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(54) **Title:** METHOD FOR REDUCING LOW SPEED PRE-IGNITION

(57) **Abstract:** Use of Fischer-Tropsch derived base oil in a lubricating composition for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine.

## METHOD FOR REDUCING LOW SPEED PRE-IGNITION

Background of the Invention

Under ideal conditions, normal combustion in a conventional spark-ignited engine occurs when a mixture of fuel and air is ignited within the combustion chamber inside the cylinder by the production of a spark originating from a spark plug. Such normal combustion is generally characterized by the expansion of the flame front across the combustion chamber in an orderly and controlled manner.

However, in some instances, the fuel/air mixture may be prematurely ignited by an ignition source prior to the spark plug firing, thereby resulting in a phenomenon known as pre-ignition. Pre-ignition is undesirable as it typically results in the presence of greatly increased temperatures and pressures within the combustion chamber, which may have a significant, negative impact on the overall efficiency and performance of an engine. Pre-ignition may cause damage to the cylinders, pistons and valves in the engine and in some instances may even culminate in engine failure.

Recently, low-speed pre-ignition ( LSPI ) has been recognized amongst many original equipment manufacturers ( OEMs ) as a potential problem for highly boosted, down-sized spark-ignited engines. Contrary to the pre-ignition phenomenon observed in the late 50 s at high speeds, LSPI typically occurs at low speeds and high loads. The occurrence of LSPI may ultimately lead to so-called monster knock or mega-knock where potentially devastating pressure waves can result in severe damage to the piston and/or cylinder. As such, any technology that

can mitigate the risk of pre-ignition, including LSPI, would be highly desirable.

#### Summary of the Invention

According to the present invention there is provided  
5 the use of Fischer-Tropsch derived base oil in a lubricating composition for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine.

According to the present invention there is further  
10 provided a method for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine, the method comprising lubricating the internal combustion engine with a lubricating composition comprising base oil and one or more performance additives wherein the base oil  
15 comprises Fischer-Tropsch derived base oil.

The features and advantages of the present invention will be apparent to those skilled in the art. While numerous changes may be made by those skilled in the art, such changes are within the spirit of the invention.

#### Detailed Description of the Invention

Accordingly, the disclosure herein provides the use  
of Fischer-Tropsch derived base oil in a lubricating composition for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine.

According to the present invention there is further  
25 provided a method for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine, the method comprising lubricating the internal combustion engine with a lubricating composition comprising base oil and one or more performance additives wherein the base oil  
30 comprises Fischer-Tropsch derived base oil.

The level of occurrence of pre-ignition in a spark-ignited engine may be assessed using any suitable method.

In general, such a method may involve running a spark-ignited engine using the relevant lubricant composition, and monitoring changes in engine pressure during its combustion cycles, i.e., changes in pressure versus crank angle. A pre-ignition event will result in an increase in engine pressure before sparking: this may occur during some engine cycles but not others. Instead, or in addition to, changes in engine performance may be monitored, for example by maximum attainable brake torque, engine speed, intake pressure and/or exhaust gas temperature. Instead, or in addition to, a suitably experienced driver may test-drive a vehicle which is driven by the spark-ignited engine, to assess the effects of a particular lubricant composition on, for example, the degree of engine knock or other aspects of engine performance. Instead, or in addition to, levels of engine damage due to pre-ignition, for example due to the associated engine knock, may be monitored over a period of time during which the spark-ignited engine is running using the relevant lubricant composition.

A reduction in the occurrence of pre-ignition may be a reduction in the rate at which pre-ignition events occur within the engine, and/or in the severity of the pre-ignition events which occur (for example, the degree pressure change which they cause). It may be manifested by a reduction in one or more of the effects which pre-ignition can have on engine performance, for example impairment of brake torque or inhibition of engine speed. It may be manifested by a reduction in the amount or severity of engine knock, in particular by a reduction in, or elimination of, mega knock. Preferably, in the present invention, a reduction in the occurrence of pre-ignition is a reduction in the rate of which pre-ignition

events occur within the engine.

Since pre-ignition, particularly if it occurs frequently, can cause significant engine damage, the lubricant compositions disclosed herein may also be used for the purpose of reducing engine damage and/or for the purpose of increasing engine longevity.

The methods and lubricant compositions herein may be used to achieve any degree of reduction in the occurrence of pre-ignition in the engine, including reduction to zero (i.e., eliminating pre-ignition). It may be used to achieve any degree of reduction in a side effect of pre-ignition, for example engine damage. It may be used for the purpose of achieving a desired target level of occurrence or side effect. The method and use herein preferably achieves a 5% reduction or more in the occurrence of pre-ignition in the engine, more preferably a 10% reduction or more in the occurrence of pre-ignition in the engine, even more preferably a 15% reduction or more in the occurrence of pre-ignition in the engine, and especially a 30% reduction or more in the occurrence of pre-ignition in the engine.

Examples of suitable methods for measuring Low Speed Pre-Ignition events can be found in the following SAE papers: SAE 2014-01-1226, SAE 2011-01-0340, SAE 2011-01-0339 and SAE 2011-01-0342. Another example of a suitable method for measuring Low Speed Pre-Ignition events is that described in the Examples hereinbelow.

Lubricant compositions of the present disclosure generally comprise a base oil comprising a Fischer-Tropsch derived base oil and one or more performance additives, and should be suitable for use in a spark-ignited internal combustion engine. In some embodiments, the lubricant compositions disclosed herein may be particularly useful

in a turbocharged spark-ignited engine, more particularly a turbocharged spark-ignited engine which operates, or may operate, or is intended to operate, with an inlet pressure of at least 1 bar.

5 Base Oil

As an essential component, the lubricating compositions herein comprise one or more Fischer-Tropsch derived base oils.

10 Fischer-Tropsch derived base oils are known in the art. By the term Fischer-Tropsch derived is meant that a base oil is, or is derived from, a synthesis product of a Fischer-Tropsch process. A Fischer-Tropsch derived base oil may also be referred to as a GTL (Gas-To-Liquids) base oil. Suitable Fischer-Tropsch derived base oils that may  
15 be conveniently used as the base oil in the lubricating composition of the present invention are those as for example disclosed in EP 0 776 959, EP 0 668 342, WO 97/21788, WO 00/15736, WO 00/14188, WO 00/14187, WO 00/14183, WO 00/14179, WO 00/08115, WO 99/41332, EP 1 029  
20 029, WO 01/18156 and WO 01/57166.

Typically, the aromatics content of a Fischer-Tropsch derived base oil, suitably determined by ASTM D 4629, will typically be below 1 wt.%, preferably below 0.5 wt.% and more preferably below 0.1 wt.%. Suitably, the base oil  
25 has a total paraffin content of at least 80 wt.%, preferably at least 85, more preferably at least 90, yet more preferably at least 95 and most preferably at least 99 wt.%. It suitably has a saturates content (as measured by IP-368) of greater than 98 wt.%. Preferably the  
30 saturates content of the base oil is greater than 99 wt.%, more preferably greater than 99.5 wt.%. It further preferably has a maximum n-paraffin content of 0.5 wt.%. The base oil preferably also has a content of naphthenic

compounds of from 0 to less than 20 wt.%, more preferably of from 0.5 to 10 wt.%.

Typically, the Fischer-Tropsch derived base oil or base oil blend has a kinematic viscosity at 100°C (as measured by ASTM D445) in the range of from 1 to 30 mm<sup>2</sup>/s (cSt), preferably from 1 to 25 mm<sup>2</sup>/s (cSt), and more preferably from 2 mm<sup>2</sup>/s to 12 mm<sup>2</sup>/s. Preferably, the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C (as measured by ASTM D445) of at least 2.5 mm<sup>2</sup>/s, more preferably at least 3.0 mm<sup>2</sup>/s. In one embodiment of the present invention, the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C of at most 5.0 mm<sup>2</sup>/s, preferably at most 4.5 mm<sup>2</sup>/s, more preferably at most 4.2 mm<sup>2</sup>/s (e.g. GTL 4 ). In another embodiment of the present invention, the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C of at most 8.5 mm<sup>2</sup>/s, preferably at most 8 mm<sup>2</sup>/s (e.g. GTL 8 ).

Further, the Fischer-Tropsch derived base oil typically has a kinematic viscosity at 40°C (as measured by ASTM D445) of from 10 to 100 mm<sup>2</sup>/s (cSt), preferably from 15 to 50 mm<sup>2</sup>/s.

Also, the Fischer-Tropsch derived base oil preferably has a pour point (as measured according to ASTM D 5950) of -24°C or below, more preferably below -30°C, even more preferably below -40°C, and most preferably below -45°C.

The flash point (as measured by ASTM D92) of the Fischer-Tropsch derived base oil is preferably greater than 120°C, more preferably even greater than 140°C.

The Fischer-Tropsch derived base oil preferably has a viscosity index (according to ASTM D 2270) in the range of from 100 to 200. Preferably, the Fischer-Tropsch

derived base oil has a viscosity index of at least 125, preferably 130. Also it is preferred that the viscosity index is below 180, preferably below 150.

In the event the Fischer-Tropsch derived base oil  
5 contains a blend of two or more Fischer-Tropsch derived base oils, the above values apply to the blend of the two or more Fischer-Tropsch derived base oils.

The lubricating oil composition described herein preferably comprises 80 wt% or greater of Fischer-Tropsch  
10 derived base oil.

The lubricating oil composition described herein may also comprise one or more other base oils in addition to the Fischer-Tropsch derived base oil. Provided that the base oil used in the lubricating composition herein  
15 comprises at least a Fischer-tropsch derived base oil, there are no particular limitations regarding the other base oil(s) used in lubricating composition according to the present invention, and various conventional mineral oils, synthetic oils as well as naturally derived esters  
20 such as vegetable oils may be conveniently used. Any base oil which belongs to Group I, Group II, Group III, Group IV, Group V and so on of the API (American Petroleum Institute) base oil categories, may be conveniently used, provided that the requirements in  
25 respect of the lubricant compositions according to the present disclosure are met. Furthermore, the base oil may conveniently comprise mixtures of one or more mineral oils and/or one or more synthetic oils; thus, the term  
30 base oil may refer to a mixture comprising more than one base oil.

Mineral oils include liquid petroleum oils and solvent-treated or acid-treated mineral lubricating oil of the paraffinic, naphthenic, or mixed paraffinic/naphthenic



type which may be further refined by hydrofinishing processes and/or dewaxing.

Naphthenic base oils have low viscosity index (VI) (generally 40 80) and a low pour point. Such base oils are produced from feedstocks rich in naphthenes and low in wax content and are used mainly for lubricants in which color and color stability are important, and VI and oxidation stability are of secondary importance.

Paraffinic base oils have higher VI (generally >95) and a high pour point. Such base oils are produced from feedstocks rich in paraffins, and are used for lubricants in which VI and oxidation stability are important.

Synthetic oils include hydrocarbon oils such as olefin oligomers (including polyalphaolefin base oils; PAOs), dibasic acid esters, polyol esters, polyalkylene glycols (PAGs), alkyl naphthalenes and dewaxed waxy isomerates.

Poly-alpha olefin base oils (PAOs) and their manufacture are well known in the art. Suitable poly-alpha olefin base oils that may be used include those derived from linear C<sub>2</sub> to C<sub>32</sub>, preferably C<sub>6</sub> to C<sub>16</sub>, alpha olefins. Particularly preferred feedstocks for said poly-alpha olefins are 1-octene, 1-decene, 1-dodecene and 1-tetradecene.

Preferably, the base oil comprises mineral oils and/or synthetic oils which contain more than 80% wt of saturates, preferably more than 90 % wt., as measured according to ASTM D2007.

It is further preferred that the base oil contains less than 1.0 wt. %, preferably less than 0.03 wt. % of sulfur, calculated as elemental sulfur and measured according to ASTM D2622, ASTM D4294, ASTM D4927 or ASTM D3120.

Preferably, the viscosity index of the base oil is more than 80, more preferably more than 120, as measured according to ASTM D2270.

Preferably, the base oil preferably has a kinematic  
5 viscosity at 100°C of at least 2.5 mm<sup>2</sup>/s (according to ASTM D445), preferably at least 3 mm<sup>2</sup>/s. In some embodiments, the base oil has a kinematic viscosity at 100°C of between 3.0 and 4.5 mm<sup>2</sup>/s.

The total amount of base oil incorporated in the  
10 lubricant compositions is preferably in an amount in the range of from 60 to 99 wt. %, more preferably in an amount in the range of from 65 to 90 wt. % and most preferably in an amount in the range of from 75 to 88 wt. %, with respect to the total weight of the lubricant composition.

15 Performance Additives

Additionally, the lubricant compositions may further  
comprise one or more performance additives such as anti-oxidants, anti-wear additives, detergents, dispersants,  
friction modifiers, viscosity index improvers, pour point  
20 depressants, corrosion inhibitors, anti-foam agents, extreme pressure additives, metal passivators and seal fix/seal compatibility agents.

Examples of suitable anti-oxidants include, but are  
not limited to, aminic antioxidants, phenolic  
25 antioxidants, and mixtures thereof. Examples of aminic antioxidants which may be conveniently used include alkylated diphenylamines, phenyl-  
-naphthylamines, phenyl-  
-naphthylamines and alkylated -naphthylamines.

Preferred aminic antioxidants include  
30 dialkyldiphenylamines such as p,p'-dioctyl-diphenylamine, p,p'-di-  
-methylbenzyl-diphenylamine and N-p-butylphenyl-  
N-p'-octylphenylamine, monoalkyldiphenylamines such as mono-t-butyl-diphenylamine and mono-octyldiphenylamine,

bis(dialkylphenyl)amines such as di-(2,4-diethylphenyl)amine and di(2-ethyl-4-nonylphenyl)amine, alkylphenyl-1-naphthylamines such as octylphenyl-1-naphthylamine and n-t-dodecylphenyl-1-naphthylamine, 1-naphthylamine, aryl-naphthylamines such as phenyl-1-naphthylamine, phenyl-2-naphthylamine, N-hexylphenyl-2-naphthylamine and N-octylphenyl-2-naphthylamine, phenylenediamines such as N,N'-diisopropyl-p-phenylenediamine and N,N'-diphenyl-p-phenylenediamine, and phenothiazines such as phenothiazine and 3,7-dioctylphenothiazine.

Preferred aminic antioxidants include those available under the following trade designations: Sonoflex OD-3 (ex. Seiko Kagaku Co.), Irganox L-57 (ex. Ciba Specialty Chemicals Co.) and phenothiazine (ex. Hodogaya Kagaku Co.).

Examples of phenolic antioxidants which may be conveniently used include C<sub>7</sub>-C<sub>9</sub> branched alkyl esters of 3,5-bis(1,1-dimethyl-ethyl)-4-hydroxy-benzenepropanoic acid, 2-t-butylphenol, 2-t-butyl-4-methylphenol, 2-t-butyl-5-methylphenol, 2,4-di-t-butylphenol, 2,4-dimethyl-6-t-butylphenol, 2-t-butyl-4-methoxyphenol, 3-t-butyl-4-methoxyphenol, 2,5-di-t-butylhydroquinone, 2,6-di-t-butyl-4-alkylphenols such as 2,6-di-t-butylphenol, 2,6-di-t-butyl-4-methylphenol and 2,6-di-t-butyl-4-ethylphenol, 2,6-di-t-butyl-4-alkoxyphenols such as 2,6-di-t-butyl-4-methoxyphenol and 2,6-di-t-butyl-4-ethoxyphenol, 3,5-di-t-butyl-4-hydroxybenzylmercaptooctylacetate, alkyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionates such as n-octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, n-butyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate and 2'-ethylhexyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, 2,6-di-t-butyl-4-dimethylamino-p-cresol, 2,2'-methylene-

bis(4-alkyl-6-t-butylphenol) such as 2,2'-methylenebis(4-methyl-6-t-butylphenol), and 2,2-methylenebis(4-ethyl-6-t-butylphenol), bisphenols such as 4,4'-butylidenebis(3-methyl-6-t-butylphenol), 4,4'-methylenebis(2,6-di-t-butylphenol), 4,4'-bis(2,6-di-t-butylphenol), 2,2-(di-p-hydroxyphenyl)propane, 2,2-bis(3,5-di-t-butyl-4-hydroxyphenyl)propane, 4,4'-cyclohexylidenebis(2,6-t-butylphenol), hexamethyleneglycol-bis[3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate], triethyleneglycolbis[3-(3-t-butyl-4-hydroxy-5-methylphenyl)propionate], 2,2'-thio[diethyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate], 3,9-bis{1,1-dimethyl-2-[3-(3-t-butyl-4-hydroxy-5-methylphenyl)propionyloxy]ethyl}2,4,8,10-tetraoxaspiro[5,5]undecane, 4,4'-thiobis(3-methyl-6-t-butylphenol) and 2,2'-thiobis(4,6-di-t-butylresorcinol), polyphenols such as tetrakis[methylene-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate]methane, 1,1,3-tris(2-methyl-4-hydroxy-5-t-butylphenyl)butane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-t-butyl-4-hydroxybenzyl)benzene, bis-[3,3'-bis(4'-hydroxy-3'-t-butylphenyl)butyric acid]glycol ester, 2-(3',5'-di-t-butyl-4-hydroxyphenyl)methyl-4-(2'',4''-di-t-butyl-3''-hydroxyphenyl)methyl-6-t-butylphenol and 2,6-bis(2'-hydroxy-3'-t-butyl-5'-methylbenzyl)-4-methylphenol, and p-t-butylphenol - formaldehyde condensates and p-t-butylphenol - acetaldehyde condensates.

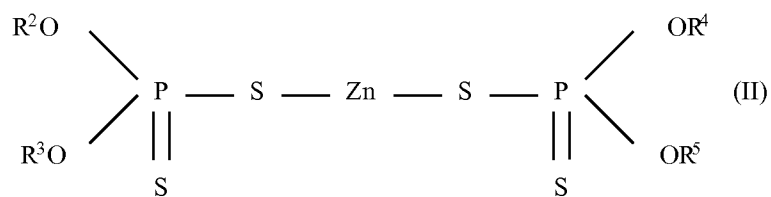
Examples of suitable phenolic antioxidants include those which are commercially available under the following trade designations: Irganox L-135 (ex. Ciba Specialty Chemicals Co.), Yoshinox SS (ex. Yoshitomi Seiyaku Co.), Antage W-400 (ex. Kawaguchi Kagaku Co.), Antage W-500 (ex. Kawaguchi Kagaku Co.), Antage W-300 (ex. Kawaguchi Kagaku Co.), Irganox L109 (ex. Ciba Speciality Chemicals Co.), Tominox 917 (ex. Yoshitomi Seiyaku Co.), Irganox

L115 (ex. Ciba Speciality Chemicals Co.), Sumilizer  
GA80 (ex. Sumitomo Kagaku), Antage RC (ex. Kawaguchi  
Kagaku Co.), Irganox L101 (ex. Ciba Speciality Chemicals  
Co.), Yoshinox 930 (ex. Yoshitomi Seiyaku Co.).

5 In a preferred embodiment, antioxidants are present  
in an amount in the range of from 0.1 to 5.0 wt. %, more  
preferably in an amount in the range of from 0.3 to 3.0  
wt. %, and most preferably in an amount in the range of  
from 0.5 to 1.5 wt. %, based on the total weight of the  
10 lubricant composition.

Anti-wear additives that may be conveniently used  
include zinc-containing compounds such as zinc  
dithiophosphate compounds selected from zinc dialkyl-,  
diaryl- and/or alkylaryl- dithiophosphates, molybdenum-  
15 containing compounds, boron-containing compounds and  
ashless anti-wear additives such as substituted or  
unsubstituted thiophosphoric acids, and salts thereof.

Zinc dithiophosphate is a well known additive in the  
art and may be conveniently represented by general formula  
20 II:



wherein R<sup>2</sup> to R<sup>5</sup> may be the same or different and are  
each a primary alkyl group containing from 1 to 20 carbon  
atoms preferably from 3 to 12 carbon atoms, a secondary  
alkyl group containing from 3 to 20 carbon atoms,  
25 preferably from 3 to 12 carbon atoms, an aryl group or an  
aryl group substituted with an alkyl group, said alkyl  
substituent containing from 1 to 20 carbon atoms  
preferably 3 to 18 carbon atoms.

Zinc dithiophosphate compounds in which R<sup>2</sup> to R<sup>5</sup> are

all different from each other can be used alone or in admixture with zinc dithiophosphate compounds in which R<sup>2</sup> to R<sup>5</sup> are all the same.

5 Examples of suitable zinc dithiophosphates include those which are commercially available under the following trade designations: Lz 1097 , Lz 1395 , Lz 677A , Lz 1095 , Lz 1370 , Lz 1371 , and Lz 1373 (ex. Lubrizol Corporation); OLOA 267 , OLOA 269R , OLOA 260 and OLOA 262 (ex. Chevron Oronite); and HITEC 7197 and  
10 HITEC 7169 (ex. Afton Chemical).

Examples of molybdenum-containing compounds may conveniently include molybdenum dithiocarbamates, trinuclear molybdenum compounds, for example as described in WO 98/26030, sulphides of molybdenum and molybdenum  
15 dithiophosphate.

Boron-containing compounds that may be conveniently used include borate esters, borated fatty amines, borated epoxides, alkali metal (or mixed alkali metal or alkaline earth metal) borates and borated overbased metal salts.

20 The lubricant compositions may generally comprise in the range of from 0.4 to 1.2 wt. % of an anti-wear additive, based on the total weight of the lubricant composition.

Typical detergents that may be used in the lubricating compositions include one or more salicylate  
25 and/or phenate and/or sulphonate detergents.

However, as metal organic and inorganic base salts which are used as detergents can contribute to the sulfated ash content of a lubricant composition, in a preferred embodiment, the amounts of such additives are  
30 minimized. Furthermore, in order to maintain a low sulphur level, salicylate detergents are preferred.

In order to maintain the total sulfated ash content

of the lubricant composition at a level of preferably not greater than 2.0 wt. %, more preferably at a level of not greater than 1.0 wt. % and most preferably at a level of not greater than 0.8 wt. %, based on the total weight of the lubricant composition, said detergents are preferably used in amounts in the range of 0.05 to 20.0 wt. %, more preferably from 1.0 to 10.0 wt. % and most preferably in the range of from 2.0 to 5.0 wt. %, based on the total weight of the lubricant composition.

Furthermore, the detergents may independently have a TBN (total base number) value in the range of from 10 to 500 mg.KOH/g, more preferably in the range of from 30 to 350 mg.KOH/g and most preferably in the range of from 50 to 300 mg.KOH/g, as measured by ISO 3771.

The lubricant compositions may additionally contain an ash-free dispersant which is preferably admixed in an amount in the range of from 5 to 15 wt. %, based on the total weight of the lubricant composition.

Examples of ash-free dispersants which may be used include the polyalkenyl succinimides and polyalkenyl succinic acid esters disclosed in Japanese Patent Nos. 1367796, 1667140, 1302811 and 1743435. Preferred dispersants include borated succinimides.

Examples of viscosity index improvers which may be conveniently used in the lubricant compositions include the styrene-butadiene copolymers, styrene-isoprene stellate copolymers and the polymethacrylate copolymer and ethylene-propylene copolymers. Such viscosity index improvers may be conveniently employed in an amount in the range of from 1 to 20 wt. %, based on the total weight of the lubricant composition.

Polymethacrylates may be conveniently employed in the lubricant compositions as effective pour point

depressants. For corrosion inhibitors, it is possible to use alkenyl succinic acid or ester moieties thereof, benzotriazole-based compounds and thiodiazole-based compounds.

5           Compounds such as polysiloxanes, dimethyl polycyclohexane and polyacrylates may be conveniently used in the lubricant compositions as anti-foam agents.

10           Compounds which may be conveniently used in the lubricant compositions as seal fix or seal compatibility agents include, for example, commercially available aromatic esters.

15           The lubricant compositions may be conveniently prepared using conventional formulation techniques by admixing one or more base oils with one or more performance additives.

20           The disclosure herein further provides the use of a lubricating composition comprising a Fischer-Tropsch derived base oil and one or more performance additives in the crankcase of a spark-ignited engine for reducing pre-ignition.

25           To facilitate a better understanding of the present invention, the following examples of certain aspects of some embodiments are given. In no way should the following examples be read to limit, or define, the entire scope of the invention.

#### Examples

30           Lubricant compositions comprising a base oil and an additive package were formulated as indicated in Table 1 below. All formulations were manufactured by blending together the base oils, the viscosity modifier and the additive package using conventional mixing techniques.

          The base oil used in Example 1 was a binary blend of GTL 4 and GTL 8. GTL 4 is a Fischer-Tropsch derived base



oil having a kinematic viscosity at 100°C (ASTM D445) of approximately 4 cst (mm<sup>2</sup>/s). The GTL 4 base oil may be conveniently manufactured by the process described in e.g. WO02/070631. GTL 8 is a Fischer-Tropsch derived base oil  
5 having a kinematic viscosity at 100°C (ASTM D445) of approximately 8 cst (mm<sup>2</sup>/s). The GTL 8 base oil may be conveniently manufactured by the process described in e.g. WO02/070631.

10 The base oil used in Comparative Example 1 was a blend of Yubase 4 and Yubase 6, both of which are commercially available from SK Lubricants.

The additive package was identical in Example 1 and Comparative Example 1 and comprised a detergent, an anti-oxidant, a viscosity modifier, a dispersant, an anti-wear  
15 additive, a pour point depressant, an anti-foam agent and a corrosion inhibitor.

Example 1 and Comparative Example 1 were formulated to meet the same performance specifications using the same additive package. Because the base oils are  
20 different in Example 1 and Comparative Example 1, the viscosity modifier was adjusted in each example such that the lubricant composition met the same viscosity specification. Therefore Example 1 and Comparative Example 1 were almost identical in terms of kV100  
25 (kinematic viscosity at 100°C), kV40 (kinematic viscosity at 40°C), CCS@-30°C (cold cranking simulation at -30°C) and HTHS@150°C (High Temperature High Shear at 150°C). Also, it is believed that there is little or no influence on LSPI with respect to Viscosity Modifier type or  
30 concentration, and therefore Example 1 and Comparative Example 1 below provide comparative data in terms of LSPI performance.

Table 1

	Example 1 (wt%)	Comparative Example 1 (wt%)
GTL 8	40	0
GTL 4	36.25	0
Yubase 4	0	59.55
Yubase 6	0	13
Viscosity Modifier	4.8	8.5
Additive Package	18.95	18.95
Total (wt%)	100	100

Example 1 and Comparative Example 1 were subjected to the following test method for measuring LSPI events and the frequency thereof.

5 Test Method for measuring LSPI

The test protocol used for measuring LSPI events involved running a quasi-steady state test on a modern turbocharged gasoline direct injection engine with a displacement of 2.0 L. The test included operation at an engine condition where the low speed pre-ignition phenomenon was known to occur. At this condition the engine controls were fixed to prevent distortion of the results by the engine settings. For this condition, the engine was held at steady conditions for 25,000 engine cycles (one test segment). This sequence was repeated over a 16 hour period to ensure statistical relevance of the results. The measurement metric for the test was to measure the combustion pressure in all four cylinders of the engine and to identify combustion cycles where low speed pre-ignition occurred. Those cycles were counted

and the average number of cycles per 25,000 engine cycle window was used to quantify the behaviour of each oil.

The following test conditions were used during the test:

- 5 - Torque/BMEP 290 Nm/18.3 bar
- Engine speed 2000 rpm
- Fuel injector location side mounted
- Piston cooling jets present, with cast-in oil galleries in the piston for enhanced cooling
- 10 - Injection timing 303 degrees BTDC (Before Top Dead Centre)
- Spark timing 0 degrees BTDC (Before Top Dead Centre)
- Exhaust gas recirculation none
- 15 - Coolant temperature 70 degrees C
- Fuel type Haltermann EEE at 93 AKI

The table below sets out the mean number of LSPI cycles per test segment for the lubricants of Example 1 and Comparative Example 1.

Table 2

Example:	Mean Total Number of LSPI cycles per test segment
Example 1	2.3
Comparative Example 1	3.6

20

The results in Table 2 show that the lubricant of Example 1 comprising a Fischer-Tropsch derived base oil was associated with a reduced LSPI occurrence compared with the lubricant of Comparative Example 1 (comprising an alternative, non-Fischer-Tropsch derived, Group III base oil).

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C L A I M S

1. Use of Fischer-Tropsch derived base oil in a lubricating composition for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine.
- 5 2. Use according to Claim 2 wherein the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C of from 2 to 12 mm<sup>2</sup>/s.
3. Use according to Claim 1 or 2 wherein the Fischer-Tropsch derived base oil has a kinematic viscosity at  
10 100°C of at least 2.5 mm<sup>2</sup>/s.
4. Use according to any of Claims 1 to 3 wherein the Fischer-Tropsch derived base oil has a kinematic viscosity at 100°C of at most 8.5 mm<sup>2</sup>/s.
5. Use according to any of Claims 1 to 4 wherein the  
15 lubricating composition comprises one or more performance additives.
6. Use according to any of Claims 1 to 5 wherein the lubricating composition is a passenger car motor oil.
7. Method for reducing the occurrence of Low Speed Pre-Ignition (LSPI) in an internal combustion engine, the  
20 method comprising lubricating the internal combustion engine with a lubricating composition comprising base oil and one or more performance additives wherein the base oil comprises Fischer-Tropsch derived base oil.

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2015/078076

A. CLASSIFICATION OF SUBJECT MATTER  
 INV. C10M107/02  
 ADD. C10N20/02 C10N40/25

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
 C10M 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, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KAZUO TAKEUCHI ET AL: "Investigation of Engine Oil Effect on Abnormal Combustion in Turbocharged Direct Injection - Spark Ignition Engines", SAE INTERNATIONAL JOURNAL OF FUELS AND LUBRICANTS, vol. 5, no. 3, 30 January 2012 (2012-01-30), pages 1017-1024, XP055203823, ISSN: 1946-3960, DOI: 10.4271/2012-01-1615 the whole document ----- -/--	1-7

Further documents are listed in the continuation of Box C.

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
9 February 2016	18/02/2016

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

International application No  
PCT/EP2015/078076

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KOSUKE FUJIMOTO ET AL: "Engine Oil Development for Preventing Pre-Ignition in Turbocharged Gasoline Engine", SAE INTERNATIONAL JOURNAL OF FUELS AND LUBRICANTS, vol. 7, no. 3, 15 April 2014 (2014-04-15), pages 869-874, XP055248491, ISSN: 1946-3960, DOI: 10.4271/2014-01-2785 abstract	1-7
X,P	----- EP 2 940 110 A1 (INFINEUM INT LTD [GB]) 4 November 2015 (2015-11-04) paragraphs [0017], [0018], [0022]; claims 1,4	7
X,P	----- WO 2015/171978 A1 (EXXONMOBIL RES & ENG CO [US]) 12 November 2015 (2015-11-12) paragraphs [0001], [0017]; claims 1,4	1-7
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Information on patent family members

International application No

PCT/EP2015/078076

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