table 9.

TABLE 9

	Baseline blend	GE3 blend	Limits (ACEA A1)
Final Average Engine Sludge (Merits)	8.56	9.35	>7.8
Final Rocker Cover Sludge (Merits)	9.44	9.56	>8
Final Average Piston Skirt Varnish (Merits)	8.71	8.79	>7.5

TABLE 9-continued

	Baseline blend	GE3 blend	Limits (ACEA A1)
Final Average Engine Varnish (Merits)	9.34	9.48	>8.9

[0331] The results of the Sequence VG Engine Test shown in Table 9, which are also illustrated in FIG. 3, demonstrate that the blended composition comprising the Guerbet-derived base stock provides superior performance in each aspect of the test, particularly in reducing average engine sludge formation, in comparison to the Baseline composition.

[0332] The results of the DV-4 soot handling test and Sequence VG Engine Test highlight the superior performance of the blended composition comprising the Guerbet-derived base stock in comparison to the Baseline composition. In particular, it has been consistently shown that the blended composition comprising the Guerbet-derived base stock exhibits substantially lower viscosity increases in response to increasing levels of soot and performs better in preventing engine sludge formation in comparison with a Baseline composition comprising the same conventional amount of dispersant.

[0333] It therefore follows that blended compositions comprising ether base stocks in accordance with the present invention will exhibit the same or improved performance even where a lower amount of dispersant is contained in the formulation compared to conventional blended compositions, such as the blended Baseline composition utilized in the above examples. Using lower than conventional amounts of dispersant in a lubricant composition is particularly advantageous as it avoids viscosity increases associated with the presence of dispersants which compromises fuel economy. Thus, the same or better fuel economy in an engine is achievable with the lubricant compositions of the invention compared to lubricant compositions comprising conventional base stocks employing greater amounts of dispersant.

[0334] The effects of using lower dispersant amounts in the lubricating compositions in accordance with the invention are further illustrated in the below example.

Example 5: Soot Blotter Test

[0335] Blended compositions comprising Guerbet-derived base stock (GE3) or a Group III base stock (Yubase 4) together with varying amounts of the same dispersant (PIBSA-PAM) were subjected to a Soot Blotter Test according to the following method:

[0336] 1. Weigh out 1 g of a standard marine heavy fuel oil (HFO).

[0337] 2. Add 99 g of candidate lubricant composition to the 1 g of HFO.

[0338] 3. Shear the HFO/lubricant mix at 3400 rpm in a Silverson stirrer for 120 seconds.

[0339] 4. Place the sheared oil/HFO mixture into an oven at 60° C. and leave for 24 hours.

[0340] 5. Remove oil from oven and spot samples of HFO/lubricant mix on to filter paper.

[0341] 6. Place filter paper into the oven at 60° C. for 60 minutes.

[0342] 7. Remove filter paper from the oven and measure average diameter of central dark spot and average diameter of the whole spot based on four measurements.

[0343] 8. Calculate percentage area of central spot based on total average area of the whole spot, calculated based on the average diameters measured in step 7.

[0344] 9. Percentage calculated in step 8 corresponds to the degree of dispersancy.

[0345] HFO contains a significant proportion of asphaltenes and therefore the Soot Blotter Test effectively tests the ability of the candidate lubricant composition to disperse and hold asphaltenes in the oil phase; higher percentages determined in the Soot Blotter Test mean that the asphaltene is better dispersed within the oil phase, indicating that soot and sludge will be better dispersed in the oil in use. Results for the Soot Blotter Test for different compositions comprising different concentrations of dispersant are shown in Table 10.

TABLE 10

Base stock	Dispersant concentration (%)	Central spot area of total (%)
Yubase 4	0	44.5
	1	50.0
	2	50.8
	4	53.5
	6	57.3
GE3	0	50.5
	1	53.3
	2	55.8
	4	60.5
	6	60.7

[0346] The results of the Soot Blotter Test shown in Table 10 demonstrate that the blended composition comprising the Guerbet-derived base stock provides superior performance in each aspect of the test, particularly in reducing average engine sludge formation, in comparison to the Baseline composition. These results are also provided in a graph shown in FIG. 4 showing central spot area of total (%) against dispersant concentration (%) which further illustrates the improvement in soot and sludge handling properties of the compositions of the invention in comparison to conventional non-ether based lubricant compositions. For example, it will be appreciated that a composition according to the invention comprising 4% dispersant provides better dispersancy than the Yubase 4 lubricant composition comprising 6% dispersant. Similarly, a composition according to the invention comprising 2% dispersant provides better dispersancy than the Yubase 4 lubricant composition comprising 6% dispersant. These results demonstrate that lubricant compositions comprising ether base-stocks according to the present invention allow for lower amounts of dispersant to be used in the formulation whilst maintaining desirable soot and sludge handling properties.

[0347] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as “40 mm” is intended to mean “about 40 mm.”

[0348] Every document cited herein, including any cross referenced or related patent or application, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. 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 incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0349] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope and spirit of this invention.

1. A lubricant composition comprising a base oil of lubricating viscosity,

wherein the base oil comprises an ether base stock of formula (A):



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

the lubricant composition further comprising from 0.5 to 7% of total dispersant additive, by weight of the lubricant composition.

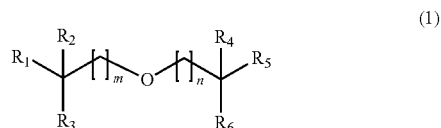
2. The lubricant composition of claim 1, wherein at least one of  $R_a$  and  $R_b$  is branched-chain alkyl, alkoxy-substituted-alkyl or cycloalkyl-substituted-alkyl.

3. The lubricant composition of claim 2, wherein  $R_a$  and  $R_b$  are 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/are branched-chain alkyl.

4. The lubricant composition of claim 1, wherein  $R_a$  contains more carbon atoms than  $R_b$ .

5. The lubricant composition of claim 1, wherein  $R_a$  contains from 12 to 30 carbon atoms, and/or  $R_b$  contains from 2 to 20 carbon atoms.

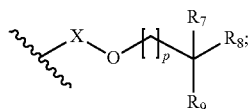
6. The lubricant composition of claim 1, wherein the ether base stock is of formula (1):



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

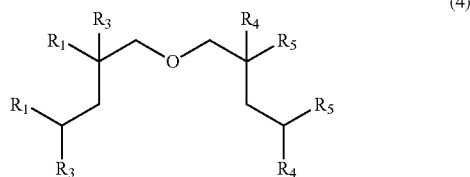
p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3, wherein m is 0 when  $R_4$  and  $R_5$  are H.

7. The lubricant composition of claim 6, wherein  $R_1$  and  $R_2$  are  $C_{1-15}$  alkyl or, together with the carbon atom to which they are attached,  $C_{5-30}$  cycloalkyl, and/or wherein  $R_3$ ,  $R_4$  and  $R_5$  are H or  $C_{1-15}$  alkyl.

8. The lubricant composition of claim 6, wherein m and n are 0, 1 or 2.

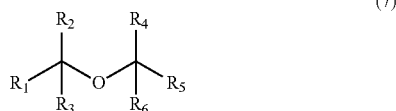
9. The lubricant composition of claim 6, wherein the ether base stock has the formula (4):



where:  $R_1$  and  $R_4$  are alkyl;

$R_3$  and  $R_5$  are H or alkyl.

10. The lubricant composition of claim 6, wherein the ether base stock has the formula (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.

11. The lubricant composition of claim 1, wherein the ether base stock contains a total number of carbon atoms of from 20 to 50.

12. The lubricant composition of claim 1, wherein the ether base stock is prepared from bio-derived feedstock containing greater than 50% by weight of biobased carbon.

13. The lubricant composition of claim 1, wherein the base oil of the lubricant composition comprises greater than 10% by weight of the ether base stock and/or wherein the lubricant composition comprises greater than 50% by weight of the base oil.

14. The lubricant composition of claim 13, wherein the base oil of the lubricant composition further comprises a

base stock selected from Group I, Group II, Group III, Group IV and Group V base stocks and mixtures thereof.

15. The lubricant composition of claim 1, wherein the lubricant composition has at least one of:

a kinematic viscosity at 40° C. of less than 60 cSt;

a kinematic viscosity at 100° C. of less than 12 cSt;

a viscosity index of greater than 100;

a viscosity at 150° C. and a shear rate of  $10^6 \text{ s}^{-1}$  of no greater than 3 cP; and

a Noack volatility of less than 25% by weight.

16. The lubricant composition of claim 1, 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;

a fuel economy performance on a CEC-L-054-96 test of at least 2.5%; and

a piston cleanliness performance on a CEC-L-088-02 test indicated by an overall piston merit of at least 8.5.

17. The lubricant composition of claim 1, wherein the total amount of dispersant additive present in the lubricant composition is from 1.0 to 7.0% by weight of the lubricant composition.

18. The lubricant composition of claim 1, wherein the dispersant additive is selected from 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; and Koch reaction products.

19. The lubricant composition of claim 1, wherein the dispersant additive is selected from those having a molecular weight of from 500 to 15,000 g/mol.

20. The lubricant composition of claim 18, wherein the dispersant additive is selected from nitrogen-containing dispersants.

21. The lubricant composition of claim 1, wherein the amount of phosphorus contained in the lubricant composition is less than 0.5 wt % based on the total weight of the lubricant composition.

22. A method of preparing a lubricant composition, said method comprising providing a base oil as defined in claim 1 and blending the base oil with 0.5 to 7% of total dispersant additive by weight of the lubricant composition, and optionally one or more additional lubricant additives in order to prepare the lubricant composition.

23. A method of lubricating a surface, said method comprising supplying a lubricant composition according to claim 1 to said surface, such as wherein the lubricant composition is supplied to a surface in an internal combustion engine.

24. (canceled)

25. A method of improving the dispersancy properties and/or viscosity profile of a lubricant composition comprising the step of providing or supplying to the lubricant composition at least one of the ether base stocks defined in claim 1.

26. (canceled)

27. A method of improving the fuel economy performance and/or piston cleanliness performance of an engine and/or a

vehicle, comprising the step of providing the engine and/or the vehicle with a lubricant composition according to claim

1.

28. (canceled)

\* \* \* \* \*