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(54) Title: USE OF ETHER BASE STOCKS

(57) Abstract: The present invention relates to the use of an ether base stock in a lubricating composition for reducing and/or preventing the loss of the lubricating composition through combustion when used for lubricating an internal combustion engine. The present invention also relates to the use of a lubricating composition comprising the ether base stock for reducing poisoning of exhaust after-treatment systems of automotive vehicles and for reducing low- speed pre-ignition (LSPI) in automotive vehicles. Methods of extending the oil drain interval of an internal combustion engine are also provided, as well as lubricating compositions comprising the ether base stock.

Use of Ether Base Stocks

The present invention relates, at least in part, to the use of an ether base stock for reducing and/or preventing the loss of lubricating composition through combustion when used in an internal combustion engine, and the use of a lubricating composition comprising an ether base stock for improving oil consumption through combustion in an internal combustion engine. The present invention also relates to the use of a lubricating composition comprising an ether base stock for reducing poisoning of exhaust after-treatment systems of automotive vehicles and for reducing low-speed pre-ignition (LSPI) in automotive vehicles. Methods of extending the oil drain interval of an internal combustion engine are also provided, as well as lubricating compositions comprising the ether base stock.

Background

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, detergency, and resistance to oxidation and corrosion. A lubricant base oil may comprise one or more lubricating base stocks.

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.

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

Table 1

Group	Saturated hydrocarbon content (% by weight) ASTM D2007		Sulphur content (% by weight) ASTM D2622, D4294, D4927, D3120 or D1552		Viscosity Index ASTM D2270

I	< 90	and/or	> 0.03	and	≥ 80 and < 120
II	≥ 90	and	≤ 0.03	and	≥ 80 and < 120
III	≥ 90	and	≤ 0.03	and	≥ 120
IV	Polyalphaolefins				
V	all base stocks not in Groups I, II, III or IV				

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.

A combination of properties is desirable in a base stock. In some instances, for example in passenger car engine oils, it may be desirable for a base stock to have a low viscosity profile, 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.

Problems may also be encountered when a base stock is incorporated into a lubricating composition and 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 base stock and oil seals that are found in engines may, in some cases, lead to loss of lubricant through failure of the oil seals. Base stocks may also undergo oxidative degradation at the high temperatures encountered in an engine. Base stocks containing polar groups such as ester or other groups may be particularly prone to at least some of these problems.

WO 2016/203310 describes an ether base stock having a desirable viscosity profile and low volatility for a given viscosity profile, but which is also suitable for use, for example, in a lubricating composition for an internal combustion engine.

One problem associated with lubricating compositions used for lubricating internal combustion engines is that consumption of the lubricating composition (also referred to as oil consumption) can occur during operation. This can occur via two pathways: by combustion of the lubricating composition or by evaporation of the base-stocks.

Combustion of the lubricating composition occurs when the lubricating composition is, undesirably, present in the combustion chamber and combusts with the fuel. Lower viscosity lubricating compositions are inherently expected to have worse oil consumption via combustion than a higher viscosity lubricating composition as they are able to reach the combustion chamber with greater ease.

Upon combustion of the lubricating composition, the additive content remains unchanged, as measured by metal content, as the additives also combust in the combustion chamber and are removed via the exhaust gases, leading to no overall proportional change in additive content of the remaining lubricating composition. Conversely, evaporation of the base-stock of the lubricating composition leads to increased levels of additive in the remaining lubricating composition and thus higher observed additive content as measured by metal content.

Oil consumption by combustion can cause catalytic systems to become less effective through poisoning of exhaust after-treatment devices, resulting in greater emissions. It can also lead to increased back pressure by blockage of particulate filters and thus give rise to greater fuel consumption. Oil consumption by combustion can also result in an increased tendency for low speed pre-ignition (LSPI), which can result in pressure spikes, engine knocking and even significant engine damage. The problem of LSPI can have a substantial impact on engine design, and particularly the ability for manufacturers to obtain the full potential of turbocharged engines in improving fuel efficiency. Furthermore, loss of metal containing additives can significantly decrease the lubricating composition's performance in regards to wear and detergency.

Additionally, the metal content of lubricating compositions is currently limited through a total ash content level dictated by API, ACEA and OEM specifications. In particular, these specifications dictate the total amount of ash from metallic elements, thereby indirectly dictating the calcium, magnesium, titanium, molybdenum and zinc levels in a lubricating composition. These specifications also dictate the sulphur and phosphorus levels of a lubricating composition. If less of the lubricating composition is lost through

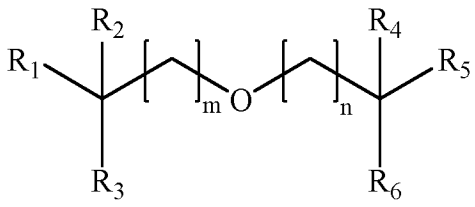
combustion, it would also allow for higher levels of metal additives to be used. As will be appreciated, metal additives do not evaporate, therefore any loss of these metal additives is attributed to combustion.

For these reasons, a vehicle operated using a lubricating composition exhibiting lower oil consumption via combustion will have lower emissions, retain catalyst activity, have increased fuel economy and retain performance for longer, due to less after-treatment poisoning.

The present invention is based on the surprising discovery that ether base stocks, although expected to reduce viscosity parameters of a lubricating composition and therefore potentially exacerbate oil consumption, have an unexpectedly beneficial effect in reducing oil consumption through combustion.

Summary

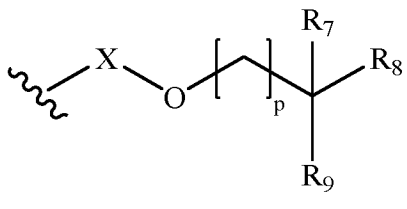
Provided is the use of a compound of formula (1), or a base oil comprising a compound of formula (1), for improving resistance of a lubricating composition to oil consumption through combustion when used for lubricating an internal combustion engine:



(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.

Also provided is the use of a lubricating composition comprising a base oil including a compound of formula (1) to improve oil consumption through combustion in an internal combustion engine.

Also provided is the use, in an internal combustion engine of an automotive vehicle comprising an exhaust after-treatment system, of a lubricating composition comprising a base oil including a compound of formula (1) for reducing poisoning of the exhaust after-treatment system.

Also provided is the use, in an internal combustion engine of an automotive vehicle, of a lubricating composition comprising a base oil including a compound of formula (1), for reducing low-speed pre-ignition (LSPI) in the automotive vehicle.

Also provided is a method for improving resistance of a lubricating composition to oil consumption through combustion when used for lubricating an internal combustion engine, said method comprising the step of incorporating a compound of formula (1), or a base oil comprising a compound of formula (1), into a lubricating composition.

Also provided is a method for improving oil consumption through combustion in an internal combustion engine, said method comprising providing or supplying to the internal combustion engine a lubricating composition comprising a base oil including a compound of formula (1).

Also provided is a method for reducing poisoning of an exhaust after-treatment system of an automotive vehicle, said method comprising providing or supplying to an internal combustion engine of the automotive vehicle a lubricating composition comprising a base oil including a compound of formula (1).

Also provided is a method for reducing low-speed pre-ignition (LSPI) in an automotive vehicle, said method comprising providing or supplying to an internal combustion engine of the automotive vehicle a lubricating composition comprising a base oil including a compound of formula (1).

Also provided is a method of extending the oil drain interval of an internal combustion engine in an automotive vehicle, said method comprising the following steps;

i) determining the oil drain interval for an internal combustion engine operating in the presence of a lubricating composition having a particular SAE viscosity grade and which

does not contain a base oil according to formula (1), wherein the oil drain interval is defined as a cumulative time period of operation of the engine, or a cumulative distance travelled by an automotive vehicle powered by the engine, at which 20 % by weight of the lubricating composition is consumed, as determined by the OM646LA (CEC L-99-08) test;

ii) at least partially replacing the lubricating composition of step i) which is in contact with the engine with a lubricating composition comprising a base stock of formula (1) and having the same SAE viscosity grade as the lubricating composition of step i); and

iii) operating the engine over an oil drain interval which is greater than that determined in step i).

Also provided is a lubricating composition for an internal combustion engine containing a base oil comprising:

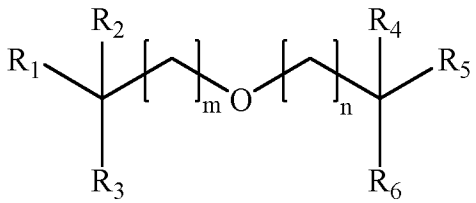
i) a compound of formula (1); and

ii) at least 500 ppm of elemental calcium, preferably from 500 to 4,000 ppm of elemental calcium, more preferably from 550 to 3.000 ppm of elemental calcium.

Detailed description

Ether base stocks

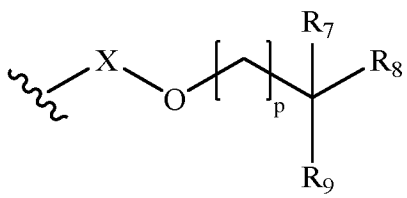
The present invention provides uses of a compound of formula (1), or a base oil comprising a compound of formula (1), as described herein:



(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

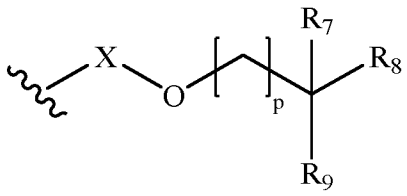
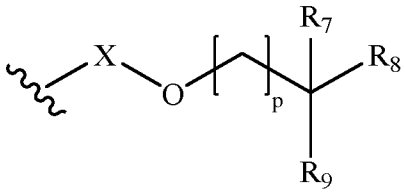
p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3.

In some embodiments, m is 0 when R_4 and R_5 are H.

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.

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.

In some embodiments, R_6 is C_{1-20} alkyl or , such as C_{1-16} alkyl or .

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

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.

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.

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

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

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

R_1 and R_2 are as described as alkyl or, together with the carbon atom to which they are attached, cycloalkyl. It will be understood that, where R_1 and R_2 are both alkyl groups, they

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

In each of the embodiments disclosed herein, the compounds may contain a total number of carbons atoms of from about 20 to about 50. For instance, the total number of carbons in the compounds may be from about 24 to about 45, such as from about 26 to about 40 or from about 28 to about 36.

The alkyl and alkylene groups mentioned herein, *i.e.* those that may be represented by R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9 and X, may be straight chain alkyl or alkylene groups, though they may also be branched. In some embodiments, each alkyl group and each alkylene group contains a single branch point or is a straight chain alkyl or alkylene group. The alkyl and alkylene groups are preferably straight chain alkyl or alkylene groups. It will be understood that the alkyl and alkylene groups do not contain any atoms other than carbon or hydrogen.

The cycloalkyl groups mentioned herein may contain a cyclopentyl, cyclohexyl or cycloheptyl group optionally having alkyl groups attached thereto.

The compounds of 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.

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.

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

The compounds 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.

The 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.

The 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).

In particular embodiments, the compounds of 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 13 %, by weight; or a kinematic viscosity at 100 °C of about 3 to about 3.5 cSt, and a Noack volatility of less than about 40 %, such as less than about 30 %, by weight.

The compounds of formula (1) are also particularly suited for blending into a lubricating 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 lubricating 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 lubricating compositions.

The compounds of formula (1) may be prepared from a wide range of commercially available feedstocks.

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 90 % by weight of biobased carbon. The biobased carbon content of the compounds may be measured according to ASTM D6866.

The term ‘improve’ as used herein in relation to ‘improving resistance of a lubricating composition to oil consumption’ and the like is intended to refer to increasing the resistance of the lubricating composition to oil consumption. The term ‘improve’ as used herein in

relation to 'improving oil consumption' and the like is intended to refer to a reduction in oil consumption. Both of these definitions relate to positive effects.

Various methods have been developed for testing the oil consumption of a lubricating composition, and for determining the oil consumption specifically through combustion, which are known to the person skilled in the art. For example, the OM646LA (CEC L-99-08) engine test is a method of defining whether a lubricating composition demonstrates a benefit in wear. However, it also reports oil consumption and end of test total acid number (TAN), total base number (TBN) and metal composition in the form of ICP parameters. The oil consumption through combustion and base-oil evaporation can also be determined. Alternative methods of testing oil consumption can be found in SAE paper 952547 and SAE paper 948274.

The compound of formula (1) may be used to improve the resistance of a lubricating composition to oil consumption through combustion. Such an improvement may therefore encompass maintenance of the amount of a lubricating composition associated with an internal combustion engine and/or an increase in the longevity or endurance of the lubricating composition when employed in lubricating an internal combustion engine, through a reduction in oil consumption by combustion.

The compound of formula (1) may be used to improve the resistance of a lubricating composition to oil consumption through combustion and therefore may, as a result, help maintain the fuel economy performance and/or piston cleanliness performance of an internal combustion engine.

A lubricating composition comprising the compound of formula (1) may be used in an internal combustion engine of an automotive vehicle, for reducing after-treatment system poisoning resulting from combustion of the lubricating composition. As will be appreciated, "poisoning" in this context will be understood to mean causing a deterioration or complete failure in performance of the after-treatment system, or a component thereof, for example by catalyst inactivation or particulate filter blocking.

The reduction in after-treatment system poisoning achievable through the use of the lubricating compositions comprising a compound of formula (1) may reduce engine emissions, retain catalyst activity of an after-treatment system for longer, retain particulate filter performance of an after-treatment system for longer, increase the fuel economy of the engine and retain engine performance for longer. By reducing combustion of the lubricating

composition used to lubricate the internal combustion engine of an automotive vehicle, harm to the catalytic components and/or blocking of particulate filter components of an after-treatment system may be advantageously reduced. In addition, reducing combustion of a lubricating composition used to lubricate an internal combustion engine means that the lubricant composition has broader compatibility with different vehicle after-treatment systems, and devices thereof. It also allows higher than conventional amounts of additives to be used, without an increased detriment to after-treatment systems compared to the use of lubricant compositions not employing a base stock comprising a compound of formula (1).

A lubricating composition comprising the compound of formula (1) may also be used in an internal combustion engine of an automotive vehicle for reducing LSPI, for example by reducing oil combustion. LSPI may be assessed using the Sequence IX test method (using a Ford engine, ASTM number yet to be defined).

The compound of formula (1) may be used in a lubricating composition to allow for an increase in the concentration of additives, particularly ash and metal additives, in the lubricant composition. This is because a reduction in oil consumption by combustion allows increased amounts of metal additives to be used without the expected increase in catalyst poisoning of an after-treatment system, increase of emissions associated with combustion of these additives, increase in blockages of particulate filters and/or the increase in LSPI which results from combustion of the lubricating composition.

This increase in the concentration of additives may result in a lubricating composition with improved properties (for example, in terms of anti-wear and detergency performance). In particular, the concentration of calcium, which has historically been particularly problematic for exacerbating LSPI, may be increased in the lubricating composition beyond conventional levels due to the presence of the base stock comprising a compound of formula (1) and its effect of reducing LSPI. This increase in the concentration of additives, particularly calcium, may also contribute further to extending the oil drain interval of an automotive vehicle powered by the internal combustion engine and lubricated by the lubricating composition comprising the compound of formula (1).

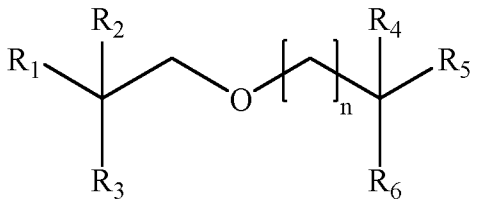
Accordingly, the present invention also provides a lubricating composition for an internal combustion engine containing a base oil comprising:

i) a compound of formula (1); and

ii) at least 500 ppm of elemental calcium, preferably from 500 to 4,000 ppm of elemental calcium, more preferably from 550 to 3.000 ppm of elemental calcium.

Guerbet-derived base stocks

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

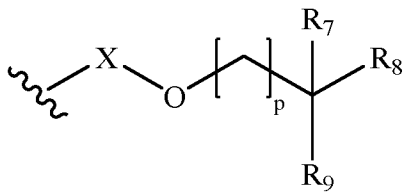


(2)

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

R_3 and R_5 are H or alkyl;

R_4 is alkyl;

R_6 is alkyl or ;

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

R_9 is H or alkyl;

X is alkylene or is absent; and

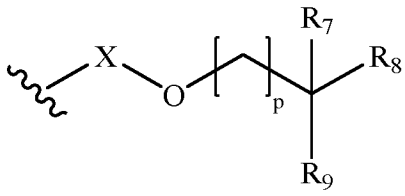
p is 0, 1, 2 or 3; and

n is 0, 1, 2 or 3.

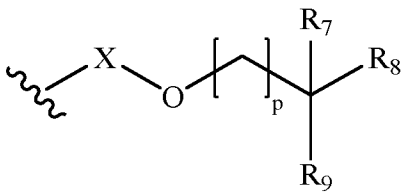
In some embodiments, R_1 and R_2 are C_{1-15} alkyl or, together with the carbon atom to which they are attached, C_{5-30} cycloalkyl, such as C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl. Preferably, R_1 and R_2 are C_{1-15} alkyl, such as C_{2-12}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

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.

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



In some embodiments, R_6 is C_{1-15} alkyl or , such as



C_{1-12} alkyl or .

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

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.

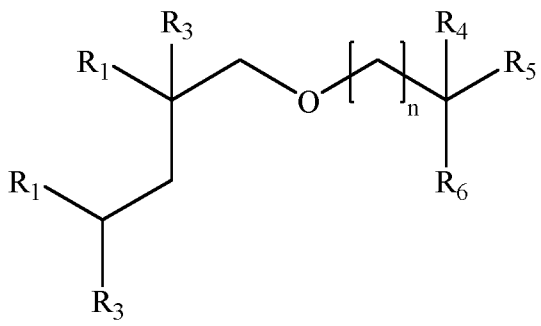
In some embodiments, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

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

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

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

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

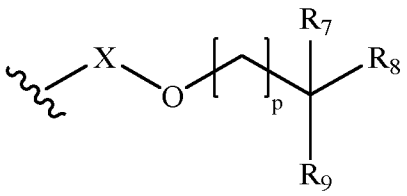


(3)

where: R_1 is alkyl;

R_3 and R_5 are H or alkyl;

R_4 is alkyl;



R_6 is alkyl or ;

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

R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

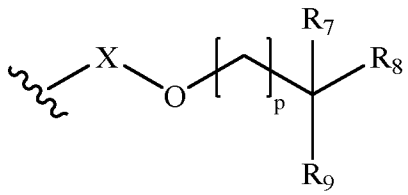
n is 0, 1, 2 or 3.

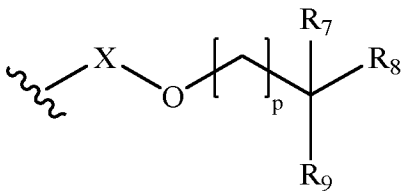
In some embodiments, R_1 is C_{1-12} alkyl, such as C_{2-10} alkyl.

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.

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

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.

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.

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.

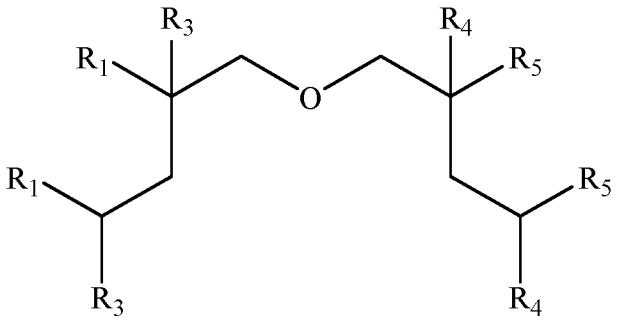
In some embodiments, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

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

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

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

One portion of the compound of formula (3) has a structure which may be derived from a Guerbet alcohol (*i.e.* the portion containing R_1 and R_3), whereas the other portion need not be derived from a Guerbet alcohol (*i.e.* the portion containing R_4, R_5 and R_6). However, in preferred embodiments, the compound may be derived from a combination of two Guerbet alcohols. A compound prepared in this way may have the formula (4):



(4)

where: R_1 and R_4 are alkyl;

R_3 and R_5 are H or alkyl.

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

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

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

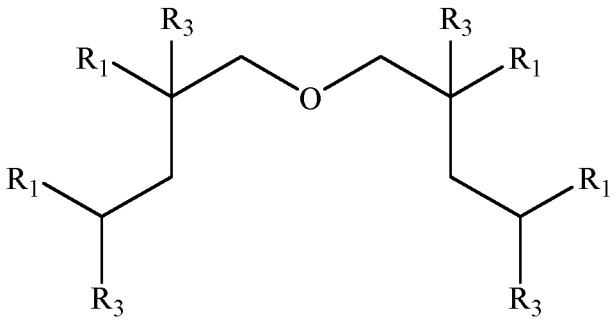
R_3 is H;

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

R_5 is H.

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

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



(5)

where: R_1 is alkyl; and

R_3 is H or alkyl.

In some embodiments, R_1 is C_{1-11} alkyl, such as C_{2-10} alkyl.

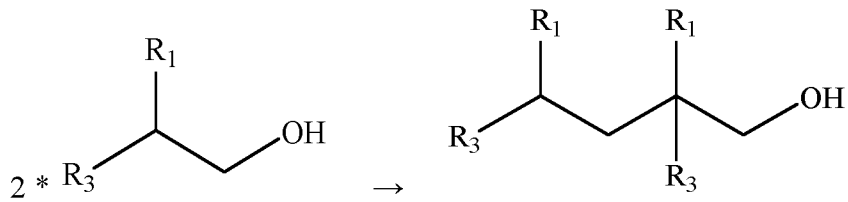
In some embodiments, R_3 is H or C_{1-9} alkyl, such as H or C_{2-8} alkyl. Preferably, R_3 is H.

In particular embodiments: R_1 is C_{3-10} alkyl, such as C_{4-8} alkyl; and

R_3 is H.

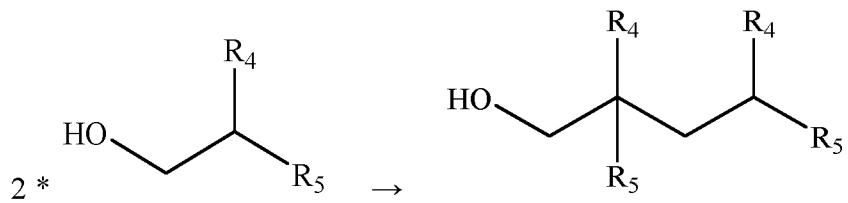
Compounds that are derived from Guerbet alcohols include compounds GE1-GE3, GE5, GE7-GE9, SE1, SE2 and TE1 as shown in Table 3.

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



where R_1 and R_3 are as defined previously;

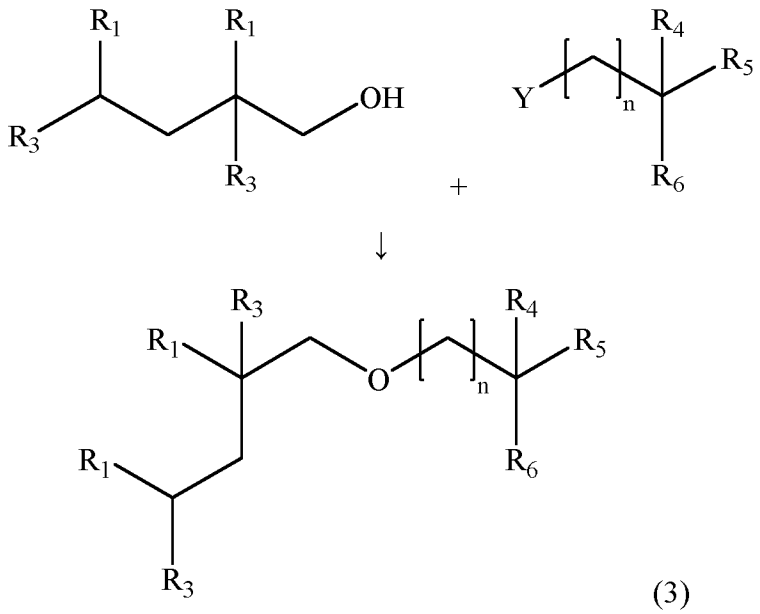
and/or:



where R_4 and R_5 are as defined previously.

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

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

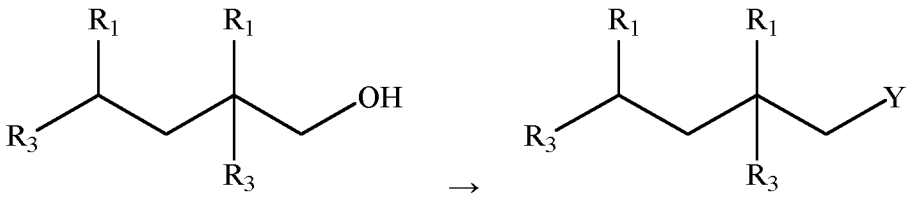


(3)

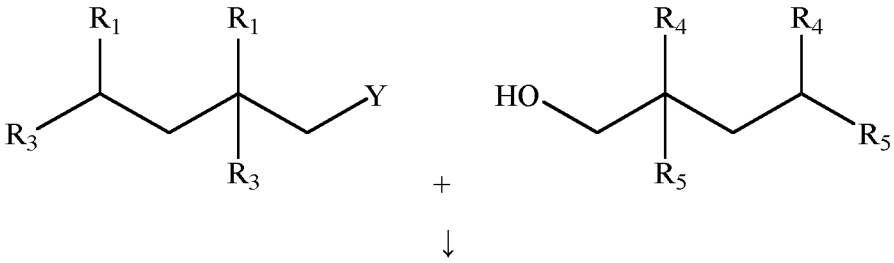
where: Y is a leaving group; and

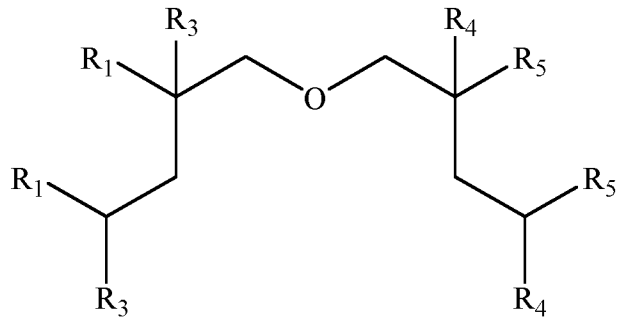
R_1, R_3, R_4, R_5, R_6 and n are as defined previously for the compound of formula (3).

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



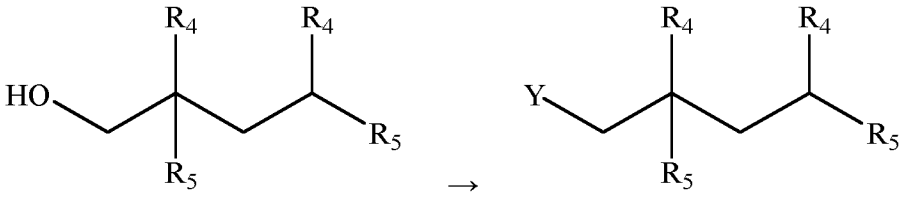
then:



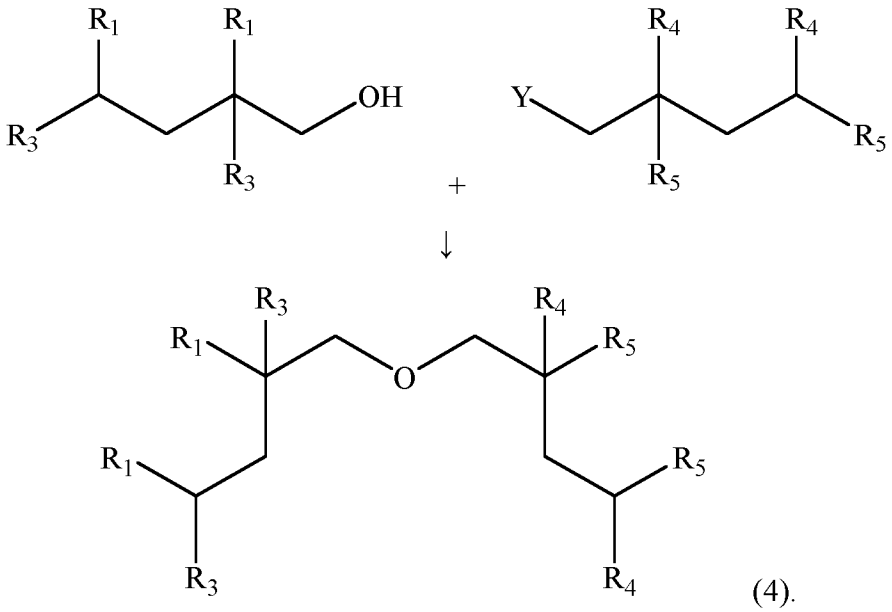


(4);

or:



then:

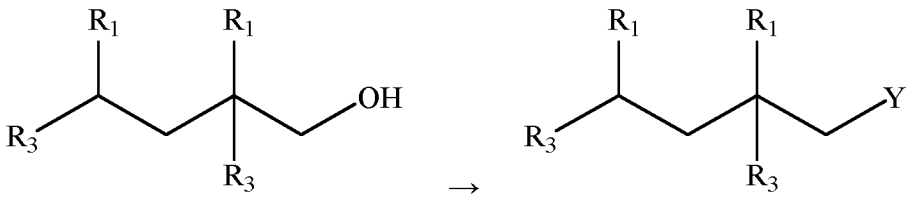


(4).

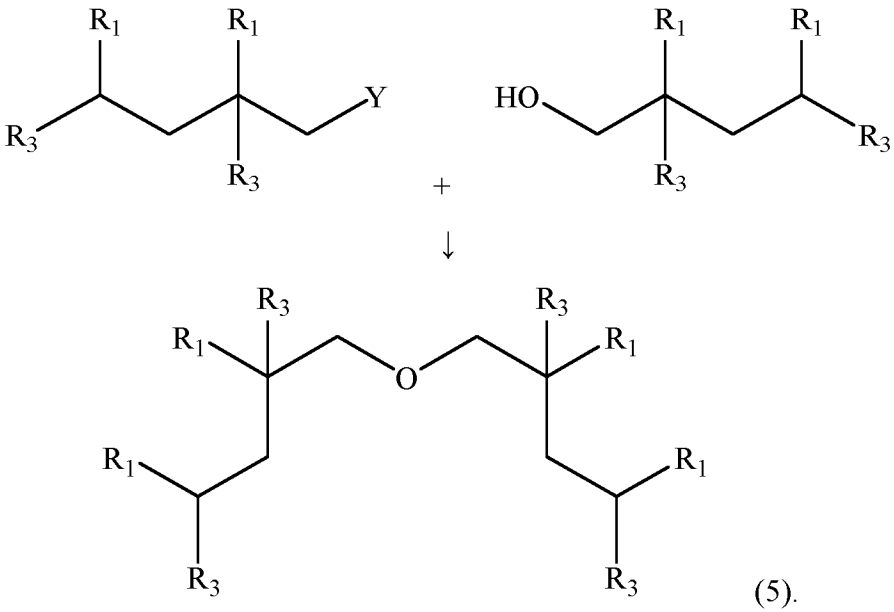
where: Y is a leaving group; and

R_1, R_3, R_4 and R_5 are as defined previously for the compound of formula (4).

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



then:



(5).

where: Y is a leaving group; and

R_1 and R_3 are as defined previously for the compound of formula (5).

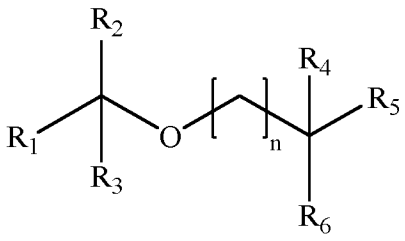
Methods and reaction conditions for modifying a Guerbet alcohol so that it contains a leaving group, Y, are known to the skilled person. For instance, a mesylate group may be introduced by reacting the Guerbet alcohol with mesyl chloride in the presence of triethylamine. A bromide group may be introduced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

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

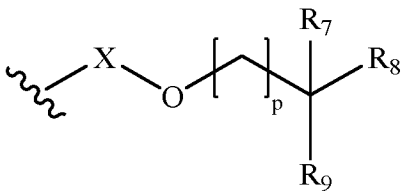
In some preferred embodiments, the compounds of formula (1) are secondary or tertiary ether compounds. In these embodiments, the compound may have the formula (6):



(6)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;

R_3, R_4 and R_5 are H or alkyl;



R_6 is alkyl or ;

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

R_9 is H or alkyl;

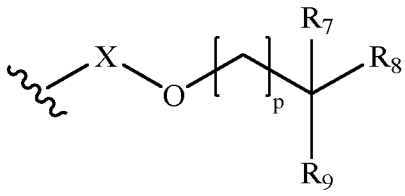
X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

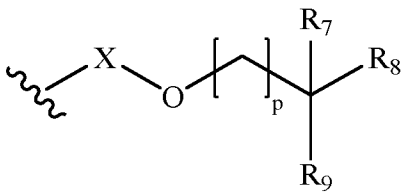
n is 0, 1, 2 or 3.

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.

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.



In some embodiments, R_6 is C_{1-20} alkyl or , such as



C_{1-16} alkyl or .

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.

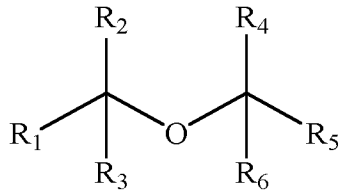
In some embodiments, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

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

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

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

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



(7)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;

R_3, R_4 and R_5 are H or alkyl; and

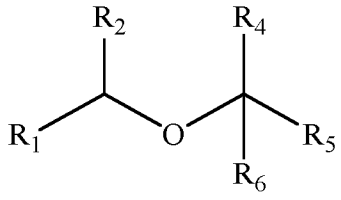
R_6 is alkyl.

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.

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.

In some embodiments, R_6 is C_{1-20} alkyl, such as C_{1-16} alkyl.

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



(8)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;

R_4 and R_5 are H or alkyl; and

R_6 is alkyl.

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

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.

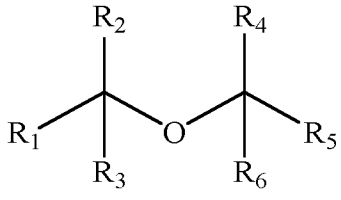
In some embodiments, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl. Preferably, R_5 is H.

In some embodiments, R_6 is C_{1-20} alkyl, such as C_{1-16} alkyl.

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

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

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



(9)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;

R_3 is alkyl;

R_4 and R_5 are H or alkyl; and

R_6 is alkyl.

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.

In some embodiments, R_3 is C_{1-12} alkyl, such as C_{1-10} alkyl.

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.

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

R_3 is C_{1-10} alkyl, such as C_{1-8} alkyl;

R_4 and R_5 are H; and

R_6 is C_{4-20} alkyl, such as C_{6-15} alkyl.

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

R_3 is C_{1-10} alkyl, such as C_{1-8} alkyl;

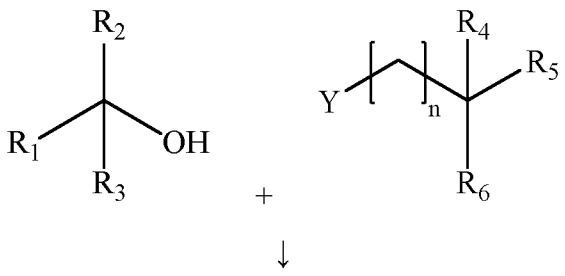
R_4 is C_{3-12} alkyl, such as C_{5-10} alkyl;

R_5 is H; and

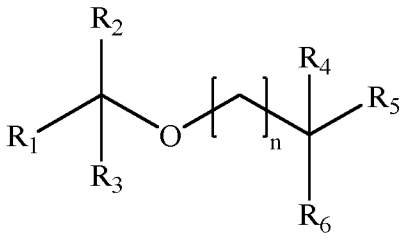
R_6 is C_{3-12} alkyl, such as C_{5-10} alkyl.

Examples of secondary and tertiary ether compounds include SE1, SE2 and TE1 as shown in Table 3.

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

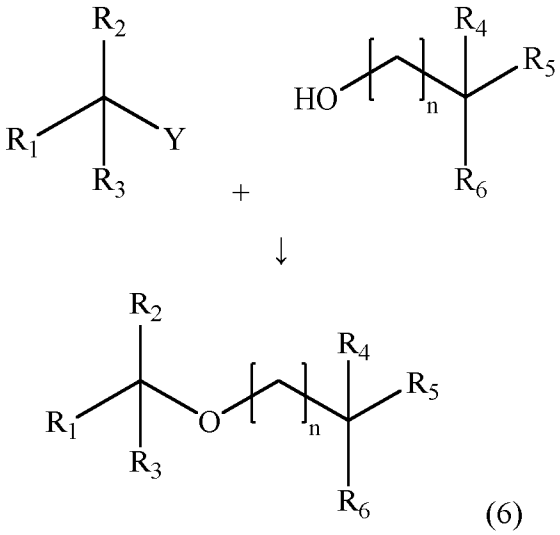


↓



(6)

or:

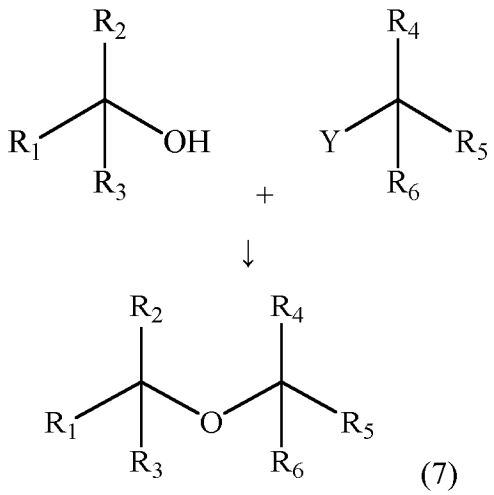


(6)

where: Y is a leaving group; and

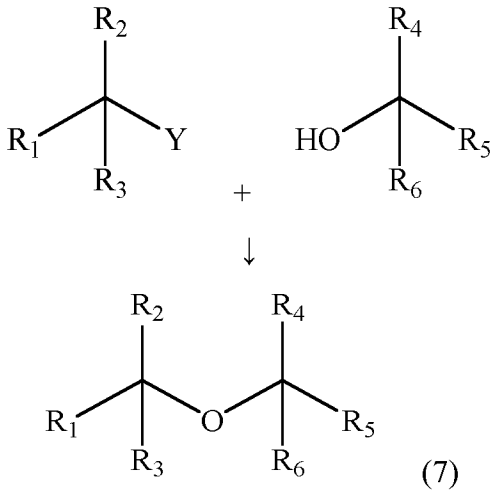
R_1, R_2, R_3, R_4, R_5, R_6 and n are as defined previously for the compound of formula (6).

Similarly:



(7)

or:



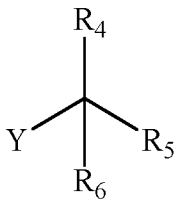
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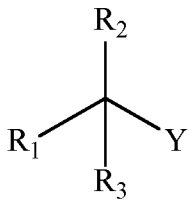
where: Y is a leaving group; and

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

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.

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.



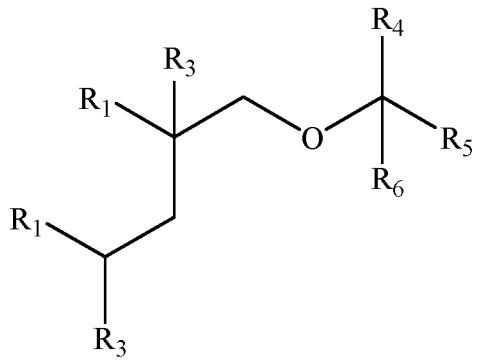
The groups and 

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

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

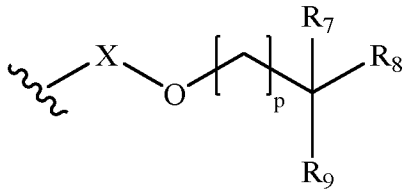
In some embodiments, the compound may comprise an ether which is derived on one side from a secondary or tertiary alcohol and is derived on the other side from a Guerbet alcohol. In these embodiments, the compound may have the formula (10):



(10)

where: R_1 and R_4 are alkyl;

R_3 and R_5 are H or alkyl;



R_6 is alkyl or ;

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

R_9 is H or alkyl;

X is alkylene or is absent; and

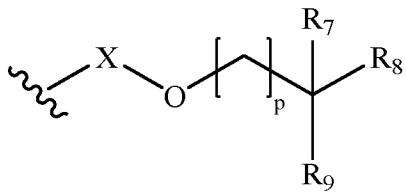
and p is 0, 1, 2 or 3.

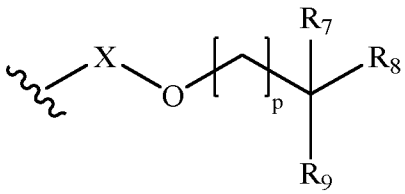
In some embodiments, R_1 is C_{1-12} alkyl, such as C_{2-10} alkyl.

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.

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

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.

In some embodiments, R_6 is C_{1-15} alkyl or , such as

C_{1-12} alkyl or .

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.

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.

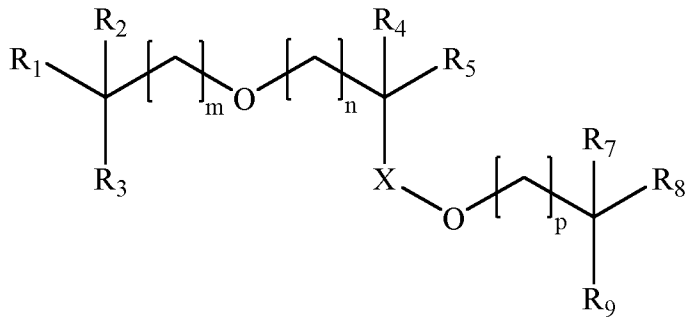
In some embodiments, X is C_{1-20} alkylene, such as C_{3-15} alkylene.

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

Examples of secondary and tertiary ether compounds derived from a Guerbet-alcohol include compounds SE1, SE2 and TE1 as shown in Table 3.

Di-ether base stocks

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):



(11)

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

R_3, R_4 and R_5 are H or alkyl;

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

R_9 is H or alkyl;

X is alkylene or is absent;

p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3.

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.

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.

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.

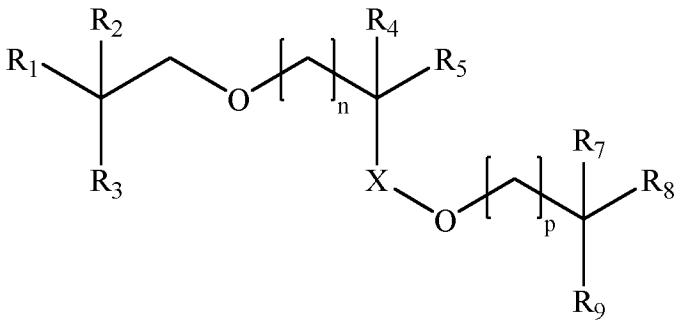
In some embodiments, R_9 is H or C_{1-20} alkyl, such as H or C_{2-12} alkyl. Preferably, R_9 is H.

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

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

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

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



(12)

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

R_3, R_4 and R_5 are H or alkyl;

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

R_9 is H or alkyl;

X is alkylene or is absent;

p is 0, 1, 2 or 3; and

n is 0, 1, 2 or 3.

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.

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

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.

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.

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

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

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

Base oils and lubricating compositions

The compounds of formula (1) may be used as part of a base oil.

The compounds of formula (1) may be used as a base stock. This base stock may form part of a base oil, for instance as one of several base stocks or alternatively may form the base oil substantially in the absence of other base stocks.

The base oils may contain an amount of compound of formula (1) which is sufficient to impart beneficial properties of the compound onto the base oil.

In an aspect, the present invention provides the use of a lubricating composition comprising a base oil including a compound of formula (1) to improve oil consumption through combustion in an internal combustion engine. In other words, the amount of oil consumption by combustion is decreased, thereby improving performance.

In some embodiments, the base oil comprises greater than about 10 %, such as greater than about 25 %, or greater than about 40 % by weight of compound of formula (1). The base oil may comprise up to about 100 %, such as up to about 90 % of compound of formula (1). The compound of formula (1) in the base oil may be composed of a single compound or a combination of compounds of formula (1).

The remainder of the base oil may be made up with base stocks which are not compounds of formula (1). Base stocks other than those of 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 and mixtures thereof. The remainder of the base oil may comprise a single base stock or a combination of base stocks other than those of formula (1).

The base oils may be used as part of a lubricating composition.

The lubricating compositions may contain an amount of base oil which is sufficient to impart beneficial properties of the compound of formula (1) onto the lubricating composition.

In some embodiments, the lubricating 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 (1).

The lubricating composition may also comprise lubricant additives. The lubricating composition may comprise a single lubricant additive, though it will typically comprise a combination of lubricant additives. The combined amount of lubricant additives (including any polymer additives) will typically be present in the lubricating composition in an amount of from about 5 % to about 40 % by weight, such as about 10 % to about 30 % by weight.

As described herein, a particular benefit of the use of a base oil comprising a compound of formula (1) in a lubricating composition for an internal combustion engine is that it allows for the use of a greater proportion of metal additives and a higher sulphated ash concentration to be used, without the expected increase in detriment to exhaust after-treatment systems associated with normal levels of combustion of the lubricant composition. The reduction in oil combustion also reduces the incidence of LSPI. Thus, it has been found to be particularly beneficial to include a higher than conventional proportion of calcium in the lubricant composition comprising the compound of formula (1). This provides excellent anti-wear and detergency properties to the lubricant composition, without detrimentally impacting after-treatment systems or increasing LSPI, as would be expected.

Thus, in another aspect, the present invention provides a lubricating composition for an internal combustion engine containing a base oil comprising:

i) a compound of formula (1); and

ii) at least 500 ppm of elemental calcium, preferably from 500 to 4,000 ppm of elemental calcium, more preferably from 550 to 3.000 ppm of elemental calcium.

In some embodiments, the lubricating composition further comprises one or more, preferably all, of:

iii)a) at least 500 ppm of elemental phosphorus, preferably from 500 to 4,000 ppm of elemental phosphorus, more preferably from 550 to 3.000 ppm of elemental phosphorus;

iii)b) at least 1,000 ppm of elemental sulphur; preferably from 1,000 to 4,000 ppm of elemental sulphur, more preferably from 1,000 to 2,000 ppm of elemental sulphur; and

iii)c) at least 0.1 wt.% sulphated ash; preferably from 0.1 to 2.5 wt.% sulphated ash, more preferably from 0.1 to 1.0 wt%, sulphated ash, even more preferably from 0.1 to 1.5 wt.% sulphated ash, or for example from 1.5 to 2.5 wt.% sulphated ash.

As will be appreciated, the content of phosphorus, sulphur and sulphated ash in the above composition may exceed the limits of the levels of these components, as dictated by API, ACEA and OEM specifications for instance, without compromising the level of emissions or increasing the detriment to after-treatment systems through the reduction in lubricant combustion resulting from the presence of a compound of formula (1).

In some embodiments, the TBN of the lubricating composition is at least 5 mg KOH/g, preferably from 5 to 50 mg KOH/g, more preferably from 6 to 40 mg KOH/g. Exemplary ranges of the TBN of the lubricating composition may include at least 15 mg KOH/g, such as from 15 to 50 mg KOH/g or from 20 to 40 mg KOH/g. Such ranges may be higher than conventional and advantageous in terms of properties of the composition but would otherwise fail some specifications. The presence of the compound of formula (1) allows higher TBN levels to be capitalised upon without compromising on emissions or impacting exhaust after-treatment systems performance.

As will be appreciated, reference herein to an "elemental" weight percentage refers to an amount on an elemental basis in the lubricating composition and not, for instance, based on the amount of an additive comprising the element in question.

Suitable lubricant additives include detergents (including metallic and non- metallic detergents), friction modifiers, dispersants (including metallic and non-metallic dispersants), 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.

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

In some embodiments, the lubricating 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 Al for example in paragraphs [0101] to [0117]. As discussed herein, a particular benefit of the use of a base oil comprising a compound of formula (1) in a lubricating composition for an internal combustion engine is that it allows for the use of a greater

proportion of metal additives and a higher sulphated ash concentration in the composition, without increasing any detriment to exhaust after-treatment systems of a vehicle powered by the engine or increasing emissions associated with lubricant composition combustion. This means that greater amounts of, for instance, molybdenum- based, sulphur-based and other ash-producing friction modifiers, can be used than is conventional, or mandated having regard to emissions.

In some embodiments, the lubricating composition comprises a dispersant. Examples of suitable ashless dispersants include oil soluble salts, esters, amino-esters, amides, imides and oxazolines of long chain hydrocarbon-substituted mono- and polycarboxylic acids or anhydrides thereof; thiocarboxylate derivatives of long chain hydrocarbons; long chain aliphatic hydrocarbons containing polyamine moieties attached directly thereto; Mannich condensation products formed by condensing a long chain substituted phenol with formaldehyde and polyalkylene polyamine; Koch reaction products and the like.

In some embodiments, the lubricating 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.

In some embodiments, the lubricating 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 15000 to about 1000000, such as about 20000 to about 600000 as determined by gel permeation chromatography or light scattering methods.

In some embodiments, the lubricating composition comprises a pour point depressant. Examples of suitable pour point depressants include C_8 to C_{18} dialkyl fumarate/vinyl acetate copolymers, methacrylates, polyacrylates, polyarylamides, polymethacrylates, polyalkyl methacrylates, vinyl fumarates, styrene esters, condensation products of haloparaffin waxes and aromatic compounds, vinyl carboxylate polymers, terpolymers of dialkyfumarates, vinyl esters of fatty acids and allyl vinyl ethers, wax naphthalene and the like. In at least some examples, the at least one lubricant additive includes at least one anti-wear additive.

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

In some embodiments, the lubricating 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.

In some embodiments, the lubricating 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.

In some embodiments, the lubricating composition comprises an antioxidant. Examples of suitable antioxidants include alkylated diphenylamines, N- alkylated phenylenediamines, 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_8 to C_{18} fatty acid, an unsaturated acid or a branched carboxylic acid, for example basic, neutral or acidic Cu(I) and/or Cu(II) salts derived from alkenyl succinic acids or anhydrides), alkaline earth metal salts of alkylphenolthioesters, suitably containing C_5 to C_{12} alkyl side chains, calcium nonylphenol sulphide, barium t-octylphenyl sulphide, dioctylphenylamine, phosphosulphised 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. As discussed herein, a particular benefit of the use of a base oil comprising a compound of formula (1) in a lubricating composition for an internal combustion engine is that it allows for the use of a greater proportion of metal additives and a higher sulphated ash concentration in the composition, without increasing any detriment to exhaust after-treatment systems of a vehicle powered by the engine or increasing emissions associated with lubricant composition combustion. This means that greater amounts of, for instance, phosphorus-based and sulphur-based antioxidants can be used than is conventional, or mandated having regard to emissions.

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

In some embodiments, the lubricating 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.

The lubricating composition may comprise lubricant additives in the amounts shown in Table 2.

Table 2

	Lubricating composition	
Additive type	Suitable amount (actives) if present by weight	Preferred amount (actives) if present by weight
Phosphorus-containing anti-wear additives	Corresponding to about 10 to about 6000 ppm P	Corresponding to about 10 to about 1000 ppm P

Molybdenum-containing anti-wear additives	Corresponding to about 10 to about 1000 ppm Mo	Corresponding to about 40 to about 600 ppm Mo
Boron-containing anti-wear additives	Corresponding to about 10 to about 500 ppm B	Corresponding to about 50 to about 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
Dispersants	About 0.1 to about 20 %	About 0.1 to about 8 %
Detergents	About 0.01 to about 6 %	About 0.01 to about 4 %
Viscosity index improvers	About 0.01 to about 20 %	About 0.01 to about 15 %
Pour point depressants	About 0.01 to about 5 %	About 0.01 to about 1.5 %
Corrosion and/or rust inhibitors	About 0.01 to about 5 %	About 0.01 to about 1.5 %
Anti-oxidants	About 0.01 to about 10 %	About 0.5 to 5 about %
Antifoams containing silicon	Corresponding to about 1 to about 20 ppm Si	Corresponding to about 1 to about 10 ppm Si
Dispersant viscosity modifiers (polymers)	About 0.1 to about 10 % (1,000 to 100,000 ppm)	About 0.5 to about 6 % (5,000 to 60,000 ppm)

The lubricating 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 lubricating 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 lubricating 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.

The lubricating compositions may have a Noack volatility of less than about 25 %, such as less than about 20 %, less than about 15 %, or less than about 10 % by weight. Noack volatility may be measured according to CEC-L-40-A-93.

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

The lubricating composition may have at least one of:

an oxidative stability performance on a CEC-L-088-02 and/or CEC-L-111-16 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 and/or CEC-L-111-16 test indicated by an overall piston merit of at least 8.5, such as 9.

The lubricating 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.

Preferred lubricating compositions meet the requirements set out in SAE J300.

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 lubricating compositions are particularly suited to use in an automotive internal combustion engine.

In another aspect, the lubricating composition comprising a compound (e.g. a base stock) of formula (1) may be used to extend the oil drain interval of an internal combustion engine in an automotive vehicle.

In still a further aspect, the invention provides a method of extending the oil drain interval of an internal combustion engine in an automotive vehicle, said method comprising the following steps;

i) determining the oil drain interval for an internal combustion engine operating in the presence of a lubricating composition having a particular SAE viscosity grade and which does not contain a base oil according to formula (1), wherein the oil drain interval is defined as a cumulative time period of operation of the engine, or a cumulative distance travelled by an automotive vehicle powered by the engine, at which 20 % by weight of the lubricating composition is consumed, as determined by the OM646LA (CEC L-99-08) test;

ii) at least partially replacing the lubricating composition of step i) which is in contact with the engine with a lubricating composition comprising a base stock of formula (1) and having the same SAE viscosity grade as the lubricating composition of step i); and

iii) operating the engine over an oil drain interval which is greater than that determined in step i).

The SAE viscosity grade may be determined by measuring the kinematic viscosity (KV) at 40 °C (KV40) and 100 °C (KV100) by ASTM D445 and by measuring the high-shear viscosity at high temperature (HTHS) at 150 °C by, CEC L-36-A-90 (ASTM D4741).

As will be appreciated, the particular advantages associated with the lubricant compositions comprising a compound of formula (1) described herein mean that the oil drain interval of an automotive vehicle may be extended, in comparison to where an alternative oil is used which has a comparable viscosity yet which does not comprise a compound of formula (1), The extension in oil drain interval may be achieved by a reduction in oil volume losses by a reduction in oil combustion as discussed herein and/or as a result of maintaining exhaust after-treatment system performance as a result of lower oil combustion.

In some embodiments, the oil drain interval is extended by 10 % or more, preferably by 15 % or more, more preferably by 20 % or more, as measured by the number of miles traveled by a vehicle powered by the engine or the number of hours of cumulative operation before an oil change is required, when compared to a lubricating composition which does not comprise a base stock of formula (1).

In some embodiments, the oil drain interval is extended by 10 % or more, preferably by 15 % or more, more preferably by 20 % or more, as measured by the time of cumulative operation of the internal combustion engine before an oil change is required, when compared to a lubricating composition which does not comprise a base stock of formula (1).

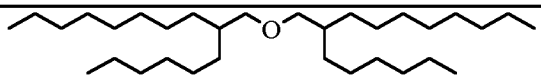
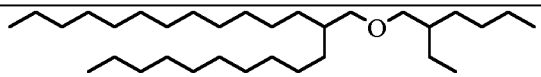
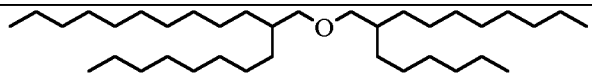
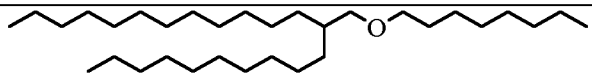
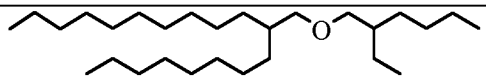
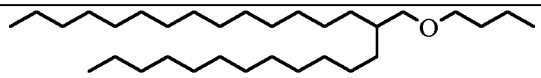
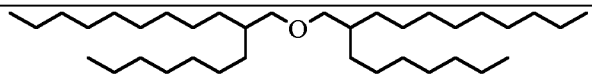
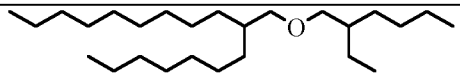
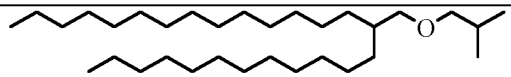
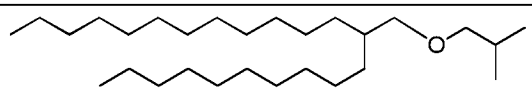
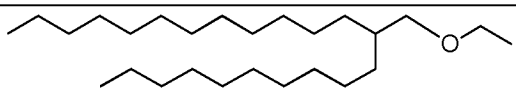
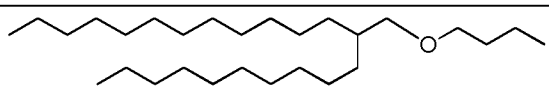
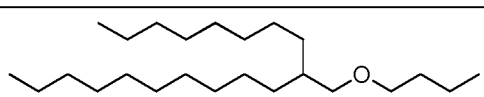
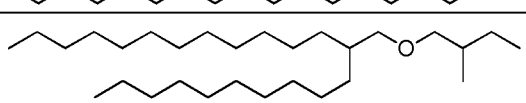
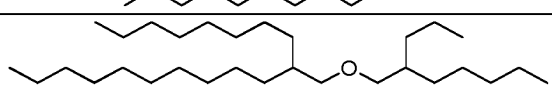
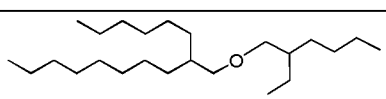
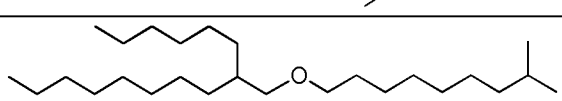
The invention will now be described with reference to the below examples, which are not limiting in nature.

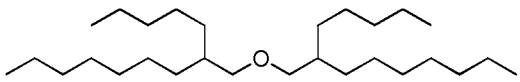
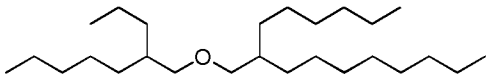
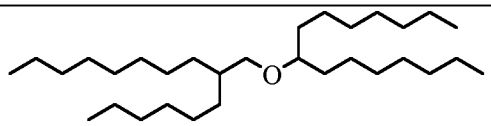
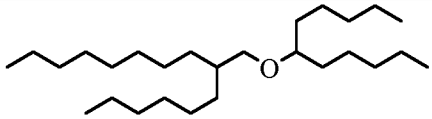
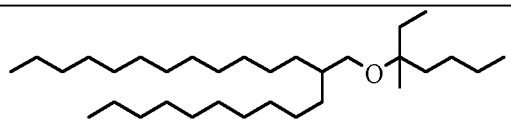
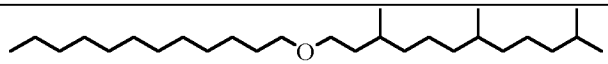
Examples

Example 1 – Properties of ether base stocks

Guerbet-derived base stocks GE1-GE3, GE5 and GE7-GE9, secondary ether base stocks SE1 and SE2, and tertiary ether base stock TE1 of formula (1) were prepared. Two further Guerbet-derived base stocks, GE4 and GE6, and an experimental group V base stock of the type previously described in WO 2014/207235, *i.e.* a farnesene-derived ether base stock, were also prepared. The structure of these compounds is shown in Table 3.

Table 3

	Molecular Weight	Chemical Formula	Structure
GE1	466.87	$C_{32}H_{66}O$	
GE2	466.87	$C_{32}H_{66}O$	
GE3	522.97	$C_{36}H_{74}O$	
GE4	466.87	$C_{32}H_{66}O$	
GE5	410.76	$C_{28}H_{58}O$	
GE6	466.87	$C_{32}H_{66}O$	
GE7	522.57	$C_{36}H_{74}O$	
GE8	382.42	$C_{26}H_{54}O$	
GE9	466.51	$C_{32}H_{66}O$	
GE10	410.76	$C_{28}H_{58}O$	
GE12	382.71	$C_{26}H_{54}O$	
GE14	410.76	$C_{28}H_{58}O$	
GE15	354.65	$C_{24}H_{50}O$	
GE16	424.79	$C_{29}H_{60}O$	
GE18	438.81	$C_{30}H_{62}O$	
GE20	354.65	$C_{24}H_{50}O$	
GE21	382.71	$C_{26}H_{54}O$	

GE22	410.76	$C_{28}H_{58}O$	
GE23	382.71	$C_{26}H_{54}O$	
SE1	452.84	$C_{31}H_{64}O$	
SE2	396.43	$C_{27}H_{56}O$	
TE1	466.87	$C_{32}H_{66}O$	
Farnesene-derived ether	396.73	$C_{27}H_{56}O$	

The following properties of the base stocks were tested:

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

Viscosity index (VI) was calculated according to ASTM D2270.

Pour point was determined according to ASTM D7346.

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.

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.

The results of the tests are summarized in Table 4, together with results obtained from conventional base stocks (Durasyn 162, a group IV base stock; Durasyn 164, a group IV

base stock; Yubase 3, a group II base stock; Yubase 4, a group III base stock; Yubase 4 Plus, a group III base stock; Nexbase 3020, a group II base stock; Nexbase 3030, a group II base stock; Nexbase 3043, a group III base stock; and Chevron 100RLV, a group II base stock). Results obtained from the farnesene-derived ether base stock are also shown for reference.

Table 4

	KV100 (cSt)	**KV40 (cSt)**	**VI**	**Pour Point (°C)**	**DSC Oxidation Onset T (°C)**	**Noack (% by weight)**
GE1	3.3	13.0	125	-42	201.26	5.9
GE2	3.5	13.7	145	-36	205.74	5.1
GE3	3.9	16.0	143	-42	202.89	2.4
GE4	3.3	11.9	146	-27	213.37	3.9
GE5	2.5	8.2	136	-60	203.87	17.9
GE6	3.8	14.6	166	-12	212.71	2.0
GE7	4.0	16.5	144	-36	206.26	6.8
GE8	2.3	7.7	111	-66	213.95	44.9
GE9	3.8	14.9	160	-15	208.17	2.5
SE1	2.7	9.6	123	-18	195.37	12.9
SE2	2.5	9.0	101	-45	183.21	51.8
TE1	3.6	14.9	133	-	212.91	6.8
Durasyn 162	1.7	5.2	92	-72	223.61	99.6
Durasyn 164	4.0	17.8	126	-75	221.31	18.8
Yubase 3	3.0	14.1	105	-36	220.74	38.6
Yubase 4	4.2	19.2	126	-12	220.00	11.7
Yubase 4 Plus	4.2	18.4	138	-18	220.32	11.6
Nexbase 3020	2.2	7.6	93	-51	221.66	81.9
Nexbase 3030	3.0	12.0	101	-39	221.05	36.8
Nexbase 3043	4.3	19.9	124	-18	222.09	13.2
Chevron 110RLV	4.6	22.6	119	-15	225.86	13.2
Farnesene-derived ether	3.2	11.6	152	-36	222.26	14.1

It can be seen that the Guerbet-derived base stock ethers have a low volatility for a given pour point compared to conventional base oils.

Example 2: Properties of lubricating compositions containing ether base stocks

Guerbet-derived ether base stocks GE2 and GE3 were blended with conventional base oil additives (additive A, a commercially available additive package; 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 lubricant blends. A Baseline blend and a farnesene-derived ether blend were 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 5 in % by weight.

Table 5

	Baseline blend	**GE2 blend**	**GE3 blend**	**Farnesene-derived blend**
Additive A	16.4	16.4	16.4	16.4
Additive B	0.15	0.15	0.15	0.15
Additive C	0.1	0.1	0.1	0.1
Additive D	4	4	4	4
Yubase 4	67.45	30.47	17.45	17.45
Yubase 6	11.9	11.9	11.9	11.9
GE2	0	36.98	0	0

GE3	0	0	50	0
Farnesene-derived ether	0	0	0	50

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

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

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

Viscosity index (VI) was calculated according to ASTM D2270.

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

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

Total base number (TBN) was determined according to ASTM D2896.

Noack volatility was tested according to ASTM D5800.

Sulphated ash content was measured according to IP 163.

The results of the tests are summarized in Table 6.

Table 6

	Baseline blend	**GE2 blend**	**GE3 blend**	**Farnesene-derived blend**
KV40 (cSt)	53.59	48.26	44.63	38.57
KV100 (cSt)	9.542	9.105	8.688	7.877
VI	164	173	177	181
CCS -30 °C (cP)	4656	2608	2702	2010
HTHS (cP)	2.98	2.85	2.75	2.62
TBN (mg KOH/g)	11.66	11.29	11.44	10.88

NOACK (% by weight)	11.2	7.7	9.7	14.9
Sulphated ash (%)	1.22	1.26	1.27	1.20

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

Example 3: The effect on oil consumption of lubricating compositions containing ether base-stocks

The oil consumption of the baseline lubricant blend and the lubricant composition containing GE3 from Example 2 were analysed. Both the baseline and the ether-containing lubricating compositions were subjected to the OM646LA (CEC L-99-08) engine test to determine whether the lubricating composition containing the ether base-stock demonstrates a benefit in oil consumption. This test also provided information on wear, TAN, TBN and ICP elements.

The OM646LA (CEC L-99-08) engine test is a 300 hour cyclic test which uses a 4 cylinder 2.2L diesel OM646 DE 22 LA engine to evaluate engine lubricant performance with respect to engine wear and overall cleanliness. From analysis of the lubricating compositions before and after this test, overall oil consumption and oil consumption by combustion was determined.

After 250 hours of operation of the test, a proportion of the lubricating oil was removed and replenished with fresh oil. The amount of each element in the lubricating oil that was removed at 250 hours was determined and subtracted from the amount of that element found to have been lost upon completion of the experiment, in order to account for this step of the test. Table 9 below provides the results of the elemental analysis, without the above-mentioned adjustment. Tables 10 and 11 below include the results with the above-mentioned adjustment to factor in the partial replacement of oil during the experiment.

As can be seen from the analysis of the lubricating composition from the OM646LA (CEC L-99-08) test in Table 9, the metal content at the beginning of the test and the end of the test for both the baseline and ether base-stock compositions is very similar for all metals. This indicates that combustion, as opposed to base-stock evaporation, is a major cause of

lubricating oil loss. Only metallic additives have been included as non-metallic additives are deemed to be volatile and thus their loss cannot be measured.

Table 9

	Baseline		
	Starting mass/ g	**End mass/ g**	**Mass lost/ g**
Calcium	34.49	16.39	18.10
Magnesium	0.15	0.08	0.07
Phosphorus	8.64	3.59	5.05
Zinc	9.53	4.32	5.21
Molybdenum	1.23	0.59	0.64
	Ether Base-Stock		
	Starting mass/ g	**End mass/ g**	**Mass lost/ g**
Calcium	30.42	16.76	13.66
Magnesium	0.11	0.10	0.01
Phosphorus	7.00	3.67	3.33
Zinc	8.15	4.41	3.74
Molybdenum	0.99	0.59	0.40

The mass percentage loss of each element was determined after adjustment of the data to compensate for the removal of oil at 250 hours. These results are shown in Table 10, and show that, in general, there is a reduced elemental loss in the ether base-stock composition when compared to the baseline composition.

Table 10

	Baseline mass lost/ g	**Ether base-stock mass lost/ g**	**Difference/ g**
Calcium	12.47	9.11	3.36
Magnesium	0.05	0	0.05
Molybdenum	0.44	0.25	0.19
Phosphorous	3.78	2.33	1.64
Zinc	3.67	2.48	1.19

The lubricating oil consumption and the amount of lubricant lost through combustion and evaporation was calculated in order to highlight the source of the improvement in consumption. These results are shown in Table 11. The ether base-stocks display lower oil

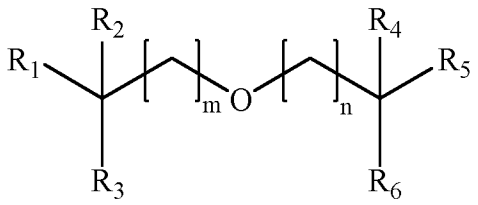
consumption than the group III baseline composition, and over 50 % extra lubricant is combusted in the baseline composition when compared to the ether-containing lubricant. This demonstrates that the ether base-stock has lower oil consumption via combustion than the baseline composition.

Table 11

	Baseline	**Ether Base-Stock**	**Percentage Difference**
Total oil added (g)	10653	9018	n/a
Oil lost via combustion (g)	3918.2	2564.2	52.8
Oil lost via evaporation (g)	3443.0	3448.8	-0.2

Claims

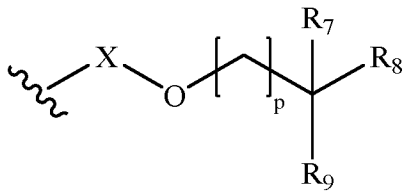
1. Use of a compound of formula (1), or a base oil comprising a compound of formula (1), for improving resistance of a lubricating composition to oil consumption through combustion when used for lubricating an internal combustion engine:



(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;

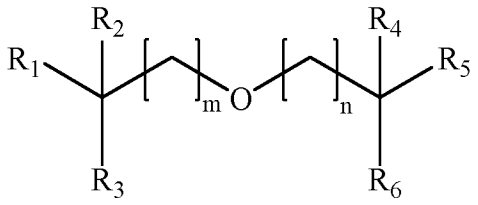
R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3.

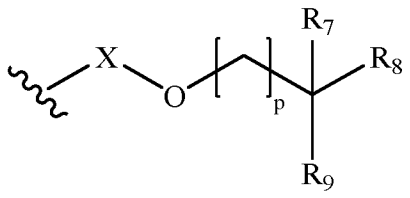
2. Use of a lubricating composition comprising a base oil including a compound of formula (1) to improve oil consumption through combustion in an internal combustion engine:



(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;

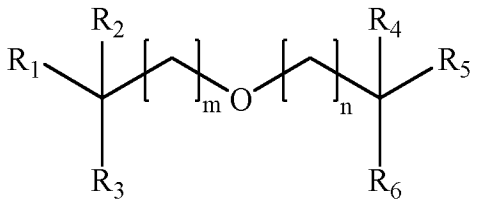
R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3.

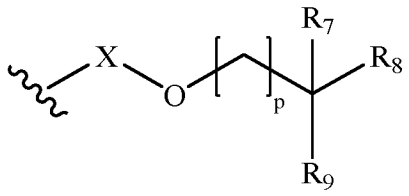
3. Use, in an internal combustion engine of an automotive vehicle comprising an exhaust after-treatment system, of a lubricating composition comprising a base oil including a compound of formula (1) for reducing poisoning of the exhaust after-treatment system:



(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;

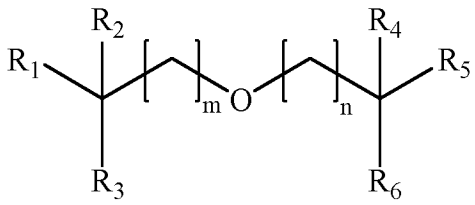
R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3.

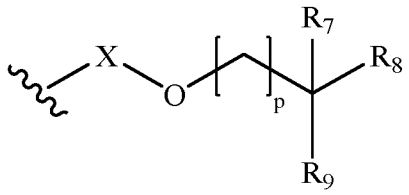
4. Use, in an internal combustion engine of an automotive vehicle, of a lubricating composition comprising a base oil including a compound of formula (1), for reducing low-speed pre-ignition (LSPI) in the automotive vehicle:



(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;

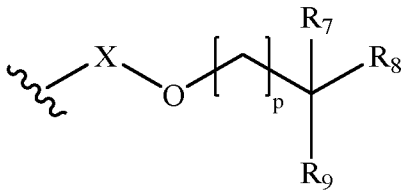
X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

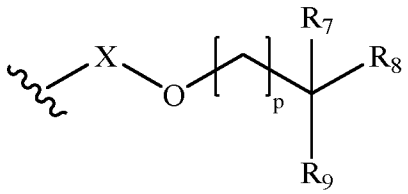
m and n are 0, 1, 2 or 3.

5. The use of any one of Claims 1 to 4, 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, such as C_{2-12} alkyl or, together with the carbon atom to which they are attached, C_{5-25} cycloalkyl; and/or wherein R_3, R_4 and R_5 are H or C_{1-15} alkyl, such as H or C_{2-12} alkyl.

6. The use of any one of Claims 1 to 5, wherein R_6 is C_{1-20} alkyl or



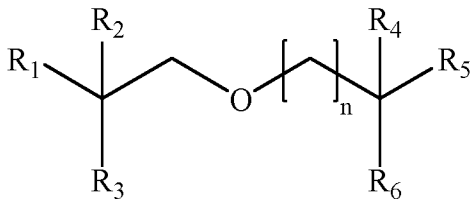
, such as C_{1-16} alkyl or



.

7. The use of any one of Claims 1 to 6, wherein m and n are 0, 1 or 2, such as 0 or 1.

8. The use of any one of Claims 1 to 7, wherein the compound has the formula (2):



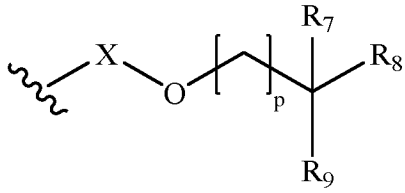
(2)

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

R_3 and R_5 are H or alkyl;

R_4 is alkyl;

R_6 is alkyl or



;

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

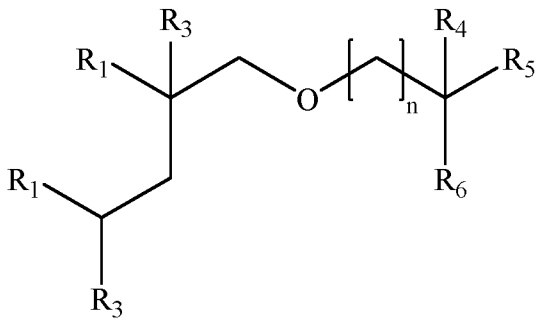
R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

n is 0, 1, 2 or 3.

9. The use of Claim 8, wherein the compound has the formula (3):

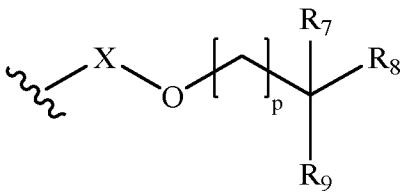


(3)

where: R_1 is alkyl;

R_3 and R_5 are H or alkyl;

R_4 is alkyl;



R_6 is alkyl or ;

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

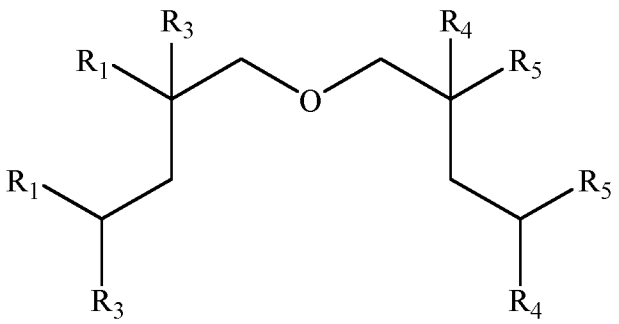
R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

n is 0, 1, 2 or 3.

10. The use of Claim 9, wherein the compound has the formula (4):



(4)

where: R_1 and R_4 are alkyl;

R_3 and R_5 are H or alkyl.

11. The use of Claim 10, wherein:

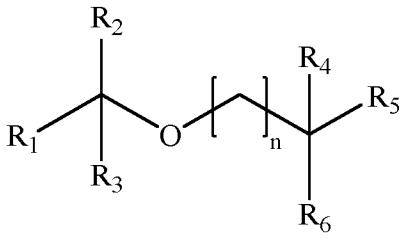
R_1 is C_{4-12} alkyl, such as C_{6-10} alkyl;

R_3 is H;

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

R_5 is H.

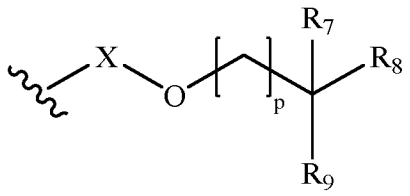
12. The use of any one of Claims 1 to 7, wherein the compound has the formula (6):



(6)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;

R_3, R_4 and R_5 are H or alkyl;

R_6 is alkyl or  ;

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

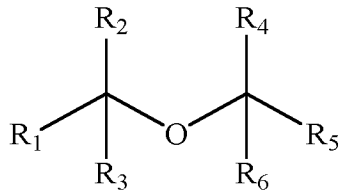
R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3; and

n is 0, 1, 2 or 3.

13. The use of Claim 12, wherein the compound has the formula (7):



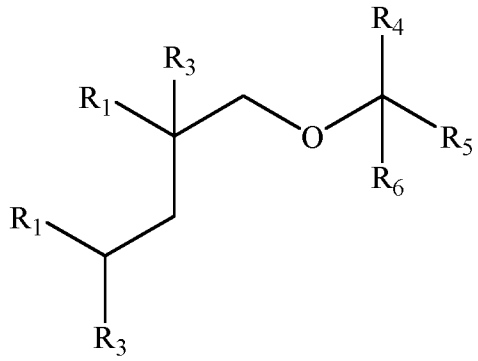
(7)

where: R_1 and R_2 are alkyl or, together with the carbon to which they are attached, cycloalkyl;

R_3, R_4 and R_5 are H or alkyl; and

R_6 is alkyl.

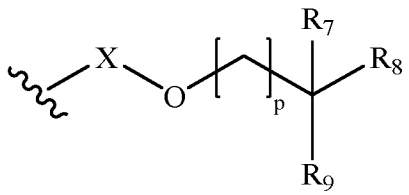
14. The use of any one of Claims 1 to 7, wherein the compound has the formula (10):



(10)

where: R_1 and R_4 are alkyl;

R_3 and R_5 are H or alkyl;

R_6 is alkyl or  ;

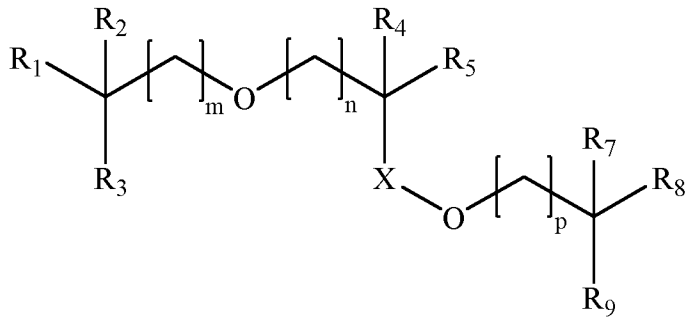
where: R_7 and R_8 are H, alkyl or, together with the carbon atom to which they are attached, cycloalkyl;

R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3.

15. The use of any one of Claims 1 to 7, wherein the compound has the formula (11):



(11)

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

R_3, R_4 and R_5 are H or alkyl;

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

R_9 is H or alkyl;

X is alkylene or is absent;

p is 0, 1, 2 or 3; and

m and n are 0, 1, 2 or 3.

16. The use of any one of Claims 1 to 15, wherein the compound contains a total number of carbons atoms of from 20 to 50, such as from 24 to 45, such as from 26 to 40 or from 28 to 36.

17. The use of any one of Claims 1 to 16, wherein the compound is prepared from bio-derived feedstock.

18. The use of Claim 1, wherein the compound contains greater than 50 %, such as greater than 70 %, or greater than 90 % by weight of biobased carbon.

19. The use of any one of Claims 1 to 18, wherein the compound has at least one of:

a kinematic viscosity at 40 °C of less than 25 cSt, such as less than 20 cSt, or less than 17 cSt;

a kinematic viscosity at 100 °C of less than 7 cSt, such as less than 5 cSt, or less than 4 cSt;

a viscosity index of greater than 100, such as greater than 110, or greater than 120;

a viscosity at 150 °C and a shear rate of 10^6 s^{-1} of no greater than 1.7 cP, such as no greater than 1.5 cP;

a Noack volatility of less than 26 %, such as less than 20%, less than 16 %, or less than 12 % by weight; and

a pour point of less than -10 °C, such as less than -25 °C, or less than -35 °C.

20. The use of any one of Claims 1 to 18, wherein the compound has a kinematic viscosity at 100 °C of 3 to 4 cSt and a Noack volatility of less than 20 %, such as less than 16 % or less than 13 %, by weight; or a kinematic viscosity at 100 °C of 2 to 3 cSt, and a Noack volatility of less than 40 %, such as less than 30 %, by weight.

21. The use of any one of Claims 1 to 20, wherein the base oil comprises greater than 10 %, such as greater than 25 %, or greater than 40 % by weight of the compound as defined therein.

22. The use of Claim 21, wherein the base oil comprises a base stock selected from Group I, Group II, Group III, Group IV and Group V base stocks and mixtures thereof.

23. The use of any one of Claims 1 to 22, wherein the lubricant composition comprises greater than 50 %, such as greater than 65 %, or greater than 80 % by weight of the base oil as defined therein.

24. The use of any one of Claims 1 to 23, wherein the lubricant composition has at least one of:

a kinematic viscosity at 40 °C of less than 60 cSt, such as less than 55 cSt, or less than 50 cSt;

a kinematic viscosity at 100 °C of less than 12 cSt, such as less than 10 cSt, or less than 9.5 cSt;

a viscosity index of greater than 100, such as greater than 110, or greater than 120;

a viscosity at 150 °C and a shear rate of 10^6 s^{-1} of no greater than 3 cP, such as no greater than 2.8 cP;

and

a Noack volatility of less than 25 %, such as no more than 20%, less than 15 %, or less than 10 % by weight.

25. The use of any one of Claims 1 to 24, wherein the lubricant composition has at least one of:

an oxidative stability performance on a CEC-L-088-02 and/or CEC-L-111-16 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 and/or CEC-L-111-16 test indicated by an overall piston merit of at least 8.5, such as 9.

26. The use of any one of Claims 1 to 25, wherein the engine is an internal combustion engine in an automotive vehicle, preferably a vehicle fitted with an exhaust after-treatment system, wherein the exhaust after-treatment system preferably comprises a NOx reduction catalyst, a particulate filter, a hydrocarbon oxidation catalyst or combinations thereof.

27. A method of extending the oil drain interval of an internal combustion engine in an automotive vehicle, said method comprising the following steps;

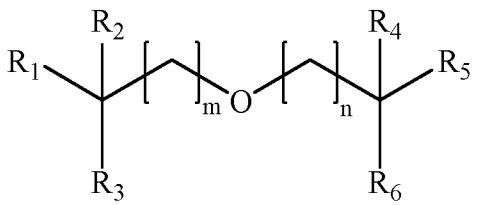
i) determining the oil drain interval for an internal combustion engine operating in the presence of a lubricating composition having a particular SAE viscosity grade and which does not contain a base oil as defined in Claim 1, wherein the oil drain interval is defined as a cumulative time period of operation of the engine, or a cumulative distance travelled by an automotive vehicle powered by the engine, at which 20 % by weight of the lubricating composition is consumed , as determined by the OM646LA (CEC L-99-08) test;

ii) at least partially replacing the lubricating composition of step i) which is in contact with the engine with a lubricating composition as defined in Claim 2, and any of Claims 3 to 25 dependent thereon, and having the same SAE viscosity grade as the lubricating composition of step i); and

iii) operating the engine over an oil drain interval which is greater than that determined in step i).

28. A lubricating composition for an internal combustion engine containing a base oil comprising:

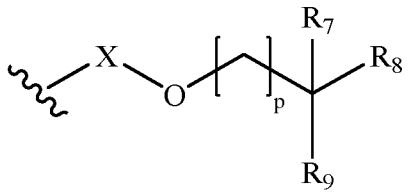
i) a compound of formula (1):



(1)

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

R_3, R_4 and R_5 are H or alkyl;

R_6 is alkyl or  ;

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

R_9 is H or alkyl;

X is alkylene or is absent; and

p is 0, 1, 2 or 3;

m and n are 0, 1, 2 or 3; and

ii) at least 500 ppm of elemental calcium, preferably from 500 to 4,000 ppm of elemental calcium, more preferably from 550 to 3.000 ppm of elemental calcium.

29. A lubricating composition according to Claim 29, wherein the lubricating composition further comprises one or more of:

iii)a) at least 500 ppm of elemental phosphorus, preferably from 500 to 4,000 ppm of elemental phosphorus, more preferably from 550 to 3.000 ppm of elemental phosphorus, ;

iii)b) at least1,000 ppm of elemental sulphur; preferably from 1,000 to 4,000 ppm of elemental sulphur, more preferably from 1,000 to 2,000 ppm of elemental sulphur; and

iii)c) at least 0.1 wt.% suphated ash; preferably from 0.1 to 2.5 wt.% sulphated ash, more preferably from 0.1 to 1.0 wt%, sulphated ash, even more preferably from 0.1 to 1.5 wt.% sulphated ash.

30. A lubricating composition according to Claim 28 or Claim 29, where the TBN of the lubricating composition is at least 5 mg KOH/g, preferably from 5 to 50 mg KOH/g, more preferably from 6 to 40 mg KOH/g.

31. A lubricating composition according to Claim 28 or Claim 29, where the TBN of the lubricating composition is at least 15 mg KOH/g, preferably from 15 to 50 mg KOH/g, more preferably from 20 to 40 mg KOH/g.

32. A lubricating composition according to any one of Claims 28 to 31, wherein the compound of formula (I) is as defined in any one of Claims 2 to 20; wherein the base oil is as defined in any one of Claims 21 to 23; and/or wherein the lubricating composition is as defined in any one of Claims 24 and 25.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/051829

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10M105/18
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10M C10N

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2018/109125 A1 (CASTROL LTD [GB]) 21 June 2018 (2018-06-21)	28-32
A	page 52, line 15 - line 19; claims 1,5-28; tables 5,6,7, 9,10	1-26

Y	WO 2016/203310 A1 (CASTROL LTD [GB]) 22 December 2016 (2016-12-22)	28-32
A	page 36 - page 42; claims 1-32; example 5; tables 5,9	1-26

A	US 4 902 437 A (VARDI JOSEPH [US] ET AL) 20 February 1990 (1990-02-20) claim 35; figure 2; example 3	1,2,5-26

A	US 2008/125337 A1 (GUINTHER GREGORY H [US] ET AL) 29 May 2008 (2008-05-29) paragraph [0025] - paragraph [0028]; claims 1,21,23; table 3	3,5-17, 19-26

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2020	29/05/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Pöllmann, Klaus

3

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/051829

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2015/322367 A1 (PATEL MRUGESH N [US] ET AL) 12 November 2015 (2015-11-12) claims 1,2; figures 4,6; examples 1,4,5,6 -----	4-17, 19-26 28-32

3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2020/051829

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

1-26, 28-32

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2, 18(completely); 5-17, 19-26(partially)

   Use of a compound of formula (1) or a base oil comprising a compound of formula (1) for improving resistance of a lubricating composition to oil consumption through combustion or to improve oil consumption in an internal combustion engine.

   ---

2. claims: 3(completely); 5-17, 19-26(partially)

   Use of a lubricating composition comprising a base oil comprising a compound of formula (1) for reducing poisoning of the exhaust after treatment system in an internal combustion engine.

   ---

3. claims: 4(completely); 5-17, 19-26(partially)

   Use of a lubricating composition comprising a base oil comprising a compound of formula (1) for reducing LSPI in an internal combustion engine.

   ---

4. claim: 27

   A method of extending the oil drain interval of an internal combustion engine comprising replacing at least partially the lubricating composition with a lubricating oil composition comprising a base oil including a compound of formula (1)

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5. claims: 28-32

   A lubricating composition for an internal combustion engine containing a base oil comprising a compound of formula (1) and at least 500 ppm of elemental calcium

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/051829

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2018109125 A1	21-06-2018	CN 110462012 A	15-11-2019
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