

**Title: LUBRICANT COMPOSITION CONTAINING VISCOSITY
INDEX IMPROVER**

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Technical Field

This invention relates to lubricant compositions containing viscosity index (VI) improvers. More particularly, this invention relates to lubricant compositions containing VI improvers in the form of polymers comprising structural units derived from ethylene, propylene and butylene.

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Background

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Petroleum products typically exhibit large variations in viscosity with variations in temperature. However, for lubricating oil compositions used for automobiles and the like, it is preferable that the temperature dependence of the viscosity be small. In order to decrease the temperature dependence of viscosity, olefin copolymers have been added to lubricating oil compositions as VI improvers.

Summary

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Ethylene-propylene copolymers have been used for many years as VI improvers in multigrade engine oil formulations. In most cases these VI improvers contain at least about 40% by weight ethylene. While these copolymers are effective VI improvers, they have the disadvantage of contributing to piston deposits and oil thickening when the oils are subjected to high temperature operations. This invention provides a solution to this problem.

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This invention relates to lubricant compositions containing VI improvers that comprise polymers with structural units derived from ethylene, propylene, and butylene. These lubricant compositions, when used as engine oils, exhibit reduced levels of piston deposits and reduced levels of viscosity increase, as compared to conventional lubricant compositions, when the engine is operated under high temperature conditions. This invention relates to a lubricant composition, comprising: an oil of lubricating viscosity; and a viscosity index improving amount of a polymer comprising from about 5 mol % to about 20 mol % structural units derived from ethylene, from about 50 mol% or 60 mol % to about 90 mol% structural units derived from propylene, and from about 5% to

about 30 mol % structural units derived from butylene. In certain embodiments the lubricant composition further comprises a dispersant and a detergent comprising an overbased sulfonate wherein the sulfonate has a total base number in the range from about 250 to about 600.

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Detailed Description

All ranges and ratio limits disclosed in the specification and claims may be combined in any manner. It is to be understood that unless specifically stated otherwise, references to "a," "an," and/or "the" may include one or more than one, and that reference to an item in the singular may also include the item in the plural.

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The terms "hydrocarbyl" and "hydrocarbon," when referring to groups attached to the remainder of a molecule, refer to groups having a purely hydrocarbon or predominantly hydrocarbon character within the context of this invention. Such groups include the following:

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(1) Purely hydrocarbon groups; that is, aliphatic, alicyclic, aromatic, aliphatic- and alicyclic-substituted aromatic, aromatic-substituted aliphatic and alicyclic groups, and the like, as well as cyclic groups wherein the ring is completed through another portion of the molecule (that is, any two indicated substituents may together form an alicyclic group). Examples include methyl, octyl, cyclohexyl, phenyl, etc.

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(2) Substituted hydrocarbon groups; that is, groups containing non-hydrocarbon substituents which do not alter the predominantly hydrocarbon character of the group. Examples include hydroxy, nitro, cyano, alkoxy, acyl, etc.

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(3) Hetero groups; that is, groups which, while predominantly hydrocarbon in character, contain atoms other than carbon in a chain or ring otherwise composed of carbon atoms. Examples include nitrogen, oxygen and sulfur.

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In general, no more than about three substituents or hetero atoms, and in one embodiment no more than one, will be present for each 10 carbon atoms in the hydrocarbyl or hydrocarbon group.

The term "lower" as used herein in conjunction with terms such as hydrocarbyl, alkyl, alkenyl, alkoxy, and the like, is intended to describe such groups which contain a total of up to 7 carbon atoms.

The term "oil-soluble" refers to a material that is soluble in mineral oil to the extent of at least about 0.5 gram per liter at 25°C.

The term "TBN" refers to total base number. This is the amount of acid (perchloric or hydrochloric) needed to neutralize all or part of a material's basicity, expressed as milligrams of KOH per gram of sample. TBN is commonly reported without correcting for the amount of oil or other diluent that may be present in a material and is used in this manner in this document, unless otherwise specified.

The term "TAN" refers to total acid number. This is the amount of base (NaOH or KOH) needed to neutralize all or part of a material's acidity, expressed as milligrams of KOH per gram of sample.

The Lubricant Composition

The lubrication composition may be comprised of one or more base oils which may be present in a major amount. The base oil may be present in an amount greater than about 60% by weight, or greater than about 70%, or greater than about 75% by weight of the lubricant composition.

The lubricant composition may have a viscosity of up to about 26.1 cSt at 100°C, or from about 5.6 to about 26.1 cSt at 100°C, or from about 6 to about 16.3 cSt at 100°C, or from about 6 to about 13 cSt at 100°C.

The lubricant composition may have an SAE Viscosity Grade of 0W-20, 0W-30, 0W-40, 0W-50, 0W-60, 5W-20, 5W-30, 5W-40, 5W-50, 5W-60, 10W-20, 10W-30, 10W-40, 10W-50, 15W-20, 15W-30, 15W-40, 15W-50 or 15W-60.

Oil of Lubricating Viscosity

The oil of lubricating viscosity may be referred to as a base oil. The base oil may be selected from any of the base oils in Groups I-V as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines. The five base oil groups are as follows:

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	All polyalphaolefins (PAO)			
Group V	All others not included in Groups I, II, III, or IV			

The base oil may contain less than about 300 ppm sulfur and/or at least about 90% saturate content, determined by test procedure described in ASTM D2007. The base oil may have a viscosity index of at least about 95, or at least about 115. The base oil may have a viscosity index of at least about 120, and comprise one or more polyalphaolefins. In certain embodiments, the base oil may have a viscosity index of up to about 130. In certain embodiments the oil of lubricating viscosity may comprise a Group II oil. In certain embodiments, the oil or oils of lubricating viscosity within the lubricant composition may overall have the qualities of a Group II oil or, alternatively, a Group III oil, even though the overall base oil may be prepared by blending multiple oils of various Groups.

Groups I, II and III are mineral oil base stocks. The base oil may comprise natural or synthetic lubricating oils and mixtures thereof. Mixture of mineral oil and synthetic oils, particularly polyalphaolefin oils and ester oils, may be used.

Natural oils may include animal oils and vegetable oils (e.g. castor oil, lard oil, and other vegetable acid esters) as well as mineral lubricating oils such as liquid petroleum oils and solvent-treated or acid treated mineral lubricating oils of the paraffinic, naphthenic, or mixed paraffinic-naphthenic types. Hydrotreated or hydrocracked oils may be included within the scope of useful oils.

Base oils derived from coal or shale may be useful. Synthetic lubricating oils may include hydrocarbon oils and halosubstituted hydrocarbon oils such as polymerized and interpolymerized olefins and mixtures thereof, alkylbenzenes, polyphenyl, (e.g., biphenyls, terphenyls, and alkylated polyphenyls), alkylated diphenyl ethers and alkylated diphenyl sulfides and their derivatives, analogs and homologues thereof. Alkylene oxide polymers and interpolymers and derivatives thereof, and those where terminal hydroxyl groups have been modified by, for example, esterification or etherification, may constitute other classes of known synthetic lubricating oils that can be used. Another suitable class of synthetic lubricating oils that may be used comprises the esters of dicarboxylic acids and those made from about C₅ to about C₁₂ monocarboxylic acids and polyols or polyol ethers.

Other suitable synthetic lubricating oils may include liquid esters of phosphorus-containing acids, polymeric tetrahydrofurans, silicon-based oils

such as the poly-alkyl-, polyaryl-, polyalkoxy-, or polyaryloxy-siloxane oils, and silicate oils.

Hydrotreated naphthenic oils may be used. Synthetic oils may be used, such as those produced by Fischer-Tropsch reactions and typically may be hydroisomerized Fischer-Tropsch hydrocarbons or waxes. The base oil may be prepared by a Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid procedures.

Unrefined, refined and rerefined oils, either natural or synthetic (as well as mixtures of two or more of any of these) of the type disclosed hereinabove may be used. Unrefined oils are those obtained directly from a natural or synthetic source without further purification treatment. Refined oils are similar to the unrefined oils except they have been further treated in one or more purification steps to improve one or more properties. Rerefined oils may be obtained by processes similar to those used to obtain refined oils applied to refined oils which have been already used in service. The rerefined oils often are additionally processed by techniques directed to removal of spent additives and oil breakdown products.

The amount of oil in a fully formulated lubricant will typically be the amount remaining to equal 100 percent after the remaining additives are accounted for. Typically this may be from about 60 to about 99 percent by weight, or from about 70 to about 97 percent, or from about 80 to about 95 percent, or from about 85 to about 93 percent by weight. The lubricant composition may be delivered as a concentrate, in which case the amount of oil is typically reduced and the concentrations of the other components are correspondingly increased. In such cases the amount of oil may be from about 30 to about 70 percent by weight, or from about 40 to about 60 percent by weight.

VI Improver

The lubricant composition contains a viscosity index improving amount of a polymer comprising structural units derived from ethylene, propylene and butylene. The polymer may be prepared by polymerizing a mixture of monomers comprising ethylene, propylene and butylene. These polymers may be referred to as copolymers or terpolymers.

The polymer may comprise from about 5 mol % to about 20 mol %, or from about 5 mol % to about 10 mol % structural units derived from ethylene; from about 60 mol % to about 90 mol %, or from about 60 mol % to about 75 mol % structural units derived from propylene; and from about 5 mol % to about 30 mol %, or from about 15 mol % to about 30 mol % structural units derived from butylene. The butylene may comprise any isomers or mixtures thereof, such as n-butylene, iso-butylene, or a mixture thereof. The butylene may comprise butene-1. Commercial sources of butylene may comprise butene-1 as well as butene-2 and butadiene. The butylene may comprise a mixture of butene-1 and isobutylene wherein the weight ratio of butene-1 to isobutylene is about 1:0.1 or less. The butylene may comprise butene-1 and be free of or essentially free of isobutylene.

The polymer may have a number average molecular weight (as determined by gel permeation chromatography (GPC) using polystyrene as the calibration standard) in the range from about 10,000 to about 500,000; or from about 30,000 to about 400,000 or from about 50,000 to about 350,000, or from about 150,000 to about 250,000. The molecular weight distribution, M_w/M_n , (as determined by GPC using polystyrene as the calibration standard, where M_w is the weight average molecular weight, and M_n is the number average molecular weight) of the polymer may be about 4 or less, or about 3 or less, or about 2.5 or less, or in the range from about 2 to about 4, or in the range from about 2 to about 3, or in the range from about 2 to about 2.5.

The method for producing the polymer may comprise polymerizing propylene, ethylene, and butylene (e.g., butene-1) in the presence of known catalysts which can conduct stereoregular polymerization of olefins into isotactic configuration or syndiotactic configuration (for example, a catalyst whose principle components are a titanium component in solid form and an organic metal compound or a metallocene catalyst in which a metallocene compound is used as a component of the catalyst). In particular, a production method which uses a metallocene catalyst which can conduct stereoregular polymerization in isotactic configuration may be used in order to obtain a lubricant composition having excellent fuel efficiency at a high temperature. Examples of such metallocene catalysts include those described in International Publication WO

2004/106430, International Publication WO 2005/019283, International Publication WO 2006/025540 and International Publication WO 2004/087775. The metallocene compounds may include diphenylmethylene(3-tert-butyl-5-ethylcyclopentadienyl)(2,7-di-tert-butylfluorenyl)zirconium dichloride, diphenyl-
5 methylene(3-tert-butyl-5-methylcyclopentadienyl)(2,7-di-tert-butylfluorenyl)-zirconium dichloride, dimethylmethylene(3-tert-butyl-5-methylcyclopentadienyl)-(fluorenyl)zirconium dichloride, and the like.

The polymer may be present on a weight basis in the lubricant composition at a concentration in the range from about 0.001% to about 2%, or in
10 the range from about 0.003% to about 1.5%, or in the range from about 0.005 to about 1%, or in the range from about 0.01% to about 0.75%. The polymer may present at a concentration in the range from about 0.5% to about 1%, or from about 0.6 to about 0.8% by weight. In other embodiments it may be present at about 0.3 to about 5 percent by weight or about 0.5 to about 2 percent by weight.

15 The polymer may be provided in a concentrate. The concentrate may comprise a diluent oil, and from about 0.5% to about 30% by weight polymer, or from about 1% to about 15% polymer, or from about 5% to about 15% by weight polymer.

The following example shows the preparation of an ethylene-propylene-butylene polymer that may be used as a viscosity index improver in the lubricant
20 composition.

Example 1

To one of the feed openings of a 310 L volume pressurized continuous polymerization reactor equipped with a stirring blade and thoroughly purged with
25 nitrogen, purified and dehydrated n-hexane is continuously introduced at a flow rate of 27.1 L/hr. A hexane solution containing methylaluminoxane (TMAO-341: TOSO FINECHEM CORPORATION) at a concentration of 37.5 mmol/L; diphenylmethylene(3-tert-butyl-5-ethylcyclopentadienyl)(2,7-di-tert-butylfluorenyl) zirconium dichloride at a concentration of 0.15 mmol/L; and triisobutylaluminum
30 (TiBA: TOSO FINECHEM CORPORATION) at a concentration of 15.0 mmol/L is continuously introduced at a flow rate of 0.1 L/hr. At the same time, to another feed opening of the continuous polymerization reactor, ethylene at a flow rate of 0.8 kg/hr, propylene at a flow rate of 11.1 kg/hr, butene-1 at a flow rate of 6.5

kg/hr, and hydrogen at a flow rate of 4.5 NL/hr (NL = normal liters, that is, liters at 1 atmosphere and 0 °C) are continuously added. Continuous solution polymerization is conducted under conditions wherein the polymerization temperature is 60°C, the total pressure is 1.0 MPa-G (G = gauge pressure), and the stirring rotation frequency is 190 rpm. Coolants are circulated through jackets equipped outside of the polymerization reactor. Also, the vapor phase is forcibly circulated using a gas blower which is separately equipped, the vapor phase is cooled by a heat exchanger, and thereby polymerization heat is removed. The polymerization product that is produced is a hexane solution comprising an ethylene/propylene/butene-1 polymer. This solution is withdrawn at a rate of 7.5 kg/hr in terms of the ethylene/propylene/butene-1 copolymer through an outlet equipped at the bottom of the polymerization reactor so that the average of solution amount in the polymerization reactor is kept at 100L. The resultant polymerization solution is poured into methanol to precipitate the ethylene/propylene/butene-1 polymer. The ethylene/propylene/butene-1 polymer is dried under reduced pressure at 130°C for 24 hours. The polymer contains 8.7 mol % structural units derived from ethylene, 68 mol % structural units derived from propylene, and 23.3 mol % structural units derived by butene-1. The polymer has a density of 865 kg/m³, a melting point of 47°C, a Mw of 220,000, and a Mw/Mn of 2.2, as determined by GPC using polystyrene as the calibration standard.

Overbased Metal-containing Detergent

The lubricant composition may contain one or more overbased metal-containing detergents. Overbased materials otherwise referred to as overbased or superbased salts, may be single phase, homogeneous Newtonian systems characterized by a metal content in excess of that which would be present for neutralization according to the stoichiometry of the metal and the particular acidic organic compound reacted with the metal. The overbased materials may be prepared by reacting an acidic material (typically an inorganic acid or lower carboxylic acid, such as carbon dioxide) with a mixture comprising an acidic organic compound, a reaction medium comprising at least one inert, organic solvent (mineral oil, naphtha, toluene, xylene, etc.) for said acidic organic material, a stoichiometric excess of a metal base, and a promoter such as a

calcium chloride, acetic acid, phenol or alcohol. The acidic organic material may have a sufficient number of carbon atoms to provide a degree of solubility in oil. The amount of excess metal is commonly expressed in terms of metal ratio. The term "metal ratio" is the ratio of the total equivalents of the metal to the equivalents of the acidic organic compound. A neutral metal salt has a metal ratio of one. A salt having 3.5 times as much metal as present in a normal salt will have metal excess of 3.5 equivalents, or a ratio of 4.5. The term "metal ratio" is also explained in standard textbook entitled "Chemistry and Technology of Lubricants," Second Edition, Edited by R. M. Mortier and S. T. Orszulik, Copyright 1997.

The metal of the overbased metal-containing detergent may be zinc, sodium, calcium, barium, magnesium, or a mixture of two or more thereof. The metal may be sodium, calcium, or magnesium or mixtures thereof; in one embodiment the metal may be a mixture of sodium and calcium.

The overbased metal-containing detergent may be selected from non-sulfur containing phenates, sulfur containing phenates, sulfonates, salixarates, salicylates, and mixtures thereof, or borated equivalents thereof. In one embodiment, the lubricant composition may be free from or substantially free from phenol-based detergent or detergents. "Substantially free from" means, in this context, less than 10 weight percent, or less than 5 or 1 or 0.1 weight percent of the detergent or detergents may be phenol-based. The overbased detergent may be borated with a borating agent such as boric acid.

The overbased metal-containing detergent may also include "hybrid" detergents formed with mixed surfactant systems including phenate and/or sulfonate components, e.g. phenate-salicylates, sulfonate-phenates, sulfonate-salicylates, sulfonates-phenates-salicylates, as described; for example, in US Patents 6,429,178; 6,429,179; 6,153,565; and 6,281,179. Where, for example, a hybrid sulfonate-phenate detergent is employed, the hybrid detergent would be considered equivalent to amounts of distinct phenate and sulfonate detergents introducing corresponding amounts of phenate and sulfonate soaps, respectively.

The overbased metal-containing detergent may comprise zinc, sodium, calcium or magnesium salts of a phenate, sulfur containing phenate, sulfonate, salixarate or salicylate. Overbased salixarates, phenates and salicylates may

have a total base number (ASTM D3896) in the range from about 180 to about 450 TBN. Overbased sulfonates may have a total base number in the range from about 250 to about 600, or in the range from about 300 to about 500. Overbased detergents are known in the art. The sulfonate detergent may be a
5 predominantly linear alkylbenzene or alkyltoluene sulfonate detergent having a metal ratio of at least about 8 as is described in paragraphs [0026] to [0037] of U.S. Patent Publication 2005/065045. The linear alkyl group may be attached to the benzene or toluene at any location along the linear alkyl chain, such as at the 2, 3, or 4 position. The linear alkylbenzene sulfonate detergent may be useful for
10 improving fuel economy.

The overbased metal-containing detergent may be a calcium or magnesium overbased detergent. The lubricant composition may comprise an overbased calcium sulfonate, an overbased calcium phenate, or a mixture thereof. The overbased detergent may comprise a calcium sulfonate with a
15 metal ratio of at least about 3.5, for example, in the range from about 3.5 to about 40, or in the range from about 5 to about 25, or in the range from about 7 to about 20.

The lubricant composition may further comprise a low overbased detergent (metal ratio of less than about 3.5, for example, in the range from about
20 0 to about 3.5, or in the range from about 0.5 to about 3.0, or in the range from about 1 to about 2.5, or in the range from about 1.5 to about 2) or a neutral detergent.

The overbased metal-containing detergent may be present in the lubricant composition at a concentration in the range from about 0.05% by weight to about
25 5% by weight of the lubricant composition. The overbased detergent may be present at a concentration in the range from about 0.1%, about 0.3%, or about 0.5% up to about 3.2%, or about 1.7%, or about 0.9% by weight of the lubricant composition. Similarly, the overbased detergent may be present in an amount suitable to provide a TBN (total base number) in the range from about 1 to about
30 10 to the lubricant composition. The overbased detergent may be present in amount which provides a TBN in the range from about 1.5 up to about 3, or up to about 5, or up to about 7, to the lubricant composition. In other embodiments,

the overbased detergent may provide at least 3 TBN to the lubricant composition, such as 3 to 7 or 4 to 6 TBN.

Metal-containing detergents, in addition to TBN, may also provide ash to the lubricant composition. Sulfated ash (ASTM D874) is another parameter often used to characterize overbased detergents and lubricant compositions. The lubricant composition may have sulfated ash levels of about 0.3 to about 1.2% by weight, or from about 0.3 to about 1.0% or from about 0.5 to about 1.0%, or greater than about 0.6%. In other embodiments (e.g., for marine diesel cylinder lubricants) the ash level may be from about 1 to about 15%, or from about 2 to about 12% by weight, or from about 4 to about 10%. The overbased detergent may account for about 50% to about 100% of the sulfated ash, or at least about 70% of the ash, or at least about 80% of the ash, or 100% of the ash. The overbased detergent may provide for no more than about 95% of the sulfated ash, or no more than about 98% of the sulfated ash.

The lubricant composition may be a marine diesel cylinder lubricant (MDCL). Lubricants of this type may be characterized by high TBN levels delivered primarily by metal containing overbased detergents. In some embodiments, the lubricant composition may have a TBN of at least about 10, or at least about 20, e.g., 10-100, 20-100, 30-100, 40-80, 30-75, or 40-70. Most of the basicity of the MDCL composition may be contributed by the detergent component, although typically a relatively small amount (e.g., less than about 5%) of the TBN may be contributed by other species such as nitrogen-containing dispersants.

Other Performance Additives

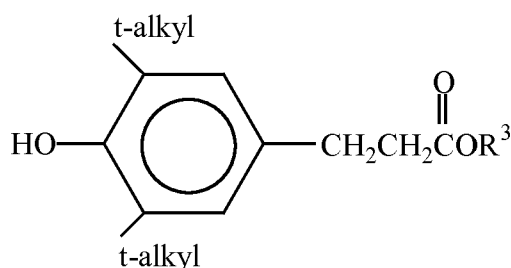
The lubricant composition may comprise other performance additives. These may include one or more metal deactivators, supplemental viscosity modifiers, supplemental detergents, friction modifiers, antiwear agents, corrosion inhibitors, dispersants, dispersant viscosity modifiers, extreme pressure agents, antioxidants, foam inhibitors, demulsifiers, pour point depressants, seal swelling agents, mixtures of two or more thereof.

Antioxidants may include sulfurized olefins, diarylamines, alkylated diarylamines, hindered phenols, molybdenum compounds (such as molybdenum dithiocarbamates), hydroxyl thioethers, or mixtures thereof. The antioxidant may

be present at a concentration in the range from about 0 wt % to about 15 wt %, or about 0.1 wt % to about 10 wt %, or about 0.5 wt % to about 5 wt %, or about 0.5 wt % to about 3 wt % of the lubricant composition.

The diarylamine or alkylated diarylamine may be a phenyl alpha-naphthylamine (PANA), an alkylated diphenylamine, or an alkylated phenyl-naphthylamine, or mixtures thereof. The alkylated diphenylamine may include di-nonylated diphenylamine, nonyl diphenylamine, octyl diphenylamine, di-octylated diphenylamine, di-decylated diphenylamine, decyl diphenylamine and mixtures thereof. In one embodiment the diphenylamine may include nonyl diphenylamine, dinonyl diphenylamine, octyl diphenylamine, dioctyl diphenylamine, or mixtures thereof. In one embodiment the diphenylamine may include nonyl diphenylamine, or dinonyl diphenylamine. The alkylated diarylamine may include octyl, di-octyl, nonyl, di-nonyl, decyl or di-decyl phenyl-naphthylamines.

The hindered phenol antioxidant may contain a secondary butyl and/or a tertiary butyl group as a sterically hindering group. The phenol group may be further substituted with a hydrocarbyl group (typically linear or branched alkyl) and/or a bridging group linking to a second aromatic group. Examples of suitable hindered phenol antioxidants include 2,6-di-tert-butylphenol, 4-methyl-2,6-di-tert-butylphenol, 4-ethyl-2,6-di-tert-butylphenol, 4-propyl-2,6-di-tert-butylphenol or 4-butyl-2,6-di-tert-butylphenol, or 4-dodecyl-2,6-di-tert-butylphenol. The hindered phenol antioxidant may be an ester, such as the ester available under the tradename Irganox™ L-135 from Ciba. Such materials may be represented by the general formula



wherein R^3 is a hydrocarbyl group such as an alkyl group containing, e.g., 1 to about 18, or 2 to about 12, or 2 to about 8, or 2 to about 6 carbon atoms; and t-alkyl can be t-butyl. A detailed description of ester-containing hindered phenol antioxidants that may be used may be found in US Patent 6,559,105.

Examples of molybdenum dithiocarbamates which may be used as an antioxidant include commercial materials sold under trade names such as Vanlube 822™ and Molyvan™ A from R. T. Vanderbilt Co., Ltd., and Adeka Sakura-Lube™ S-100, S-165, S-525 and S-600 from Asahi Denka Kogyo K. K, and mixtures thereof.

The lubricant composition may further include one or more supplemental viscosity modifiers. These may include hydrogenated styrene-butadiene rubbers, ethylene-propylene copolymers, polymethacrylates, polyacrylates, hydrogenated styrene-isoprene polymers, hydrogenated diene polymers, poly(alkyl styrenes), polyolefins, esters of maleic anhydride-olefin copolymers (such as those described in International Application WO 2010/014655), esters of maleic anhydride-styrene copolymers, or mixtures or two or more thereof.

The dispersant viscosity modifier may include functionalized polyolefins, for example, ethylene-propylene copolymers that have been functionalized with an acylating agent such as maleic anhydride and an amine; polymethacrylates functionalized with an amine; or esterified styrene-maleic anhydride copolymers reacted with an amine. More detailed description of dispersant viscosity modifiers are disclosed in International Publication WO2006/015130 or U.S. Patents 4,863,623; 6,107,257; 6,107,258; and 6,117,825. The dispersant viscosity modifier may include those described in U.S. Patent 4,863,623 (see column 2, line 15 to column 3, line 52) or in International Publication WO2006/015130 (see page 2, paragraph [0008] and preparative examples described in paragraphs [0065] to [0073]). The dispersant viscosity modifier may be present at a concentration of up to about 15 wt %, or up to about 10 wt %, or in the range from about 0.05 wt % to about 5 wt %, or from about 0.2 wt % to about 2 wt % of the lubricant composition.

The lubricant composition may further include one or more dispersants. The dispersant may be a succinimide dispersant, a Mannich dispersant, a succinamide dispersant, a polyolefin succinic acid ester, amide, or ester-amide, or mixtures thereof. The dispersant may be present as a single dispersant, or it may be present as a mixture of two or more (e.g., three) different dispersants, wherein at least one may be a succinimide dispersant.

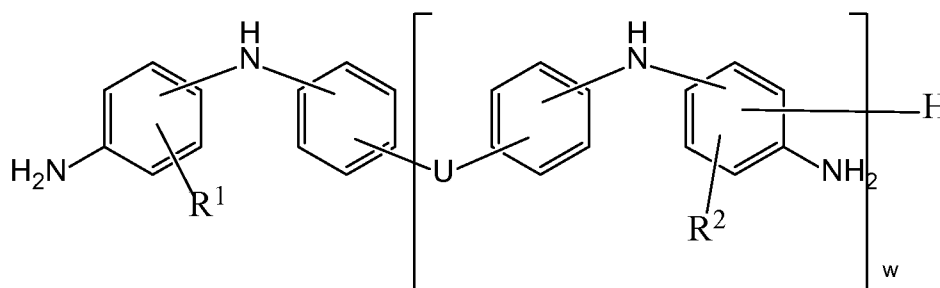
The succinimide dispersant may be derived from one or more aliphatic polyamines. The aliphatic polyamine may be an aliphatic polyamine such as ethylenepolyamine (i.e., a poly(ethyleneamine)), a propylenepolyamine, a butylenepolyamine, or a mixture of two or more thereof. The aliphatic polyamine
5 may be ethylenepolyamine. The aliphatic polyamine may be selected from ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylene-pentamine, pentaethylenehexamine, polyamine still bottoms, or a mixture of two or more thereof.

The succinimide dispersant may be derived from an aromatic amine,
10 aromatic polyamine, or mixture thereof. The aromatic amine may have one or more aromatic moieties linked by a hydrocarbylene group and/or a heteroatom such as 4-amino diphenylamine. The aromatic amine may be a nitro-substituted aromatic amine. Examples of nitro-substituted aromatic amines may include 2-nitroaniline, 3-nitroaniline, and 4-nitroaniline. 3-nitroaniline may be particularly
15 useful. Other aromatic amines may be present along with the nitroaniline. Condensation products with nitroaniline and optionally also with Disperse Orange 3 (that is, 4-(4-nitrophenylazo)aniline) are disclosed in U.S. Patent Publication 2006/0025316.

The dispersant may comprise a polymer functionalized with an amine,
20 e.g., a succinimide dispersant. The amine may be an amine having at least 2, or at least 3, or at least 4 aromatic groups, for instance, from about 4 to about 10, or from about 4 to about 8, or from about 4 to about 6 aromatic groups, and at least one primary or secondary amino group or, alternatively, at least one secondary amino group. The amine may comprise both a primary and at least one
25 secondary amino group. The amine may comprise at least about 4 aromatic groups and at least 2 of any combination of secondary or tertiary amino groups.

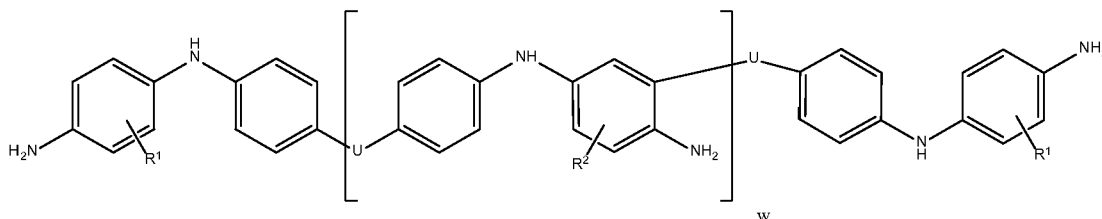
An example of an amine having 2 aromatic groups is N-phenyl-p-phenylenediamine. An example of an amine having at least 3 or 4 aromatic groups may be represented by Formula (1):

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Formula 1

wherein, independently, each variable is as follows: R^1 may be hydrogen or a C_{1-5} alkyl group (typically hydrogen); R^2 may be hydrogen or a C_{1-5} alkyl group (typically hydrogen); U may be an aliphatic, alicyclic or aromatic group (when U is aliphatic, the aliphatic group may be a linear or branched alkylene group containing 1 to about 5, or 1 to about 2 carbon atoms); and w may be from 1 to about 10, or 1 to about 4, or 1 to 2 (typically 1). When U is an aliphatic group, U may be an alkylene group containing 1 to about 5 carbon atoms. Alternatively, the amine may also be represented by Formula (1a)



Formula (1a)

wherein each variable U, R^1 , and R^2 are the same as described above and w is 0 to about 9, or 0 to about 3, or 0 to about 1 (typically 0).

The dispersant may be a polyolefin succinic acid ester, amide, or ester-amide. For instance, a polyolefin succinic acid ester may be a polyisobutylene succinic acid ester of pentaerythritol, or mixtures thereof. A polyolefin succinic acid ester-amide may be a polyisobutylene succinic acid reacted with an alcohol (such as pentaerythritol) and an amine (such as a polyamine, typically diethylenetriamine, polyamine still bottoms, tetraethylenepentamine (TEPA), and the like).

The dispersant may be an N-substituted long chain alkenyl succinimide. An example of an N-substituted long chain alkenyl succinimide is polyisobutylene succinimide, that is, a polyisobutene substituted succinimide dispersant. Typically the polyisobutylene from which polyisobutylene succinic anhydride is

derived has a number average molecular weight of from about 350 to about 5000, or from about 550 to about 3000 or from about 750 to about 2500. Succinimide dispersants and their preparation are disclosed, for instance in US Patents 3,172,892, 3,219,666, 3,316,177, 3,340,281, 3,351,552, 3,381,022, 3,433,744, 3,444,170, 3,467,668, 3,501,405, 3,542,680, 3,576,743, 3,632,511, 4,234,435, Re 26,433, and 6,165,235, 7,238,650 and EP Patent Application 0 355 895 A.

The dispersants may also be post-treated by conventional methods by a reaction with any of a variety of agents. Among these are boron compounds (such as boric acid), urea, thiourea, dimercaptiothiadiazoles, carbon disulfide, aldehydes, ketones, carboxylic acids such as terephthalic acid, hydrocarbon-substituted succinic anhydrides, maleic anhydride, nitriles, epoxides, and phosphorus compounds. The post-treated dispersant may be borated. The post-treated dispersant may result from a reaction of the dispersant with a dimercaptiothiadiazole. The post-treated dispersant may result from a reaction of the dispersant with phosphoric or phosphorous acid.

The dispersant may be present in the lubricant composition at a concentration in the range from about 0.01 wt % to about 20 wt %, or from about 0.1 wt % to about 15 wt %, or from about 0.1 wt % to about 10 wt %, or from about 1 wt % to about 6 wt %, or from about 1 to about 3 wt % of the lubricating composition.

If the dispersant contains basic nitrogen atoms, such basicity may be measured as TBN of the dispersant. In one embodiment, the TBN of a useful succinimide dispersant may be about 10 to about 30 on an oil-free (corrected) basis, which would correspond to about 5 to about 15 if measured on a dispersant sample containing 50% oil.

In one embodiment, the viscosity index improving amount of the polymer (that is, the amount of the VI polymer) is about 0.5 to about 2 percent by weight, the amount of the dispersant is about 0.01 to about 20 percent by weight, and the amount of the overbased sulfonate is about 0.05 to about 5 percent by weight.

The friction modifier may be selected from long chain fatty acid derivatives of amines, long chain fatty esters, or derivatives of a long chain fatty epoxides; fatty imidazolines; amine salts of alkylphosphoric acids; fatty alkyl tartrates; fatty

alkyl tartrides; fatty alkyl tartrides; fatty glycolates; and fatty glycolamides. As used herein the term "fatty alkyl or fatty" in relation to friction modifiers means a carbon chain having from about 10 to about 22 carbon atoms, typically a straight carbon chain. Alternatively, mono-branched alkyl groups may be used in place of the fatty alkyl groups. Typical mono-branched alkyl groups may include beta-branched groups such as 2-ethylhexyl, 2-propylheptyl, and the like. The friction modifier may be present in the lubricant composition at a concentration in the range from 0 wt % to about 6 wt %, or about 0.01 wt % to about 4 wt %, or from about 0.05 wt % to about 2 wt %, or from about 0.1 wt % to about 2 wt % of the lubricant composition.

Examples of friction modifiers that may be used may include long chain fatty acid derivatives of amines, fatty esters, or fatty epoxides; fatty imidazolines such as condensation products of carboxylic acids and polyalkylene-polyamines; amine salts of alkylphosphoric acids; fatty alkyl tartrates; fatty alkyl tartrides; fatty alkyl tartrides; fatty phosphonates; fatty phosphites; borated phospholipids, borated fatty epoxides; glycerol esters; borated glycerol esters; fatty amines; alkoxyated fatty amines; borated alkoxyated fatty amines; hydroxyalkyl and polyhydroxyalkyl fatty amines including tertiary hydroxyalkyl fatty amines; hydroxy alkyl amides; metal salts of fatty acids; metal salts of alkyl salicylates; fatty oxazolines; fatty ethoxyated alcohols; condensation products of carboxylic acids and polyalkylene polyamines; or reaction products from fatty carboxylic acids with guanidine, aminoguanidine, urea, or thiourea and salts thereof.

Friction modifiers may also encompass materials such as sulfurized fatty compounds and olefins, molybdenum dialkyldithiophosphates, molybdenum dithiocarbamates, and monoesters of a polyol and an aliphatic carboxylic acid derived or derivable from sunflower oil or soybean oil.

The friction modifier may be a long chain fatty acid ester. The long chain fatty acid ester may be a mono-ester, diester, (tri)glyceride, or a mixture of two or more thereof.

The lubricant composition may optionally further include at least one antiwear agent. Examples of suitable antiwear agents may include tartrates, tartrides, oil soluble amine salts of phosphorus compounds, sulfurized olefins,

metal dihydrocarbyldithiophosphates (such as zinc dialkyldithiophosphates), phosphites (such as dibutyl phosphite), phosphonates, thiocarbamate-containing compounds, such as thiocarbamate esters, thiocarbamate amides, thiocarbamic ethers, alkylene-coupled thiocarbamates, and bis(S-alkyldithiocarbamyl) disulfides. The antiwear agent may, in one embodiment, include a tartrate, or tartrime as disclosed in International Publication WO 2006/044411 or Canadian Patent CA 1 183 125. The tartrate or tartrime may contain alkyl group(s), where the sum of carbon atoms on the alkyl groups is at least about 8.

Another class of additives may include oil-soluble titanium compounds such as disclosed in U.S. Patent 7,727,943 and U.S. Patent Publication 2006/0014651. These may function as antiwear agents, friction modifiers, antioxidants, deposit control additives, and the like. These additives may be multifunctional additives. For example, one of these additives may provide both antiwear and antioxidant properties. The oil soluble titanium compound may be a titanium (IV) alkoxide. The titanium alkoxide may be formed from a monohydric alcohol, a polyol or mixtures thereof. The monohydric alkoxides may contain from 2 to about 16 carbon atoms, or from 3 to about 10 carbon atoms. The titanium alkoxide may be titanium (IV) isopropoxide. The titanium alkoxide may be titanium (IV) 2-ethylhexoxide. The titanium compound may comprise the alkoxide of a vicinal 1,2-diol or polyol. The 1,2-vicinal diol may comprise a fatty acid mono-ester of glycerol, such as oleic acid esters.

The oil soluble titanium compound may be a titanium carboxylate. The titanium carboxylate may be derived from a titanium alkoxide and a carboxylic acid selected from the group consisting of a non-linear mono-carboxylic acid and a carboxylic acid having more than about 22 up to about 25 carbon atoms. Examples of titanium/carboxylic acid products may include titanium reaction products with acids selected from the group comprising caproic acid, caprylic acid, lauric acid, myristic acid, palmitic acid, stearic acid, arachidic acid, oleic acid, erucic acid, linoleic acid, linolenic acid, cyclohexanecarboxylic acid, phenylacetic acid, benzoic acid, neodecanoic acid, and the like. Methods for making such titanium/carboxylic acid products are described, for example, in U.S. Patent 5,260,466.

Extreme Pressure (EP) agents that are soluble in the oil may include sulfur- and chlorosulfur-containing EP agents, dimercaptothiadiazole or CS₂ derivatives of dispersants (typically succinimide dispersants), derivative of chlorinated hydrocarbon EP agents and phosphorus EP agents. Examples of such EP agents may include chlorinated wax; sulfurized olefins (such as sulfurized isobutylene), a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazole, or oligomers thereof, organic sulfides and polysulfides such as dibenzyldisulfide, bis-(chlorobenzyl) disulfide, dibutyl tetrasulfide, sulfurized methyl ester of oleic acid, sulfurized alkylphenol, sulfurized dipentene, sulfurized terpene, and sulfurized Diels-Alder adducts; phosphosulfurized hydrocarbons such as the reaction product of phosphorus sulfide with turpentine or methyl oleate; phosphorus esters such as the dihydrocarbon and trihydrocarbon phosphites, e.g., dibutyl phosphite, diheptyl phosphite, dicyclohexyl phosphite, pentylphenyl phosphite; dipentylphenyl phosphite, tridecyl phosphite, distearyl phosphite and polypropylene substituted phenol phosphite; metal thiocarbamates such as zinc dioctyldithiocarbamate and barium heptylphenol diacid; amine salts of alkyl and dialkylphosphoric acids or derivatives including, for example, the amine salt of a reaction product of a dialkyldithiophosphoric acid with propylene oxide and subsequently followed by a further reaction with P₂O₅; and mixtures thereof (as described in US 3,197,405).

Foam inhibitors that may be used in the lubricant composition may include polysiloxanes, copolymers of ethyl acrylate and 2-ethylhexylacrylate, and optionally also vinyl acetate; demulsifiers including fluorinated polysiloxanes, trialkyl phosphates, polyethylene glycols, polyethylene oxides, polypropylene oxides and (ethylene oxide-propylene oxide) polymers.

Pour point depressants that may be used in the lubricant composition may include polyalphaolefins, esters of maleic anhydride-styrene copolymers, poly(meth)acrylates, polyacrylates or polyacrylamides.

Demulsifiers that may be used may include trialkyl phosphates, and various polymers and copolymers of ethylene glycol, ethylene oxide, propylene oxide, or mixtures of two or more thereof.

Metal deactivators may include derivatives of benzotriazoles (typically tolyltriazole), 1,2,4-triazoles, benzimidazoles, 2-alkyldithiobenzimidazoles or 2-

alkyldithio-benzothiazoles. The metal deactivators may also be described as corrosion inhibitors.

Seal swell agents that may be used may include sulfolene derivatives such as Exxon Necton-37™ (FN 1380) and Exxon Mineral Seal Oil™ (FN 3200).

5 Industrial Application

10 The lubricant composition may be used to lubricate a mechanical device, by supplying the lubricant as described herein to the device. The device may be an internal combustion engine such as a gasoline-fired or diesel-fired automobile engine, a heavy duty diesel engine, a marine diesel engine, or a stationary gas
15 engine. Such engines may be sump lubricated, and the lubricant may be provided to the sump from whence it may lubricate the moving parts of the engine. Alternatively, the lubricant may be supplied from a separate source, not a part of a sump.

20 The internal combustion engine may be a diesel fueled engine (typically a heavy duty diesel engine), a gasoline fueled engine, a natural gas fueled engine, a mixed gasoline/alcohol fueled engine, or a hydrogen fueled internal combustion engine. The internal combustion engine may be a diesel fueled engine or a gasoline fueled engine. The internal combustion engine may be a heavy duty diesel engine.

25 The internal combustion engine may be a 2-stroke or 4-stroke engine. Suitable internal combustion engines may include marine diesel engines (which may comprise a cylinder which is lubricated with said lubricant), aviation piston engines, low-load diesel engines, and automobile and truck engines. The marine diesel engine may be lubricated with a marine diesel cylinder lubricant (typically in a 2-stroke engine), a system oil (typically in a 2-stroke engine), or a crankcase lubricant (typically in a 4-stroke engine).

30 One class of internal combustion engines is direct injected combustion engines wherein the fuel is injected directly into the cylinder. Specific examples of direct injection may include wall guided and spray guided direct injection engines. The lubricant composition may be used to lubricate a gasoline direct injection engine.

The lubricant composition may be suitable for use as any engine lubricant irrespective of the sulfur, phosphorus or sulfated ash content. The sulfur content

of the lubricant composition when used as an engine oil may be about 1 wt % or less, or about 0.8 wt % or less, or about 0.5 wt % or less, or about 0.3 wt % or less. The sulfur content may be in the range of about 0.001 wt % to about 0.5 wt %, or about 0.01 wt % to about 0.3 wt %. The phosphorus content may be about 0.2 wt % or less, or about 0.12 wt % or less, or about 0.1 wt % or less, or about 0.085 wt % or less, or about 0.08 wt % or less, or about 0.06 wt % or less, or about 0.055 wt % or less, or about 0.05 wt % or less. The phosphorus content may be from about 0.04 wt % to about 0.12 wt %. The phosphorus content may be from about 100 ppm to about 1000 ppm, or about 200 ppm to about 600 ppm. The total sulfated ash content may be about 0.3 wt % to 1.2 wt %, or about 0.5 wt % to about 1.1 wt % of the lubricant composition. The sulfated ash content may be about 0.5 wt % to 1.1 wt % of the lubricant composition. The lubricant composition may be characterized by a chlorine content of up to about 100 ppm, or up to about 50 ppm, or up to about 10 ppm.

The lubricant composition may be an engine oil, wherein the lubricant composition may be characterized as having at least one of (i) a sulfur content of about 0.5 wt % or less, (ii) a phosphorus content of about 0.12 wt % or less, and (iii) a sulfated ash content of about 0.5 wt % to about 1.1 wt % of the lubricant composition.

The lubricant composition may be a marine diesel cylinder lubricant, which may be used to lubricate a marine diesel cylinder. The marine diesel cylinder may be in a 2-stroke marine diesel engine. Marine diesel cylinder lubricants are typically used for one pass and are consumed, rather than being retained in a sump. These lubricants may require a high detergent level, imparting high levels of basicity as measured by TBN to the lubricant, typically resulting in TBN levels of about 20 or greater, such as about 30 or greater, or about 40 or greater, or about 50 or greater, or about 70 or greater, and typically up to about 80, or up to about 100, or up to about 300.

The lubricant composition may be used in a method of operating an internal combustion engine wherein piston deposit merit ratings are increased and viscosity increase is reduced.

In one embodiment the disclosed technology provides a method of reducing levels of piston deposits in an internal combustion engine, comprising

lubricating the engine with a lubricant composition as described herein. In one embodiment, the disclosed technology provides The use of a viscosity index improving amount of a polymer comprising from about 5 mol % to about 20 mol % structural units derived from ethylene, from about 50 mol % to about 90 mol % structural units derived from propylene, and from about 5% to about 30 mol % structural units derived from butylene, in a lubricant composition further comprising an oil of lubricating viscosity, a dispersant; and a detergent comprising an overbased sulfonate wherein the sulfonate has a total base number in the range from about 250 to about 600, to reduce the level of piston deposits in an engine lubricated by said lubricant composition.

Example 2

Fully formulated engine oils are blended with a polymer made in accordance with disclosure in Example 1 (hereinafter Polymer 1) and a commercially available olefin copolymer (hereinafter Comparative OCP or Comp OCP), and tested for “non-viscometric” benefits. In the ASTM Sequence IIIG test, there is a marked improvement in deposit performance when Polymer 1 is used as compared to Comp OCP. Polymer 1 and Comp OCP have the properties shown in Table 1.

Table 1 – Polymer Compositions

	Polymer 1	Comp OCP
Ethylene (mol%)	8.7	57
Propylene (mol%)	68.0	43
Butylene (mol%)	23.3	0
Mw	220,000	290,000
Shear Stability Index	35	45

The polymers from Table 1 are used to make the engine oil (EO) formulations shown in Table 2. Polymer 1 is used to formulate EO No. 1. Comp OCP is used to formulate Comp EO. In Table 2, some of the additives are provided with a blend oil and the weight percent of the blend oil for these is shown. Also, in Table 2, except as otherwise indicated, all numerical values are in parts by weight (and all percents are by weight).

Table 2 – Engine Oil (EO) Formulations

Description	EO No. 1	Comp EO
Group II Base Oil	100	100
Polyisobutene (PIB) substituted succinimide dispersant; PIB Mn = 2200 ; 14 TBN	4	4
Antiwear agent: Mixed C ₃ -C ₆ secondary zinc dialkyldithiophosphate (ZDDP) (10% oil)	0.2	0.2
Antiwear agent: C ₆ secondary ZDDP (8% oil)	0.66	0.66
Diaryl amine antioxidant	0.8	0.9
Hindered phenol ester antioxidant	0.45	0.35
Sulfurized olefin antioxidant	0.2	0.2
Fatty amide friction modifier	0.1	0.1
300 TBN Ca sulfonate (42% oil)	0.88	0.88
400 TBN Ca sulfonate (42% oil)	0.4	0.4
450 TBN Na sulfonate (31% oil)	0.25	0.25
Silicone anti-foam agent	0.009	0.009
Pour point depressant: esterified maleic anhydride-styrene copolymer	0.25	0.25
Polymer 1 (86% oil) [oil free amount]	5.25 [0.73]	
Comp OCP (91% oil) [oil free amount]		7 [0.63]

ASTM Sequence IIIG tests are performed using the engine oil formulations shown in Table 2. The results of these tests are shown in Table 3.

5

Table 3 – ASTM Sequence IIIG Test Results

	EO No. 1	Comp EP
Viscosity Grade	5W-30	5W-30
Base Oil Viscosity at 100°C (cSt)	4.8	4.9
Lubricant Composition, kinematic viscosity at 100°C (cSt)	9.83	10.3
High temperature, high shear viscosity (cP) ASTMD4683	2.87	3.02
Cold cranking simulator (cP at -30°C) ASTM D4684	6324	6152
Viscosity Increase	76.9%	138%
Weighted Piston Deposit Rating	4.05	3.88

The results of these tests show a significantly increased piston deposit rating and a significant reduction in thickening in the engine oil when using EO
5 No. 1 as compared to the Comp EO.

While the invention has been explained in relation to various embodiments, it is to be understood that various modifications thereof may become apparent to those skilled in the art upon reading this specification. Therefore, it is to be understood that the invention includes all such modifications
10 that may fall within the scope of the appended claims.

The amount of each chemical component described is presented exclusive of any solvent or diluent oil, which may be customarily present in the commercial material (that is, on an active chemical basis), unless otherwise indicated, e.g., unless an amount of oil is indicated. However, unless otherwise indicated, each
15 chemical or composition referred to herein should be interpreted as being a commercial grade material which may contain the isomers, by-products, derivatives, and other such materials which are normally understood to be present in the commercial grade.

It is known that some of the materials described above may interact in the
20 final formulation, so that the components of the final formulation may be different from those that are initially added. For instance, metal ions (of, e.g., a detergent) can migrate to other acidic or anionic sites of other molecules. The products formed thereby, including the products formed upon employing the composition of the present invention in its intended use, may not be susceptible of easy description.
25 Nevertheless, all such modifications and reaction products are included within the scope of the present invention; the present invention encompasses the composition prepared by admixing the components described above.

Each of the documents referred to above is incorporated herein by reference, including any prior applications, whether or not specifically listed
30 above, from which priority is claimed. The mention of any document is not an admission that such document qualifies as prior art or constitutes the general knowledge of the skilled person in any jurisdiction. Except in the Examples, or where otherwise explicitly indicated, all numerical quantities in this description

specifying amounts of materials, reaction conditions, molecular weights, number of carbon atoms, and the like, are to be understood as modified by the word "about." It is to be understood that the upper and lower amount, range, and ratio limits set forth herein may be independently combined. Similarly, the ranges and
5 amounts for each element of the invention can be used together with ranges or amounts for any of the other elements. As used herein, the expression "consisting essentially of" permits the inclusion of substances that do not materially affect the basic and novel characteristics of the composition under consideration.

Claims

1. A lubricant composition, comprising:
at least 60 percent by weight of an oil of lubricating viscosity;
5 a viscosity index improving amount of 0.001 to 2 percent by weight of
a polymer comprising from 5 mol % to 20 mol % structural units derived from eth-
ylene, from 50 mol % to 90 mol% structural units derived from propylene, and from
5% to 30 mol % structural units derived from butylene;
0.01 to 20 percent by weight of a succinimide dispersant; and
10 0.05 to 5 percent by weight of a detergent comprising an overbased
calcium, magnesium, or sodium sulfonate wherein the sulfonate has a total base
number in the range from 250 to 600.
2. The composition of claim 1 wherein the viscosity index improving amount
of the polymer is 0.5 to 2 percent by weight.
- 15 3. The composition of claim 1 or 2 wherein the dispersant comprises a poly-
isobutene substituted succinimide dispersant.
4. The composition of any one of the preceding claims wherein the overbased
sulfonate is present in an amount suitable to provide a TBN (total base number) in
the range from 1 to 10 to the lubricant composition.
- 20 5. The composition of any one of the preceding claims wherein the com-
position further comprises at least one of an antiwear agent, an antioxidant, a friction
modifier, a pour point depressant, and an antifoam agent.
6. The composition of any one of the preceding claims wherein the com-
position further comprises one or more metal deactivators, additional supplemental
25 viscosity modifiers, supplemental detergents, corrosion inhibitors, dispersant viscos-
ity modifiers, extreme pressure agents, demulsifiers, seal swelling agents, or a mix-
ture of two or more thereof.
7. The composition of any one of the preceding claims wherein the oil of
lubricating viscosity comprises a Group II oil.

8. The composition of any one of the preceding claims wherein the oil of lubricating viscosity has a kinematic viscosity at 100°C of less than 5 cSt, and a viscosity index of less than 130.

5 9. The composition of any one of the preceding claims wherein the polymer has a number average molecular weight in the range from 10,000 to 500,000.

10. The composition of any one of the preceding claims wherein the polymer has a Mw/Mn of 4 or less.

10 11. The composition of any one of the preceding claims wherein the polymer comprises from 5 to 10 mol% structural units derived from ethylene, from 60 to 75 mol% structural units derived from propylene, from 15 to 30 mol% structural units derived from butylene, a number average molecular weight in the range from 150,000 to 250,000, and a Mw/Mn in the range from 2 to 2.5.

15 12. The composition of any one of the preceding claims wherein the composition has a sulfur content of 1% by weight or less, a phosphorus content of 0.2% by weight or less, and a sulfated ash content in the range of from 0.3 to 1.2% by weight.

13. A method of lubricating an internal combustion engine, comprising: supplying to the engine the lubricant composition of any one of the preceding claims.

20 14. A method of reducing levels of piston deposits in an internal combustion engine, comprising lubricating the engine with the lubricant composition of any one of claims 1 to 12.

25 15. The use of a viscosity index improving amount of 0.001 to 2 percent by weight of a polymer comprising from 5 mol % to 20 mol % structural units derived from ethylene, from 50 mol % to 90 mol% structural units derived from propylene, and from 5% to 30 mol % structural units derived from butylene,

in a lubricant composition further comprising at least 60 percent by weight of an oil of lubricating viscosity, 0.01 to 20 percent by weight of a succinimide dispersant; and 0.05 to 5 percent by weight of a detergent comprising an overbased cal-

cium, magnesium, or sodium sulfonate wherein the sulfonate has a total base number in the range from 250 to 600,

to reduce the level of piston deposits in an engine lubricated by said lubricant composition.