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(71) Applicant (for all designated States except US): **CHEVRON U.S.A. INC.** [US/US]; 6001 Bollinger Canyon Road, San Ramon, California 94583 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **VAN DAM, Willem** [NL/US]; 6001 Bollinger Canyon Road, San Ramon, California 94583-2324 (US). **MC GEEHAN, Jim** [US/US]; 6001 Bollinger Canyon Road, San Ramon, California 94583-2324 (US). **MILLER, Trevor** [US/US]; 6001 Bollinger Canyon Road, San Ramon, California 94583-2324 (US). **BOOTH, James** [GB/US]; 6001 Bollinger Canyon Road, San Ramon, California 94583-2324 (US).

(74) Agents: **PRATER, Penny L.** et al.; Chevron Corporation, Law Department, P.O. Box 6006, San Ramon, California 94583-0806 (US).

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(54) Title: LUBRICATING OIL WITH IMPROVED WEAR PROPERTIES

(57) Abstract: Provided is a lubricating oil composition for internal combustion engines comprising at least one hydrocarbon base stock which is determined to exhibit a 40°C PVC/100°C PVC ratio approaching one or greater, and one or more lubricating additives. Also provided is a method for preparing such a composition, which includes determining the 40°C PVC/100°C PVC ratio of a hydrocarbon base stock oil, and selecting a hydrocarbon base stock oil which exhibits a 40°C PVC/100°C PVC ratio approaching one. One or more lubricating additives is then added to the selected base stock oil.



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LUBRICATING OIL WITH IMPROVED WEAR PROPERTIES

FIELD OF THE INVENTION

[0001] The present invention relates to a lubricating oil composition having improved wear properties, and in particular valve train wear properties. More particularly, the present invention employs base stocks exhibiting low temperature sensitivity of the Pressure-Viscosity-Coefficient (PVC) to obtain improved wear properties.

BACKGROUND OF THE INVENTION

[0002] Lubricating oils for internal combustion engines contain one or more additives in addition to at least one base lubricating oil. Lubricating oils are used to perform the critical function of lubricating moving parts in the internal combustion engine. Lubricating oils perform this function by maintaining a sufficiently high lubricating film thickness on metal surfaces in order to maintain low friction and reduce wear of the metal parts. Reduction in friction ultimately results in improved fuel economy and enhanced mechanical efficiency.

[0003] Reduction in friction can be accomplished by reducing the viscosity of the lubricating oil. While this approach works well at higher contact speeds, it may increase wear at lower contact speeds if a sufficiently thick lubricating oil cannot be maintained. Conventional lubricating oils rely on friction reducing agents, such as surface active friction modifiers, for protecting the metal surfaces at these lower contact speeds.

[0004] Fischer-Tropsch derived base oils have been blended to make lubricating oils. See, US 2008/0128322; US 2006/0027486; US 2006/0070914; US 2006/0076266; US 2006/0076227; US 2007/0049507; US 2006/0172898; US 2004/0235682; and U.S. Patent Nos. 7195706 and 7141157. Some of the blends comprise two or more Fischer-Tropsch derived base oils. Additives have also been used in the blends to enhance certain targeted properties. Specifications throughout the world are continually getting more stringent, making it more difficult to meet the specification.

[0005] In evaluation, lubricants for internal combustion engines have to deal with many contradicting requirements. Those requirements come in the form of limits for performance parameters measured in engine and bench tests as well as physical and chemical requirements. Typically included in those lubricant specifications are engine tests evaluating the lubricant's capability in protecting the engine's valve train from wear. Wear protection is traditionally

obtained from anti-wear additives, such as ZnDTP and other surface active materials. Another approach used to obtain wear protection is to increase the viscosity of the lubricant by going to higher viscosity grade lubricants, which increases the separation between the valve train components. The industry is constantly searching, however, for improved ways to obtain wear protection for internal combustion engines. Improved wear protection in a more economic and simple manner would be of great benefit of the industry.

SUMMARY OF THE INVENTION

[0006] Provided is a lubricating oil composition for internal combustion engines which provides improved wear protection for valve train components through the selection of a base stock having specific temperature sensitivity characteristics. The lubricating oil composition comprises at least one hydrocarbon base stock which is selected due to it exhibiting a 40°C PVC/100°C PVC ratio approaching one or greater, and one or more lubricating additives. Also provided is a method for preparing such a composition, which includes determining the 40°C PVC/100°C PVC ratio of a hydrocarbon base stock oil, and selecting a hydrocarbon base stock oil which exhibits a 40°C PVC/100°C PVC ratio approaching one. One or more lubricating additives is then added to the selected base stock oil.

[0007] Among other factors, the present lubricating oil composition and method for preparing same is based on the discovery of a relationship between temperature sensitivity of the Pressure-Viscosity-Coefficient (PVC) of a base stock and the wear properties exhibited by that base stock. Thus, by determining the temperature sensitivity of the PVC of a base stock and selecting the correct base stock for a lubricating oil composition, the wear properties of the lubricating oil composition are improved immediately. The need for additional additives is reduced and the need for higher viscosity grade lubricants is avoided. A lower viscosity oil can be used in the present composition, while still exhibiting excellent cam wear properties.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0008] The present lubricant composition provides greatly improved valve train wear control due to the selection of base stocks with specific temperature sensitivity characteristics. The base stocks of choice exhibit less temperature sensitivity of the Pressure-Viscosity-Coefficient (PVC) than conventionally used base stocks, thus minimizing the reduction of

contact film thickness with increasing temperature, relative to ‘typical’ base oils. Such base stocks have been found to exhibit higher PVC at the temperature levels experienced in the valve train’s wear contacts of an internal combustion engine. As a result of this higher PVC, these base stocks behave more solid-like under extremely high contact pressures, greater than 0.5 GPa. By measuring the PVC of a base oil at 40°C and 100°C, the temperature sensitivity of the PVC can be determined by the ratio of 40°C PVC/100°C PVC. As this ratio approaches 1.00, the base stock PVC is less sensitive to the temperature. Base stocks showing this behavior have been found to provide improved wear protection. Such base stocks surprisingly cover a broad range of viscosity indices (VI), indicating that the characteristic of interest is not necessarily correlated with VI or any of its associated parameters such as the VII content or the lubricant’s VII dosage related shear behavior.

[0009] The PVC of a base stock can be determined using a calculation procedure as follows:

Measure the EHL film thickness of the samples and the reference oil, e.g.,
Squalane, at desired temperatures, i.e., 40°C and 100°C.

Calculate the PVC values by applying the following equation:

$$\alpha S = \alpha R [(hS/hR) (\eta S/\eta R) - 0.67]^{1/0.53}$$

[00010] The subscripts S and R refer to the samples and the reference oil, respectively; α is the PVC value; h the film thickness, and η the dynamic viscosity.

[00011] The h values are measured on an EHL system, the viscosity η data can be measured or obtained by a provider of the base stock. The parameter values α and η of the reference oil, Squalane, are available in the literature.

[00012] The EHL film thickness is measured on an EHL Ultra Thin Film Measurement System, a computer controlled instrument for measuring the film thickness and traction coefficient (friction coefficient) of lubricants in the elastohydrodynamic (EHL) lubricating regime. The instrument can measure lubricant film thickness down to 1 nm with a precision of +/- 1 nm. Traction coefficient can be measured at any slide/roll ratio from pure rolling up to 100%. The instrument measures these lubricant properties in the contact formed between a steel ball and a rotating glass or steel disk. The contact pressures and shear rates in this contact are similar to those found in for example, gears, rolling element bearings and cams.

[00013] Once the PVC ratio is determined, a base stock oil having a ratio approaching one or greater is selected. The 40°C PVC/100°C PVC ratio is generally at least 0.85, e.g., in the

range of from 0.85 to 1.05. In another embodiment, the ratio is at least 0.90, e.g., in the range of from 0.09 to 1.05; and the ratio in another embodiment is at least 0.95, e.g., in the range of from 0.95 to 1.05. The measurements can be at 20 N or 50N, which values have not generally been found to change the results of the determination. Suitable additives can then be added to the selected base stock oil to obtain the lubricating oil composition.

[00014] The base stock oil can be any suitable base stock oil as long as it exhibits a 40°C PVC/100°C PVC ratio approaching one, e.g., at least 0.85. The base stock oil can be any base stock oil, conventional or FTBO, but the use of an FTBO has been found quite advantageous. The viscosity of the base stock oil also can vary greatly, as long as the ratio is met, e.g., a kinematic viscosity at 100°C of 7 mm²/sec or higher can be used. The selected base stock oil can be used alone, or in a mixture with other base stock oils meeting the PVC ratio requirement.

[00015] The selected base stock oil or oils can be used alone to formulate the lubricating oil composition, or can be blended with a minor amount, i.e., less than 50 wt%, of another base stock oil not meeting the PVC ratio requirement. The blending component can comprise any suitable base stock oil, with good results being achieved with Fischer-Tropsch derived base oils. The mixing component can have any suitable viscosity as well, e.g., at least 7 mm²/sec, or at least 10 mm²/sec. When conventional base oils are mixed with the selected base stock oil, the amount blended will generally be a maximum of 30 wt%, or even 10 wt%, based on the total weight of the lubricating oil composition. Conventional base oils include any hydrocarbon base stocks, conventional mineral oil derived base oils as well as synthetic oils, including synthetic esters.

[00016] The base stock or blend of base stocks used in the lubricating oil composition will generally have a kinematic viscosity at 100°C in the range of from 3 to 12 mm²/sec, and more likely in the range of from 4 to 10 mm²/sec. Various additives can be added to adjust the viscosity if desired.

[00017] In preparing the present lubricating oil composition, therefore, one first determines the 40°C PVC/100°C PVC ratio of a hydrocarbon base stock. Then a hydrocarbon base stock is selected which has been determined to have a 40°C PVC/100°C PVC ratio approaching one, e.g., at least 0.85. This can be mixed with other such base stock oils, or blended with a minor amount, i.e., less than 50 wt %, of base stock oil, conventional,

FTBO, etc., which does not meet the PVC ratio. Suitable lubricating additives can be added to prepare the final lubricating oil composition.

[00018] Fischer-Tropsch derived base oils are well known. In Fischer Tropsch chemistry, syngas is converted to liquid hydrocarbons by contact with a Fischer Tropsch catalyst under reactive conditions. Typically, methane and optionally heavier hydrocarbons (ethane and heavier) can be sent through a conventional syngas generator to provide synthesis gas. Generally, synthesis gas contains hydrogen and carbon monoxide, and may include minor amounts of carbon dioxide and/or water. The presence of sulfur, nitrogen, halogen, selenium, phosphorus and arsenic contaminants in the syngas is undesirable. For this reason and depending on the quality of the syngas, it is preferred to remove sulfur and other contaminants from the feed before performing the Fischer-Tropsch chemistry. Means for removing these contaminants are well known to those of skill in the art.

[00019] In the Fischer-Tropsch process, contacting a synthesis gas comprising a mixture of H_2 and CO with a Fischer-Tropsch catalyst under suitable temperature and pressure reactive conditions forms liquid and gaseous hydrocarbons. Examples of conditions for performing Fischer-Tropsch type reactions are well known to those of skill in the art.

[00020] The fractions of the Fischer-Tropsch synthesis process may range from C_1 to C_{200+} with a majority in the C_5 to C_{100+} range. The reaction can be conducted in a variety of reactor types, such as fixed bed reactors containing one or more catalyst beds, slurry reactors, fluidized bed reactors, or a combination of different type reactors. Such reaction processes and reactors are well known and documented in the literature.

[00021] The slurry Fischer-Tropsch process, which is preferred in the practice of the invention, utilizes superior heat (and mass) transfer characteristics for the strongly exothermic synthesis reaction and is able to produce relatively high molecular weight, paraffinic hydrocarbons when using a cobalt catalyst. A particularly preferred Fischer-Tropsch process is taught in European Patent Application No. 9400600.7 (Publication No. EP 060 9079 B1).

[00022] In general, Fischer Tropsch catalysts contain a Group VII transition metal on a metal oxide support. The catalysts may also contain a noble metal promoter(s) and/or crystalline molecular sieves. Suitable Fischer-Tropsch catalysts comprise one or more of Fe, Ni, Co, Ru and Re, with cobalt being preferred. A preferred Fischer-Tropsch catalyst comprises effective amounts of cobalt and one or more of Re, Ru, Pt, Fe, Ni, Th, Zr, Hf, U,

Mg and La on a suitable inorganic support material, preferably one which comprises one or more refractory metal oxides. Useful catalysts and their preparation are known and illustrated in U.S. Patent No. 4,568,663, which is intended to be illustrative but not limiting the selection of the catalyst.

[00023] A particularly preferred Fischer-Tropsch process is taught in European Patent Application No. 9400600.7 (Publication No. EP 060 9079 B1). Examples of processes producing waxes of higher carbon number distribution are taught in PCT International Application PCT/98EP/08545 (Publication No. WO9934917 A1).

[00024] The fractions from Fischer-Tropsch reactions generally include a light reaction fraction and a waxy reaction fraction, which typically contain predominantly paraffins. It is the waxy reaction fraction (i.e., the wax fraction) that is used as a feedstock to the process for providing the Fischer-Tropsch derived lubricating base oil used in the blended lubricants and blended finished lubricants of the present invention.

[00025] Isomerized Fischer-Tropsch distillate fractions are prepared from the waxy fractions of the Fischer-Tropsch syncrude by a process including hydroisomerization. Preferably, the Fischer-Tropsch lubricant base oils are made by a process as described in U.S. Patent No. 7,083,713, herein incorporated by reference in its entirety.

[00026] Hydroisomerization is intended to improve the cold flow properties of the lubricating base oil by the selective addition of branching into the molecular structure. Hydroisomerization ideally will achieve high conversion levels of the Fischer-Tropsch wax to non-waxy iso-paraffins while at the same time minimizing the conversion by cracking.

[00027] Hydroisomerization catalysts useful in the present invention comprise a shape selective intermediate pore size molecular sieve and optionally a catalytically active metal hydrogenation component on a refractory oxide support. Preferred shape selective intermediate pore size molecular sieves used for hydroisomerization are based upon aluminum phosphates, with SAPO-11 being preferred. SM-3 is a particularly preferred shape selective intermediate pore size SAPO, which has a crystalline structure falling within that of the SAPO-11 molecular sieves. The preparation of SM-3 and its unique characteristics are described in U.S. Patent Nos. 4,943,424 and 5,158,665. Other shape selective intermediate pore size molecular sieves used for hydroisomerization are zeolites, and SSZ-32 and ZSM-23 are preferred.

[00028] A particularly preferred intermediate pore size molecular sieve, which is useful in the present process, is described in U.S. Patent Nos. 5,135,638 and 5,282,958, the contents of which are hereby incorporated by reference in their entirety.

[00029] Hydroisomerization catalysts useful in the present invention comprise a catalytically active hydrogenation metal. The presence of a catalytically active hydrogenation metal leads to fraction improvement, especially VI and stability. Typically catalytically active hydrogenation metals include chromium, molybdenum, nickel, vanadium, cobalt, tungsten, zinc, platinum, and palladium. The metals platinum and palladium are especially preferred, with platinum most especially preferred.

[00030] The refractory oxide support may be selected from those oxide supports, which are conventionally used for catalysts, including silica, alumina, silica-alumina, magnesia, titania and combinations thereof.

[00031] Suitable conditions for performing hydroisomerization are described in U.S. Patent Nos. 5,282,958 and 5,135,638, the contents of which are incorporated by reference in their entirety.

[00032] Hydrogen is present in the reaction zone during the hydroisomerization process. Hydrogen may be separated from the fraction and recycled to the reaction zone.

[00033] A waxy feed to the hydroisomerization process may be hydrotreated prior to hydroisomerization dewaxing. Hydrotreating refers to a catalytic process, usually carried out in the presence of free hydrogen, in which the primary purpose is the removal of various metal contaminants, such as arsenic, aluminum, and cobalt; heteroatoms, such as sulfur and nitrogen; oxygenates; or aromatics from the feed stock.

[00034] Catalysts used in carrying out hydrotreating operations are well known in the art, for example, U.S. Patent Nos. 4,347,121 and 4,810,357, the contents of which are hereby incorporated by reference in their entirety. Other suitable catalysts are described, for example, in U.S. Patent Nos. 4,157,294 and 3,904,513. The non-noble hydrogenation metals, such as nickel-molybdenum, are usually present in the final catalyst composition as oxides.

[00035] Typical hydrotreating conditions vary over a wide range.

[00036] Hydrofinishing is a hydrotreating process that may be used as a step following hydroisomerization to provide the Fischer-Tropsch lubricating base oil. Hydrofinishing is intended to improve oxidation stability, UV stability, and appearance of the Fischer-Tropsch

lubricating base oil fraction by removing traces of aromatics, olefins, color bodies, and solvents. A general description of hydrofinishing may be found in U.S. Patent Nos. 3,852,207 and 4,673,487.

[00037] The conditions for hydrofinishing will be tailored to achieve an isomerized Fischer-Tropsch derived distillate fraction comprising weight percent aromatics less than 0.30.

[00038] Suitable hydrofinishing catalysts include noble metals from Group VIIIA, such as platinum or palladium or an alumina or siliceous matrix, and unsulfided Group VIIIA and Group VIB, such as nickel-molybdenum or nickel-tin on an alumina or silica matrix. U.S. Patent No. 3,852,207 describes a suitable noble metal catalyst and mild conditions. Other suitable catalysts are described in U.S. Patent Nos. 4,157,294 and 3,904,513.

[00039] Clay treating to remove impurities is an alternative final process step to provide an isomerized Fischer-Tropsch derived distillate fraction.

[00040] The separation of Fischer-Tropsch derived fractions and petroleum derived fractions into various fractions having characteristic boiling ranges is generally accomplished by either atmospheric or vacuum distillation or by a combination of atmospheric and vacuum distillation. Fractionating the lubricating base oil into different boiling range cuts enables the lubricating base oil manufacturing plant to produce more than one grade, or viscosity, or lubricating base oil.

[00041] The process to make an isomerized Fischer-Tropsch derived distillate fraction may also include a solvent dewaxing step following the hydroisomerization process. Solvent dewaxing optionally may be used to remove small amounts of remaining waxy molecules from the lubricating base oil after hydroisomerization dewaxing. Solvent dewaxing is done by dissolving the lubricating base oil in a solvent, such as methyl ethyl ketone, methyl isobutyl ketone, or toluene, and precipitating the wax molecules. Solvent dewaxing is described in U.S. Patent Nos. 4,477,333, 3,773,650 and 3,775,288 and 7,018,525.

[00042] Conventional synthetic oils include hydrocarbon synthetic oils and synthetic esters. Useful synthetic hydrocarbon oils include liquid polymers of alpha-olefins having the proper viscosity. Especially useful are the hydrogenated liquid oligomers of C₆ to C₁₂ alpha-olefins such as 1-decene trimer. Similarly, alkyl benzenes of proper viscosity, such as didodecyl benzene, may be used. Useful synthetic esters include the esters of monocarboxylic acids and polycarboxylic acids as well as mono-hydroxy alkanols and polyols.

Typical examples are didodecyl adipate, pentaerthritol tetracapoate, di-2-ethylhexyl adipate, di-laurylsebacate and the like. Complex esters prepared from mixtures of mono- and di-carboxylic acid and mono- and di-hydroxy alkanols can also be used.

[00043] Below are listed the American Petroleum Institute's (API) base oil categories, Groups I-V. Preferred are base oils in Groups II-V. Any suitable base stock oil, conventional or FTBO can be used as the selected base stock long as the PVC ratio requirement is met.

<u>API Base Oil Categories</u>				
Base Oil Category	Sulfur (%)		Saturates (%)	Viscosity Index
Group I	>0.03	and/or	<90	80 to 120
Group II	<0.03	and	>90	80 to 120
Group III	<0.03	and	>90	>120
Group IV	PAO synthetic lubricants			
Group V	All other base oils not included in Group I, II, III, IV			

[00044] If desired, any of the conventional lubricating additives can be added to fine tune the characteristics and properties of the final lubricating oil composition. Below is described a number of such exemplary lubricating additives.

Dispersants

[00045] The lubricating oil composition of the present invention can contain dispersants. Typically, the ashless dispersants are nitrogen-containing dispersants formed by reacting alkenyl succinic acid anhydride with an amine. Examples of such dispersants are alkenyl succinimides and succinamides. These dispersants can be further modified by reaction with, for example, boron or ethylene carbonate. Ester-based ashless dispersants derived from long chain hydrocarbon-substituted carboxylic acids and hydroxy compounds may also be employed. Preferred ashless dispersants are those derived from polyisobutenyl succinic anhydride. A large number of dispersants are commercially available.

Anti-Wear Agents

[00046] Traditional wear inhibitors may be employed in the lubricating oil compositions of this invention. As their name implies, these agents reduce wear of moving metallic parts.

Examples of such anti-wear agents include, but are not limited to phosphates, phosphites, carbamates, esters, sulfur containing compounds, and molybdenum complexes. The lubricating oil composition of this invention may comprise one or more anti-wear agents, such as metal di-thio di-phosphates and metal di-thiocarbamates or mixtures thereof. A preferred anti-wear agent for use in this invention comprises zinc di-thio di-phosphate.

Anti-Oxidants

[00047] Anti-oxidants are used in lubricating oils for inhibition of decomposition processes that occur naturally in lubricating oils as they age or oxidize in the presence of air. These oxidation processes may cause formation of gums, lacquers and sludge resulting in an increase in acidity and viscosity. Examples of useful anti-oxidants are hindered phenol oxidation inhibitors, such as 4,4'-methylene-bis(2,6-di-tert-butylphenol), 4,4'-bis(2,6-di-tert-butylphenol), 4,4'-bis(2-methyl-6-tert-butylphenol), 2,2'-methylene-bis(4-methyl-6-tert-butylphenol), 4,4'-butylidene-bis(3-methyl-6-tert-butylphenol), 4,4'-isopropylidene-bis(2,6-di-tert-butylphenol), 2,2'-methylene-bis(4-methyl-6-nonylphenol), 2,2'-isobutylidene-bis(4,6-dimethylphenol), 2,2'-5-methylene-bis(4-methyl-6-cyclohexylphenol), 2,6-di-tert-butyl-4-methylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,4-dimethyl-6-tert-butyl-phenol, 2,6-di-tert-butyl-4-dimethylamino-p-cresol, 2,6-di-tert-butyl-4-(N,N'-di-methylaminomethylphenol), 4,4'-thiobis(2-methyl-6-tert-butylphenol), 2,2'-thiobis(4-methyl-6-tert-butylphenol), bis(3-methyl-4-hydroxy-5-tert-butylbenzyl)-sulfide, and bis(3,5-di-tert-butyl-4-hydroxybenzyl). Examples of alkylated and non-alkylated aromatic amines are alkylated diphenylamine, phenyl-alpha-naphthylamine, and alkylated-alpha-naphthylamine. Other classes of anti-oxidants are esters of thiodicarboxylic acids, salts of di-thiophosphoric acids, alkyl or aryl phosphates and molybdenum compounds, such as amine-molybdenum complex compound and molybdenum di-thiocarbamates may also be used as anti-oxidants, provided the molybdenum compounds do not include tri-nuclear molybdenum. However, their addition will contribute to the phosphorus, sulfur and sulfated ash content of the lubricating oil.

Low, Medium and High Overbased Metal Detergents

[00048] Examples of the low and medium overbased metal detergents employed in the lubricating oil composition of the present invention are low, medium or high overbased sulfonates, salicylates, phenates or Mannich condensation products of alkylphenols, aldehydes and amines. These detergents may be alkali metal detergents or alkaline earth

metal detergents. Preferably they are alkaline earth metal detergents and more preferably they are calcium detergents. The TBN of these detergents is greater than 1 and about 500, or more. These detergents are well known in the art and are commercially available.

Other Additives

[00049] The lubricating oil composition of the present invention may also contain, in addition to the additives discussed above, other additives used to impart desirable properties to the lubricating oil composition of the present invention. Thus, the lubricating oil may contain one or more of additives, such as viscosity index improvers, pour point depressants, demulsifiers, extreme pressure agents and foam inhibitors. These additional additives are described in more detail below.

Viscosity Index Improvers

[00050] Viscosity index improvers are added to lubricating oil to regulate viscosity changes due to the change in temperature. Some commercially available examples of viscosity index improvers are olefin copolymers, such as ethylene-propylene copolymers, styrene-isoprene copolymers, hydrated styrene-isoprene copolymers, polybutene, polyisobutylene, polymethacrylates, vinylpyrrolidone and methacrylate copolymers and dispersant type viscosity index improvers.

Extreme Pressure Agents

[00051] Extreme pressure agents that may be used in the lubricating oil composition of the present invention include alkaline earth metal borated extreme pressure agents and alkali metal borated extreme pressure agents. Extreme pressure agents containing molybdenum may also be employed in the lubricating oil composition of the present invention, provided the molybdenum compounds do not include tri-nuclear molybdenum. Sulfurized olefins, zinc dialky-1-dithiophosphate (primary alkyl, secondary alkyl, and aryl type), di-phenyl sulfide, methyl tri-chlorostearate, chlorinated naphthalene, fluoroalkylpolysiloxane, lead naphthenate, neutralized or partially neutralized phosphates, di-thiophosphates, and sulfur-free phosphates. The preferred extreme pressure agents are those that will not contribute to the phosphorous content of the lubricating oil.

Pour Point Depressants

[00052] Pour point depressants are additives that optimize the low temperatures fluidity of the lubricating oil. Examples are various copolymers.

Rust Inhibitors

[00053] Rust inhibitors include nonionic polyoxyethylene surface active agents, such as polyoxyethylene lauryl ether, polyoxyethylene higher alcohol ether, polyoxyethylene nonyl phenyl ether, polyoxyethylene octyl phenyl ether, polyoxyethylene octyl stearyl ether, polyoxyethylene oleyl ether, polyoxyethylene sorbitol monostearate, polyoxyethylene sorbitol mono-oleate, and polyethylene glycol mono-oleate. Other compounds that may also be employed as rust inhibitors include stearic acid and other fatty acids, di-carboxylic acids, metal soaps, fatty acid amine salts, metal salts of heavy sulfonic acid, partial carboxylic acid ester of polyhydric alcohol, and phosphoric ester. However, preferred rust inhibitors are those that do not contribute to the phosphorus or sulfur content of the lubricating oil. Some of the above listed rust inhibitors may have friction modifying properties. However, these could be added in quantities sufficient for rust inhibition, but not high enough to provide their friction modifying property.

Corrosion Inhibitors

[00054] Corrosion inhibitors are included in lubricating oils to protect vulnerable metal surfaces. Such corrosion inhibitors are generally used in very small amounts in the range of from about 0.02 weight percent to about 1.0 weight percent. Examples of corrosion inhibitors that may be used are sulfurized olefin corrosion inhibitor and the co-sulfurized alkenyl ester/alpha olefin corrosion inhibitor.

Metal Deactivators

[00055] Metal deactivators that may be employed in the lubricating oil composition of the present invention include but are not limited to di-salicylidene propylenediamine, triazole derivatives, mercaptobenzothiazoles, thiodiazole derivatives, and mercaptobenzimidazoles.

Demulsifiers

[00056] Addition product of alkylphenol and ethylene oxide, polyoxyethylene alkyl ether, and polyoxyethylene sorbitan ester may be employed in the lubricating oil composition of the present invention.

Foam Inhibitors

[00057] Useful foam inhibitors for the present invention are alkyl methacrylate polymers, dimethyl silicone polymers and polysiloxane type foam inhibitors.

[00058] For best overall results in terms of affording the properties desired in a conventional lubricating oil composition for lubricating diesel engines, gasoline engines and natural gas engines, the lubricating oil may contain a compatible combination of additives of each of the above classes of additives in effective amounts.

[00059] The various additive materials or classes of materials herein described are well known materials and can be readily purchased commercially or prepared by known procedures or obvious modification thereof.

EXAMPLE 1

[00060] The following runs were made to demonstrate the superior wear characteristics of the lubricating oils of the present invention. Five separate comparative lubricating oils were made using SAE 15W-40 formulation with an additive package, using Group II base stocks. The lubricant of the present invention used a Fischer Tropsch base oil, also known as Gas-to-Liquid base oil (FTBO or GTL), and was blended with another FTBO (FTBO 14). The actual viscosity of the base oils was different depending on the viscosity grade of the lubricant. The FTBO used for the lubricant of the present invention (FTBO 7) had a Kinematic Viscosity at 100°C of 7 mm²/sec.

[00061] The PVC ratio for each of the lubricating base stocks used was determined as follows:

Pressure viscosity coefficient (PVC) calculation procedures:

Measure the EHL film thickness of the samples and the reference oil,

Squalane, at desired temperatures, i.e., 40°C and 100°C

Calculate the PVC values by applying the following equation:

$$\alpha_S = \alpha_R [(h_S/h_R) (\eta_S/\eta_R)^{-0.67}]^{1/0.53}$$

[00062] The subscripts S and R refer to the samples and the reference oil, respectively; α is the PVC value; h the film thickness, and η the dynamic viscosity.

[00063] The h values are measured on an EHL system, the viscosity η data can be measured or obtained by a provider of the base stock. The parameter values α and η of the reference oil, Squalane, are available in the literature.

[00064] The EHL film thickness was measured on an EHL Ultra Thin Film Measurement System, a computer controlled instrument for measuring the film thickness and traction coefficient (friction coefficient) of lubricants in the elastohydrodynamic (EHL) lubricating regime.

[00065] The FTBO 7 had a 40°C PVC/100°C PVC ratio of about 0.88, while the base stock with which it was blended, FTBO 14, had a 40°C PVC/100°C PVC ratio of about 0.97. In the comparative lubricating oils, the Motiva Star 5 and Motiva Star 8 had a 40°C PVC/100°C PVC ratio of less than 0.80, as did the EHC 110 and EHC 60 lubricating oils.

[00066] The following results were obtained by running the oils with the same additive package, but differing base oils through the Daimler OM611 test, which evaluates engine crankcase lubricants with respect to wear under severe operating conditions.

Viscosity Grade	Comparatives					Example
	15W-40	15W-40	15W-40	15W-40	15W-40	10W-40
Inlet Camshaft wear [μm]	78	117	60	132	131	38
Outlet Camshaft wear [μm]	166	174	139	183	188	58
Base oil %						
Motiva Star 5	19	21	—	—	—	—
Motiva Star 8	81	79	—	—	—	—
EHC 110	—	—	29	36	36	—
EHC 60	—	—	71	64	64	—
Chevron FTBO 7	—	—	—	—	—	68
Chevron FTBO 14	—	—	—	—	—	32
Viscosity modifier	6	7	6.7	6.1	6.5	0.95

[00067] The results show that the present formulation exhibited cam wear that was excellent, as it was 37.9/57.6 μm (inlet/outlet valve), far lower than any of the other 5 runs.

EXAMPLE 2

[00068] The following results were obtained by running oils with the same additive package, but differing base oils through the Cummins ISB valve-train wear test (ASTM D7484). The PVC ratio for each lubricating oil was determined in Example 1, and is the same as noted in Example 1.

	Comparative	Example A	Example B
Viscosity Grade	15W-40	10W-40	5W-30
Camshaft wear [μm]	49	15	37
Tappet weight loss [mg]	91	36	47
Base oil %			
Motiva Star 5	21	—	—
Motiva Star 8	79	—	—
Chevron FTBO 7	—	69	100
Chevron FTBO 14	—	31	—
Viscosity modifier	7	1.65	0.8

[00069] The overall performance demonstrated in the OM 611 Engine Test and in the Cummins ISB Engine Test (ASTM D7484) clearly demonstrates the improved wear performance of the present lubricating compositions. In both tests/examples, the comparatives were blended to a higher viscosity grade than the lubricant of the present invention, yet the lower viscosity grade lubricant of the present invention provided significant and surprising wear benefits. In all cases, the comparative and the present lubricant differ only in the base stock selection, with no differences in surface active additives.

[00070] The determination and selection of a base stock oil having a 40°C PVC/100°C PVC ratio approaching one provided for superior wear properties, even at lower viscosity grades.

[00071] Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of the invention. Other objects and advantages will become apparent to those skilled in the art from a review of the preceeding description.

WHAT IS CLAIMED IS:

1. A lubricating oil composition for internal combustion engines comprising:
 - a) at least one hydrocarbon base stock which is selected once it is determined to exhibit a 40°C PVC/100°C PVC ratio approaching one or greater; and
 - b) one or more lubricating additives.
2. The composition of claim 1, wherein the at least one hydrocarbon base stock is blended with a minor amount of a different base stock.
3. The composition of claim 2, wherein the different base stock is a Fischer-Tropsch derived base oil.
4. The composition of claim 1, wherein the at least one hydrocarbon base stock which is selected because it exhibits a 40°C PVC/100°C PVC ratio is a Fischer-Tropsch derived base oil.
5. The composition of claim 3, wherein the Fischer-Tropsch derived base oil blended with the hydrocarbon base stock exhibits a kinematic viscosity at 100°C of at least 7 mm²/sec.
6. The composition of claim 1, wherein the at least one hydrocarbon base stock exhibits a kinematic viscosity at 100°C in the range of from 3 to 12 mm²/sec.
7. The composition of claim 1, wherein the composition contains no viscosity modifier.
8. The composition of claim 1, wherein the composition contains one or more detergents.
9. The composition of claim 1, wherein the composition contains one or more dispersants.
10. The composition of claim 1, wherein the composition contains one or more anti-oxidants.

11. The lubricating oil composition of claim 1, wherein the composition further comprises one or more conventional base oils, and wherein the conventional base oil is a maximum of 30 weight percent based on the total weight of the lubricating oil composition.
12. A method for lubricating an internal combustion engine and reducing the wear comprising lubricating the internal combustion engine with the lubricating oil composition of claim 1.
13. A method for preparing the lubricating oil composition of claim 1, comprising:
 - a) determining the 40°C PVC/100°C PVC ratio of a hydrocarbon base stock oil;
 - b) selecting a hydrocarbon base stock oil once it is determined to have a 40°C PVC/100°C PVC ratio approaching one; and
 - c) adding one or more lubricating additives.
14. The method of claim 13, further comprising blending the hydrocarbon base stock oil of b) with a Fischer-Tropsch derived base oil
15. The method of claim 13, wherein the hydrocarbon base stock oil is a Fischer-Tropsch derived base oil.