

FUNCTIONAL FLUIDS LUBRICATING OIL COMPOSITIONS

BACKGROUND OF THE DISCLOSURE

[0001] Modern lubricating oil formulations are designed to exacting specifications often set by original equipment manufacturers. To meet such specifications, various additives are used, together with base oils of lubricating viscosity. Depending on the application, a typical lubricating oil composition may contain dispersants, detergents, anti-oxidants, wear inhibitors, rust inhibitors, corrosion inhibitors, foam inhibitors, and friction modifiers just to name a few. Different applications will govern the type of additives that will go into a lubricating oil composition.

[0002] A functional fluid is a term which encompasses a variety of fluids including but not limited to tractor hydraulic fluids, power transmission fluids including automatic transmission fluids, continuously variable transmission fluids and manual transmission fluids, hydraulic fluids, gear oils, power steering fluids, fluids used in wind turbines and fluids related to power train components. It should be noted that within each of these fluids such as, for example, automatic transmission fluids, there are a variety of different types of fluids due to the various transmissions having different designs which have led to the need for fluids of markedly different functional characteristics.

[0003] With respect to tractor hydraulic fluids, these fluids are all-purpose (or multi-purpose) products used for all lubricant applications in a tractor except for lubricating the engine. Also included as a tractor hydraulic fluid for the purposes of this invention are so-called Super Tractor Oil Universal fluids or “STOU” fluids, which also lubricate the engine. These lubricating applications may include lubrication of gearboxes, power take-off and clutch(es), rear axles, reduction gears, wet brakes, and hydraulic accessories. The components included within a tractor fluid must be carefully chosen so that the final resulting fluid composition will provide all the necessary characteristics required in the different applications. Such characteristics may include the ability to provide proper frictional properties for preventing wet brake and/or clutch chatter of oil immersed brakes and clutches while simultaneously providing the ability to actuate wet brakes and clutches, particularly provide power take-off (PTO) clutch performance. A tractor fluid must provide sufficient antiwear and extreme pressure properties as well as water tolerance/filterability capabilities. The extreme pressure (EP) properties of tractor fluids, important in gearing applications, may be demonstrated by the ability of the fluid to pass a spiral bevel test as well as a straight spur

gear test. The tractor fluid may need to pass wet brake chatter tests while providing adequate wet brake capacity when used in oil immersed disk brakes which are comprised of cellulose, bronze, graphitic-compositions and asbestos, among other materials. The tractor fluid may need to demonstrate its ability to provide friction retention for power shift transmission clutches such as those clutches which include, cellulose and graphitic clutches, among other materials.

[0004] When the functional fluid is a tractor hydraulic fluid, the fluids must have enough friction for the system to operate effectively. The term “friction durability” will be used to describe the property of the fluid to retain its original frictional properties. For example, a fluid with good friction durability will exhibit small changes in the frictional properties during its useful life. It is important that the tractor hydraulic fluid maintains its frictional properties throughout its life to ensure optimal operation of brakes and clutches.

[0005] The present disclosure generally relates to lubricating oil compositions which improve or maintain frictional durability while maintaining low torque variation at low speed when used as tractor hydraulic fluids.

SUMMARY OF THE DISCLOSURE

[0006] In accordance with one embodiment of the present disclosure, there is provided a tractor hydraulic fluid composition which comprises:

- (a) a major amount of an oil of lubricating viscosity, and
- (b) a detergent system comprising:
 - (i) a low overbased sulfonate detergent;
 - (ii) a high overbased sulfonate detergent; and
 - (iii) a high overbased phenate detergent having an alkyl group derived from an isomerized normal alpha olefin having from about 10 to about 40 carbon atoms per molecule.

[0007] Also provided is a method of improving frictional durability while maintaining low torque variation at low speed of a tractor hydraulic system comprising lubricating said hydraulic system with a lubricating oil composition comprising:

- (a) a major amount of an oil of lubricating viscosity, and
- (b) a detergent system comprising:
 - (i) a low overbased sulfonate detergent;
 - (ii) a high overbased sulfonate detergent; and

- (iii) a high overbased phenate detergent having an alkyl group derived from an isomerized normal alpha olefin having from about 10 to about 40 carbon atoms per molecule.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0008] While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

[0009] To facilitate the understanding of the subject matter disclosed herein, a number of terms, abbreviations or other shorthand as used herein are defined below. Any term, abbreviation or shorthand not defined is understood to have the ordinary meaning used by a skilled artisan contemporaneous with the submission of this application.

DEFINITIONS

[0010] As used herein, the following terms have the following meanings, unless expressly stated to the contrary. In this specification, the following words and expressions, if and when used, have the meanings given below.

[0011] A “major amount” means in excess of 50 weight % of a composition.

[0012] A “minor amount” means less than 50 weight % of a composition, expressed in respect of the stated additive and in respect of the total mass of all the additives present in the composition, reckoned as active ingredient of the additive or additives.

[0013] “Active ingredients” or “actives” or “oil free” refers to additive material that is not diluent or solvent.

[0014] The abbreviation “ppm” means parts per million by weight, based on the total weight of the lubricating oil composition.

[0015] Total base number (TBN) was determined in accordance with ASTM D2896. TBN numbers are reported on an “actives” or “oil-free” basis.

[0016] Metal – The term “metal” refers to alkali metals, alkaline earth metals, or mixtures thereof.

[0017] Kinematic viscosity at 100°C (KV₁₀₀) was determined in accordance with ASTM D445.

[0018] Olefins – The term “olefins” refers to a class of unsaturated aliphatic hydrocarbons having one or more carbon-carbon double bonds, obtained by a number of processes. Those containing one double bond are called mono-alkenes, and those with two double bonds are called dienes, alkyldienes, or diolefins. Alpha olefins are particularly reactive because the double bond is between the first and second carbons. Examples are 1-octene and 1-octadecene, which are used as the starting point for medium-biodegradable surfactants. Linear and branched olefins are also included in the definition of olefins.

[0019] Normal Alpha Olefins – The term “Normal Alpha Olefins” refers to olefins which are straight chain, non-branched hydrocarbons with carbon-carbon double bond present in beginning and end of the chain.

[0020] Isomerized Normal Alpha Olefin. The term “Isomerized Normal Alpha Olefin” as used herein refers to an alpha olefin that has been subjected to isomerization conditions which results in an alteration of the distribution of the olefin species present and/or the introduction of branching along the alkyl chain. The isomerized olefin product may be obtained by isomerizing a linear alpha olefin containing from about 10 to about 40 carbon atoms, preferably from about 20 to about 28 carbon atoms, and preferably from about 20 to about 24 carbon atoms.

[0021] All ASTM standards referred to herein are the most current versions as of the filing date of the present application.

[0022] In one aspect, the lubricating oil composition of the present disclosure improves frictional durability while maintaining low torque variation at low speed when used as a tractor hydraulic fluid. In another aspect, the lubricating oil composition of the present disclosure maintains frictional durability while maintaining low torque variation at low speed when used as a tractor hydraulic fluid

[0023] In one aspect, the lubricating oil composition of the present disclosure comprises a detergent system comprising: a low overbased sulfonate detergent, a high overbased sulfonate detergent; and a high overbased phenate detergent.

[0024] In another aspect, the detergent system of the present disclosure provides synergistic performance benefits when used in lubricating oil compositions for tractor hydraulic fluids.

Oil of lubricating viscosity

[0025] The oil of lubricating viscosity (sometimes referred to as “base stock” or “base oil”) is the primary liquid constituent of a lubricant, into which additives and possibly other oils are blended, for example to produce a final lubricant (or lubricant composition). A base oil is useful for making concentrates as well as for making lubricating oil compositions therefrom, and may be selected from natural and synthetic lubricating oils and combinations thereof.

[0026] Natural oils include animal and vegetable oils, liquid petroleum oils and hydrotreated, solvent-treated mineral lubricating oils of the paraffinic, naphthenic and mixed paraffinic-naphthenic types. Oils of lubricating viscosity derived from coal or shale are also useful base oils.

[0027] Synthetic lubricating oils include hydrocarbon oils such as polymerized and interpolymers of olefins (e.g., polybutylenes, polypropylenes, propylene-isobutylene copolymers, chlorinated polybutylenes, poly(1-hexenes), poly(1-octenes), poly(1-decenes); alkylbenzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di(2-ethylhexyl)benzenes; polyphenols (e.g., biphenyls, terphenyls, alkylated polyphenols); and alkylated diphenyl ethers and alkylated diphenyl sulfides and the derivatives, analogues and homologues thereof.

[0028] Another suitable class of synthetic lubricating oils comprises the esters of dicarboxylic acids (e.g., malonic acid, alkyl malonic acids, alkenyl malonic acids, succinic acid, alkyl succinic acids and alkenyl succinic acids, maleic acid, fumaric acid, azelaic acid, suberic acid, sebacic acid, adipic acid, linoleic acid dimer, phthalic acid) with a variety of alcohols (e.g., butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, ethylene glycol, diethylene glycol monoether, propylene glycol). Specific examples of these esters include dibutyl adipate, di(2-ethylhexyl) sebacate, di-*n*-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, the 2-ethylhexyl diester of linoleic acid dimer, and the complex ester formed by reacting one mole of sebacic acid with two moles of tetraethylene glycol and two moles of 2-ethylhexanoic acid.

[0029] Esters useful as synthetic oils also include those made from C₅ to C₁₂ monocarboxylic acids and polyols, and polyol ethers such as neopentyl glycol, trimethylolpropane, pentaerythritol, dipentaerythritol and tripentaerythritol.

[0030] The base oil may be derived from Fischer-Tropsch synthesized hydrocarbons. Fischer-Tropsch synthesized hydrocarbons are made from synthesis gas containing H₂ and CO using a Fischer-Tropsch catalyst. Such hydrocarbons typically require further processing in

order to be useful as the base oil. For example, the hydrocarbons may be hydroisomerized; hydrocracked and hydroisomerized; dewaxed; or hydroisomerized and dewaxed; using processes known to those skilled in the art.

[0031] Unrefined, refined and re-refined oils can be used in the present lubricating oil composition. Unrefined oils are those obtained directly from a natural or synthetic source without further purification treatment. For example, a shale oil obtained directly from retorting operations, a petroleum oil obtained directly from distillation or ester oil obtained directly from an esterification process and used without further treatment would be unrefined oil. 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. Many such purification techniques, such as distillation, solvent extraction, acid or base extraction, filtration and percolation are known to those skilled in the art.

[0032] Re-refined oils are obtained by processes similar to those used to obtain refined oils applied to refined oils which have been already used in service. Such re-refined oils are also known as reclaimed or reprocessed oils and often are additionally processed by techniques for approval of spent additive and oil breakdown products.

[0033] Hence, the base oil which may be used to make the present lubricating oil composition 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 (API Publication 1509). Such base oil groups are summarized in Table 1 below:

Table 1

Group ^(a)	<u>Base Oil Properties</u>		
	Saturates ^(b) , wt. %	Sulfur ^(c) , wt. %	Viscosity Index ^(d)
Group I	<90 and/or	>0.03	80 to <120
Group II	≥90	≤0.03	80 to <120
Group III	≥90	≤0.03	≥120
Group IV	Polyalphaolefins (PAOs)		
Group V	All other base stocks not included in Groups I, II, III or IV		

^(a) Groups I-III are mineral oil base stocks.

^(b) Determined in accordance with ASTM D2007.

^(c) Determined in accordance with ASTM D2622, ASTM D3120, ASTM D4294 or ASTM D4927.

^(d) Determined in accordance with ASTM D2270.

[0034] Base oils suitable for use herein are any of the variety corresponding to API Group II, Group III, Group IV, and Group V oils and combinations thereof, preferably the Group III to Group V oils due to their exceptional volatility, stability, viscometric and cleanliness features.

[0035] The oil of lubricating viscosity for use in the lubricating oil compositions of this disclosure, also referred to as a base oil, is typically present in a major amount, e.g., an amount of greater than 50 wt. %, preferably greater than about 70 wt. %, more preferably from about 80 to about 99.5 wt. % and most preferably from about 85 to about 98 wt. %, based on the total weight of the composition. The expression "base oil" as used herein shall be understood to mean a base stock or blend of base stocks which is a lubricant component that is produced by a single manufacturer to the same specifications (independent of feed source or manufacturer's location); that meets the same manufacturer's specification; and that is identified by a unique formula, product identification number, or both. The base oil for use herein can be any presently known or later-discovered oil of lubricating viscosity used in formulating lubricating oil compositions for any and all such applications, e.g., engine oils, marine cylinder oils, functional fluids such as hydraulic oils, gear oils, transmission fluids, etc. Additionally, the base oils for use herein can optionally contain viscosity index improvers, e.g., polymeric alkylmethacrylates; olefinic copolymers, e.g., an ethylene-propylene copolymer or a styrene-butadiene copolymer; and the like and mixtures thereof.

[0036] As one skilled in the art would readily appreciate, the viscosity of the base oil is dependent upon the application. Accordingly, the viscosity of a base oil for use herein will ordinarily range from about 2 to about 2000 centistokes (cSt) at 100° Centigrade (C.). Generally, individually the base oils used as engine oils will have a kinematic viscosity range at 100° C. of about 2 cSt to about 30 cSt, preferably about 3 cSt to about 16 cSt, and most preferably about 4 cSt to about 12 cSt and will be selected or blended depending on the desired end use and the additives in the finished oil to give the desired grade of engine oil, e.g., a lubricating oil composition having an SAE Viscosity Grade of 0W, 0W-8, 0W-12, 0W-16, 0W-20, 0W-26, 0W-30, 0W-40, 0W-50, 0W-60, 5W, 5W-20, 5W-30, 5W-40, 5W-50, 5W-60, 10W, 10W-20, 10W-30, 10W-40, 10W-50, 15W, 15W-20, 15W-30, 15W-40, 20, 30, 40, 50 and the like. Also, oils could be blended in viscosity grades specific to tractor hydraulic fluids such as J20C and/or J20D.

Low Overbased (LOB) Sulfonate Detergent

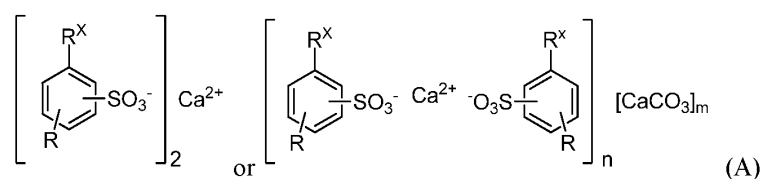
[0037] The compositions described herein comprise low overbased alkaryl sulfonate salts. In particular, the compositions comprise:

- (i) at least one low overbased alkaryl sulfonate calcium salt wherein the alkaryl group is an aryl group substituted with an alkyl group derived from propylene or isobutylene oligomers; and / or
- (ii) at least one low overbased alkaryl sulfonate calcium salt, wherein the alkaryl group is an aryl group substituted with an alkyl group derived from at least one normal alpha olefin or an isomerized normal alpha olefin, said olefin having from about 18 to about 30 carbon atoms.

These low overbased alkaryl sulfonate calcium salts can serve, *e.g.*, as detergents and friction providers in the compositions described herein.

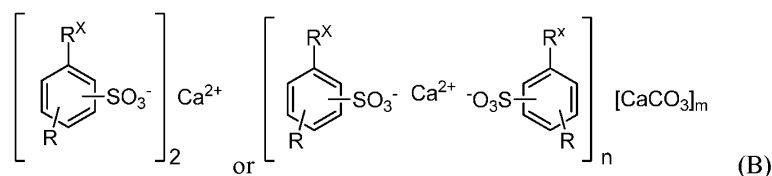
[0038] In some embodiments, the low overbased alkaryl sulfonate detergent is derived from an alkali metal, an alkaline earth metal, or mixtures thereof.

[0039] In some embodiments, the at least one low overbased alkaryl sulfonate calcium salt having an alkaryl group that is an aryl group substituted with an alkyl group derived from propylene or isobutylene oligomers has the following formula A:



wherein R is an alkyl group derived from propylene or isobutylene oligomers; R^X is hydrogen or methyl, m is 0 to 5; and n is 1 or greater. In some embodiments, m is 0.1-5. In some embodiments, n is 1. In some embodiments, the alkyl group has 3-36, 9-27, or 15-18 carbons. In some embodiments, the alkyl group is derived from propylene oligomers.

[0040] In some embodiments, the at least one low overbased alkaryl sulfonate calcium salt having an alkaryl group that is an aryl group substituted with an alkyl group derived from at least one normal alpha olefin or an isomerized normal alpha olefin, said olefin having from about 18 to about 30 carbon atoms, has the following structure B:



wherein R is an alkyl group derived from at least one normal alpha olefin or an isomerized normal alpha olefin, said olefin having from about 18 to about 30 carbon atoms;

R^X is hydrogen or methyl, m is 0 to 5; and n is 1 or greater.

In some embodiments, m is 0.1-5. In some embodiments, n is 1.

[0041] In some embodiments, each of the low overbased alkaryl sulfonate calcium salts (A) or (B) above is a low overbased alkyl-substituted benzene or low overbased alkyl-substituted toluene sulfonate calcium salt.

[0042] The calcium content accounted for by the at least one low overbased alkaryl sulfonate calcium salt (A) or (B) present in the oil composition is 0.001 to 0.1 weight percent of the lubricating oil composition. In some embodiments, the calcium content is 0.01 to 0.09, 0.01 to 0.08, 0.01 to 0.07, or 0.01 to 0.06, 0.01 to 0.05, 0.01 to 0.04, 0.01 to 0.03, 0.01 to 0.02 weight percent of the lubricating oil.

[0043] In some embodiments, the low overbased alkaryl sulfonate calcium salt (B) is one wherein the alkaryl group is an aryl group substituted with an alkyl group derived from at least one normal alpha olefin or an isomerized normal alpha olefin, said olefin having from about 20 to about 24 carbon atoms.

[0044] In some embodiments, each or both of the alkaryl sulfonate calcium salts (A) or (B) is low overbased, wherein the TBN is less than 150, less than 140, less than 130, less than 120, less than 110, less than 100, less than 90, less than 80, less than 70, less than 60, less than 50, less than 40, less than 30, less than 20, or less than 10. In some embodiments, each or both of the alkaryl sulfonate calcium salts (A) or (B) has a TBN of 2-100, 2-80, or 2-60.

High Overbased (HOB) Sulfonate Detergent

[0045] The lubricating oil composition of the present invention can contain one or more high overbased sulfonate detergents having a TBN of 300-800, 400-800, 400-700, 450-700, 500-700, 500-700, 500-600 mg KOH/g on an actives basis.

[0046] Sulfonates may be prepared from sulfonic acids which are typically obtained by the sulfonation of alkyl substituted aromatic hydrocarbons such as those obtained from the fractionation of petroleum or by the alkylation of aromatic hydrocarbons. Examples included those obtained by alkylating benzene, toluene, xylene, naphthalene, diphenyl or their halogen derivatives. The alkylation may be carried out in the presence of a catalyst with alkylating agents having from about 3 to more than 70 carbon atoms. The alkaryl sulfonates usually contain from about 9 to about 80 or more carbon atoms, preferably from about 16 to about 60

carbon atoms, preferably about 16 to 30 carbon atoms, and more preferably 20-24 carbon atoms per alkyl substituted aromatic moiety.

[0047] In some embodiments, the high overbased detergent is a high overbased alkaryl sulfonate calcium detergent. In some embodiments, the calcium content of the high overbased detergent is 0.001 to 2.0, 0.01 to 1.0, 0.01 to 0.90, 0.01 to 0.70, 0.01 to 0.50, 0.01 to 0.40, 0.01 to 0.30; 0.01 to 0.20, 0.01 to 0.17 weight percent of the lubricating oil composition.

High Overbased (HOB) Phenate Detergent

[0048] In one aspect of the present disclosure, the high overbased phenate detergent is a phenolic-based detergent. In another aspect of the present disclosure, the phenolic-based detergent is an isomerized olefin phenate detergent.

[0049] In one aspect of the present disclosure, the high overbased phenate detergent has a TBN of 300-600, 300-500, 300-450, 300- 400, 325-425, 350-425, 350-400 mgKOH/gram on an oil free basis.

[0050] In one aspect of the present disclosure, the phenolic-based detergent is an alkylated phenate detergent wherein the alkyl group is derived from an isomerized normal alpha olefin having from about 10 to about 40 carbon atoms per molecule.

[0051] In one aspect of the present disclosure, the phenolic-based detergent has an isomerization level (I) of the normal alpha olefin is between from about 0.10 to about 0.40, preferably from about 0.10 to about 0.30, preferably from about 0.12 to about 0.30, and more preferably from about 0.22 to about 0.30.

[0052] In one aspect of the present disclosure, the phenate detergent is a sulfurized phenate detergent.

[0053] In one aspect of the present disclosure, the isomerized olefin phenate detergent can be prepared as described in US Patent 8,580,717 which is herein incorporated in its entirety.

[0054] In one aspect of the present disclosure, the alkyl group is derived from an isomerized alpha olefin having from about 14 to about 30, from about 16 to about 30, from about 18 to about 30, from about 20 to about 28, 20 to about 24, or from about 18 to about 28 carbon atoms per molecule.

[0055] In another embodiment, the isomerization level of the alpha olefin is about 0.26, and having from about 20 to about 24 carbon atoms.

[0056] In some embodiments, the calcium content of the high overbased phenate detergent is from 0.005 to 0.08, 0.01 to 0.08, 0.01 to 0.07, 0.01 to 0.06, 0.01 to 0.05, 0.01 to 0.045 weight percent, based on the weight of the oil composition.

Other Detergents

[0057] Other detergents that may be used include oil-soluble overbased sulfonate, salixarate, salicylate, saligenin, complex detergents and naphthenate detergents and other oil-soluble alkylhydroxybenzoates of a metal, particularly the alkali or alkaline earth metals, e.g., barium, sodium, potassium, lithium, calcium, and magnesium. The most commonly used metals are calcium and magnesium, which may both be present in detergents used in a lubricant, and mixtures of calcium and/or magnesium with sodium.

[0058] Overbased metal detergents are generally produced by carbonating a mixture of hydrocarbons, detergent acid, for example: sulfonic acid, alkylhydroxybenzoate etc., metal oxide or hydroxides (for example calcium oxide or calcium hydroxide) and promoters such as xylene, methanol and water. For example, for preparing an overbased calcium sulfonate, in carbonation, the calcium oxide or hydroxide reacts with the gaseous carbon dioxide to form calcium carbonate. The sulfonic acid is neutralized with an excess of CaO or Ca(OH)₂, to form the sulfonate.

[0059] Overbased detergents may be low overbased, e.g., an overbased salt having a TBN below 100 on an actives basis. In one embodiment, the TBN of a low overbased salt may be from about 30 to about 100. In another embodiment, the TBN of a low overbased salt may be from about 30 to about 80. Overbased detergents may be medium overbased, e.g., an overbased salt having a TBN from about 100 to about 250. In one embodiment, the TBN of a medium overbased salt may be from about 100 to about 200. In another embodiment, the TBN of a medium overbased salt may be from about 125 to about 175. Overbased detergents may be high overbased, e.g., an overbased salt having a TBN above 250. In one embodiment, the TBN of a high overbased salt may be from about 250 to about 800 on an actives basis.

[0060] In one embodiment, the detergent can be one or more alkali or alkaline earth metal salts of an alkyl-substituted hydroxyaromatic carboxylic acid. Suitable hydroxyaromatic compounds include mononuclear monohydroxy and polyhydroxy aromatic hydrocarbons having 1 to 4, and preferably 1 to 3, hydroxyl groups. Suitable hydroxyaromatic compounds include phenol, catechol, resorcinol, hydroquinone, pyrogallol, cresol, and the like. The preferred hydroxyaromatic compound is phenol.

[0061] The alkyl substituted moiety of the alkali or alkaline earth metal salt of an alkyl-substituted hydroxyaromatic carboxylic acid is derived from an alpha olefin having from about 10 to about 80 carbon atoms. The olefins employed may be linear, isomerized linear, branched or partially branched linear. The olefin may be a mixture of linear olefins, a mixture of isomerized linear olefins, a mixture of branched olefins, a mixture of partially branched linear or a mixture of any of the foregoing.

[0062] In one embodiment, the mixture of linear olefins that may be used is a mixture of normal alpha olefins selected from olefins having from about 10 to about 40 carbon atoms per molecule. In one embodiment, the normal alpha olefins are isomerized using at least one of a solid or liquid catalyst.

[0063] In one embodiment, at least about 50 mole%, at least about 75 mole%, at least about 80 mole%, at least about 85 mole%, at least about 90 mole%, at least about 95 mole% of the alkyl groups contained within the alkali or alkaline earth metal salt of an alkyl-substituted hydroxyaromatic carboxylic acid such as the alkyl groups of an alkaline earth metal salt of an alkyl-substituted hydroxybenzoic acid detergent are a C₂₀ or higher. In another embodiment, the alkali or alkaline earth metal salt of an alkyl-substituted hydroxyaromatic carboxylic acid is an alkali or alkaline earth metal salt of an alkyl-substituted hydroxybenzoic acid that is derived from an alkyl-substituted hydroxybenzoic acid in which the alkyl groups are C₂₀ to about C₂₈ normal alpha-olefins. In another embodiment, the alkyl group is derived from at least two alkylated phenols. The alkyl group on at least one of the at least two alkyl phenols is derived from an isomerized alpha olefin. The alkyl group on the second alkyl phenol may be derived from branched or partially branched olefins, highly isomerized olefins or mixtures thereof.

[0064] In another embodiment, the alkali or alkaline earth metal salt of an alkyl-substituted hydroxyaromatic carboxylic acid is a salicylate derived from an alkyl group with 20-40 carbon atoms, preferably 20-28 carbon atoms, more preferably, isomerized 20-24 NAO.

Antiwear Agents

[0065] The lubricating oil composition disclosed herein can comprise one or more antiwear agent. Antiwear agents reduce wear of metal parts. Suitable anti-wear agents include dihydrocarbyl dithiophosphate metal salts such as zinc dihydrocarbyl dithiophosphates (ZDDP) of formula (Formula 1):



wherein R¹ and R² may be the same or different hydrocarbyl radicals having from 1 to 18 (e.g., 2 to 12) carbon atoms and including radicals such as alkyl, alkenyl, aryl, arylalkyl,

alkaryl and cycloaliphatic radicals. Particularly preferred as R^1 and R^2 groups are alkyl groups having from 2 to 8 carbon atoms (e.g., the alkyl radicals may be ethyl, *n*-propyl, isopropyl, *n*-butyl, isobutyl, *sec*-butyl, *n*-pentyl, isopentyl, *n*-hexyl, isohexyl, 2-ethylhexyl). In order to obtain oil solubility, the total number of carbon atoms (i.e., R^1+R^2) will be at least 5. The zinc dihydrocarbyl dithiophosphate can therefore comprise zinc dialkyl dithiophosphates. The zinc dialkyl dithiophosphate is a primary, secondary zinc dialkyl dithiophosphate, or a combination thereof. ZDDP may be present at 3 wt. % or less (e.g., 0.1 to 1.5 wt. %, or 0.5 to 1.0 wt %) of the lubricating oil composition.

Antioxidants

[0066] The lubricating oil composition disclosed herein can comprise one or more antioxidant. Antioxidants reduce the tendency of mineral oils during to deteriorate during service. Oxidative deterioration can be evidenced by sludge in the lubricant, varnish-like deposits on the metal surfaces, and by viscosity growth. Suitable antioxidants include hindered phenols, aromatic amines, hindered amines (also known as HALS-Hindered Amine light Stabilizers) and sulfurized alkylphenols and alkali and alkaline earth metals salts thereof.

[0067] The hindered amines used in this invention are of many types, with three types predominating: pyrimidines, piperidines and stable nitroxide compounds. Many more are described in the book "Nitrones, Nitronates, and Nitroxides", E. Breuer, et al., 1989, John Wiley & Sons and in Patents such as US9315760.

[0068] The hindered phenol antioxidant often contains 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; 4-butyl-2,6-di-*tert*-butylphenol; and 4-dodecyl-2,6-di-*tert*-butylphenol. Other useful hindered phenol antioxidants include 2,6-di-alkyl-phenolic propionic ester derivatives such as IRGANOX® L-135 from Ciba and bis-phenolic antioxidants such as 4,4'-bis(2,6-di-*tert*-butylphenol) and 4,4'-methylenebis(2,6-di-*tert*-butylphenol).

Typical aromatic amine antioxidants have at least two aromatic groups attached directly to one amine nitrogen. Typical aromatic amine antioxidants have alkyl substituent groups of at least 6 carbon atoms. Particular examples of aromatic amine antioxidants useful herein include 4,4'-dioctyldiphenylamine, 4,4'-dinonyldiphenylamine, *N*-phenyl-1-naphthylamine, *N*-(4-*tert*-

octylphenyl)-1-naphthylamine, and *N*-(4-octylphenyl)-1-naphthylamine. Antioxidants may be present at 0.01 to 5 wt. % (e.g., 0.1 to 2 wt. %) of the lubricating oil composition.

Dispersants

[0069] The lubricating oil composition disclosed herein can comprise one or more dispersant. Dispersants maintain in suspension materials resulting from oxidation that are insoluble in oil, thus preventing sludge flocculation and precipitation or deposition on metal parts. Dispersants useful herein include nitrogen-containing, ashless (metal-free) dispersants known to be effective to reduce formation of deposits upon use in gasoline and diesel engines.

[0070] Suitable dispersants include hydrocarbyl succinimides, hydrocarbyl succinamides, mixed ester/amides of hydrocarbyl-substituted succinic acid, hydroxyesters of hydrocarbyl-substituted succinic acid, and Mannich condensation products of hydrocarbyl-substituted phenols, formaldehyde and polyamines. Also suitable are condensation products of polyamines and hydrocarbyl-substituted phenyl acids. Mixtures of these dispersants can also be used. Basic nitrogen-containing ashless dispersants are well-known lubricating oil additives and methods for their preparation are extensively described in the patent literature. Preferred dispersants are the alkenyl succinimides and succinamides where the alkenyl-substituent is a long-chain of preferably greater than 40 carbon atoms. These materials are readily made by reacting a hydrocarbyl-substituted dicarboxylic acid material with a molecule containing amine functionality. Examples of suitable amines are polyamines such as polyalkylene polyamines, hydroxy-substituted polyamines and polyoxyalkylene polyamines.

[0071] Particularly preferred ashless dispersants are the polyisobutenyl succinimides formed from polyisobutenyl succinic anhydride and a polyalkylene polyamine such as a polyethylene polyamine of formula 2:



wherein *z* is 1 to 11. The polyisobutenyl group is derived from polyisobutene and preferably has a number average molecular weight (*M_n*) in a range of 700 to 3000 Daltons (e.g., 900 to 2500 Daltons). For example, the polyisobutenyl succinimide may be a mono-succinimide or a bis-succinimide derived from a polyisobutenyl group having a *M_n* of 900 to 2500 Daltons. As is known in the art, the dispersants may be post-treated (e.g., with a boronating agent or a cyclic carbonate, ethylene carbonate etc).

[0072] Nitrogen-containing ashless (metal-free) dispersants are basic, and contribute to the TBN of a lubricating oil composition to which they are added, without introducing

additional sulfated ash. Dispersants may be present at 0.1 to 10 wt. % (e.g., 2 to 5 wt. %) of the lubricating oil composition.

Foam Inhibitors

[0073] The lubricating oil composition disclosed herein can comprise one or more foam inhibitor that can break up foams in oils. Non-limiting examples of suitable foam inhibitors or anti-foam inhibitors include silicone oils or polydimethylsiloxanes, fluorosilicones, alkoxyated aliphatic acids, polyethers (e.g., polyethylene glycols), branched polyvinyl ethers, alkyl acrylate polymers, alkyl methacrylate polymers, polyalkoxyamines and combinations thereof.

Additional Co-Additives

[0074] The lubricating oil compositions of the present disclosure may also contain other conventional additives that can impart or improve any desirable property of the lubricating oil composition in which these additives are dispersed or dissolved. Any additive known to a person of ordinary skill in the art may be used in the lubricating oil compositions disclosed herein. Some suitable additives have been described in Mortier et al., "Chemistry and Technology of Lubricants", 2nd Edition, London, Springer, (1996); and Leslie R. Rudnick, "Lubricant Additives: Chemistry and Applications", New York, Marcel Dekker (2003), both of which are incorporated herein by reference. For example, the lubricating oil compositions can be blended with antioxidants, anti-wear agents, detergents such as metal detergents, rust inhibitors, dehazing agents, demulsifying agents, metal deactivating agents, friction modifiers, pour point depressants, antifoaming agents, co-solvents, corrosion-inhibitors, ashless dispersants, multifunctional agents, dyes, extreme pressure agents and the like and mixtures thereof. A variety of the additives are known and commercially available. These additives, or their analogous compounds, can be employed for the preparation of the lubricating oil compositions of the disclosure by the usual blending procedures.

[0075] In the preparation of lubricating oil formulations, it is common practice to introduce the additives in the form of 10 to 100 wt. % active ingredient concentrates in hydrocarbon oil, e.g. mineral lubricating oil, or other suitable solvent.

[0076] Usually these concentrates may be diluted with 3 to 100, e.g., 5 to 40, parts by weight of lubricating oil per part by weight of the additive package in forming finished lubricants, e.g. tractor hydraulic fluids. The purpose of concentrates, of course, is to make the

handling of the various materials less difficult and awkward as well as to facilitate solution or dispersion in the final blend.

[0077] Each of the foregoing additives, when used, is used at a functionally effective amount to impart the desired properties to the lubricant. Thus, for example, if an additive is a friction modifier, a functionally effective amount of this friction modifier would be an amount sufficient to impart the desired friction modifying characteristics to the lubricant.

[0078] In general, the concentration of each of the additives in the lubricating oil composition, when used, may range from about 0.001 wt. % to about 20 wt. %, from about 0.01 wt. % to about 15 wt. %, or from about 0.1 wt. % to about 10 wt. %, from about 0.005 wt.% to about 5 wt.%, or from about 0.1 wt.% to about 2.5 wt.%, based on the total weight of the lubricating oil composition. Further, the total amount of the additives in the lubricating oil composition may range from about 0.001 wt.% to about 20 wt.%, from about 0.01 wt.% to about 10 wt.%, or from about 0.1 wt.% to about 5 wt.%, based on the total weight of the lubricating oil composition.

[0079] The following examples are presented to exemplify embodiments of the invention but are not intended to limit the invention to the specific embodiments set forth. Unless indicated to the contrary, all parts and percentages are by weight. All numerical values are approximate. When numerical ranges are given, it should be understood that embodiments outside the stated ranges may still fall within the scope of the invention. Specific details described in each example should not be construed as necessary features of the invention.

EXAMPLES

The following examples are intended for illustrative purposes only and do not limit in any way the scope of the present disclosure.

Isomerization level (I) and NMR method

[0080] The isomerization level (I) of the olefin was determined by hydrogen-1 (1H) NMR. The NMR spectra were obtained on a Bruker Ultrashield Plus 400 in chloroform-d1 at 400 MHz using TopSpin 3.2 spectral processing software.

[0081] The isomerization level (I) represents the relative amount of methyl groups (-CH3) (chemical shift 0.3-1.01 ppm) attached to the methylene backbone groups (-CH2-) (chemical shift 1.01-1.38 ppm) and is defined by Equation (1) as shown below,

$$I = m/(m+n) \qquad \text{Equation (I)}$$

where m is NMR integral for methyl groups with chemical shifts between 0.3 ± 0.03 to 1.01 ± 0.03 ppm, and n is NMR integral for methylene groups with chemical shifts between 1.01 ± 0.03 to 1.38 ± 0.10 ppm.

[0082] The isomerized level (I) of the alpha olefin is between from about 0.1 to about 0.4, preferably from about 0.1 to about 0.3, more preferably from about 0.12 to about 0.3.

[0083] In one embodiment, the isomerization level of the NAO is about 0.16, and having from about 20 to about 24 carbon atoms.

[0084] In another embodiment, the isomerization level of the NAO is about 0.26, and having from about 20 to about 24 carbon atoms.

[0085] Provided herein are Tractor Hydraulic Fluid Compositions which are envisioned for the present disclosure. Examples of the disclosure will generally include test formulations disclosed in Table 2 below.

TABLE 2: TEST COMPOSITIONS

Description	Wt. %
LOB Sulfonate	0.001 to 5.0
HOB Sulfonate	0.001 to 5.0
HOB Phenate	0.001 to 5.0
Other Additives (Example: Dispersants, Other Detergents, Antioxidants, Viscosity Improvers, Wear Inhibitors, Foam Inhibitors, Friction Modifiers, etc.)	0.01 to 30
Base Oils	0.1 to 99.9

[0086] Examples of the disclosure will generally include test formulations disclosed in Table 3 below.

Table 3: Formulation Compositions

	Ex 1	Comp A	Ex 2	Comp B	Ex 3	Comp C
Phenate 1 (wt. % Ca)	0.012	0	0.020	0	0.040	0
Phenate 2 (wt. % Ca)	0	0.012	0	0.020	0	0.040
LOB sulfonate (wt. % Ca)	0.024	0.024	0.024	0.024	0.024	0.024
HOB sulfonate (wt. % Ca)	0.240	0.240	0.240	0.240	0.240	0.240
Friction Modifier (wt%)	0.75	0.75	0.75	0.75	0.75	0.75
ZnDTP (mM)	15	15	15	15	15	15
Foam inhibitor (wt%)	0.02	0.02	0.02	0.02	0.02	0.02
Dispersant PMA (wt%)	4.22	4.22	4.22	4.22	4.22	4.22
PPD (wt%)	0.2	0.2	0.2	0.2	0.2	0.2
Base oil (wt%)	11.42	11.42	11.45	11.47	11.45	11.45

Phenate 1 is Ca phenate derived from C20-24 isomerized olefin

Phenate 2 is Ca phenate derived from tetrapropylene

[0087]

The test formulations in Table 3 were evaluated in the R20 test which is an axle brake screener test. It is a friction endurance test that tracks friction coefficients and brake noise at various friction plate engagement steps that include multiple pressures and speeds. This test is part of the ZF TE-ML 05E and TE-ML 05F specifications for axles of off-road vehicles from ZF Friedrichshafen AG, Friedrichshafen, Germany, and is available there.

[0088] The results of the R20 test are in Table 4 below.

Table 4: Max Torque Variation at Various Facing Pressure (MPa)

MPa	Ex 1	Comp A	Ex 2	Comp B	Ex 3	Comp C
1.0	836.03	1016.85	921.59	1032.88	436.73	536.66
1.5	1154.23	1293.91	1128.87	1210.25	441.63	676.45
2.0	1183.84	1430.68	1069.86	1311.69	441.26	704.81
2.5	1269.61	1551.67	1191.98	1408.00	438.54	757.37
3.0	1387.19	1586.69	1080.82	1459.35	182.45	698.06
3.5	1316.18	1398.84	378.19	1479.77	87.71	309.99
4.0	656.43	1476.73	419.93	871.95	74.80	102.41

[0089]

The R20 friction testing was performed to compare the low speed brake torque variation performance of formulations containing Phenate 1 (Ca phenate derived from C20-24

isomerized olefin) versus analogous formulations containing Phenate 2 (Ca phenate derived from tetrapropylene). The results of R20 testing demonstrate that Example formulations 1, 2 and 3 comprising Phenate 1 show reduced low speed brake torque variation as compared to Comparative formulations A, B, and C comprising Phenate 2. This means that formulations containing phenate 1 improved clutch and brake capacity while maintaining low torque variation at low speed. The benefit of mitigated low speed brake torque variation is decreased energy loss and vibration, which correlates to lower risk of damage to mechanical parts, decreased operator discomfort, and less tendency for brake noise.

WHAT IS CLAIMED IS:

1. A tractor hydraulic fluid composition comprising:
 - (a) a major amount of an oil of lubricating viscosity, and
 - (b) a detergent system comprising:
 - (i) a low overbased sulfonate detergent;
 - (ii) a high overbased sulfonate detergent; and
 - (iii) a high overbased phenate detergent having an alkyl group derived from an isomerized normal alpha olefin having from about 10 to about 40 carbon atoms per molecule.
2. The lubricating oil composition of claim 1 wherein the high overbased phenate detergent is a calcium phenate detergent.
3. The lubricating oil composition of claim 2 wherein the calcium phenate detergent is derived from C20 to C24 isomerized olefins.
4. The lubricating oil composition of claim 1 wherein the composition comprises from 0.005 to 0.08 wt.% Ca from the high overbased phenate detergent.
5. The lubricating oil composition of claim 1 wherein the composition comprises from 0.01 to 0.06 wt.% Ca from the high overbased phenate detergent.
6. The lubricating oil composition of claim 1 wherein the composition comprises a zinc diakyl dithiophosphate detergent.
7. A method of improving brake and clutch capacity while maintaining low torque variation at low speed of a tractor hydraulic system, the method comprising lubricating said tractor hydraulic system with a lubricating oil composition comprising:
 - (a) a major amount of an oil of lubricating viscosity, and
 - (b) a detergent system comprising:
 - (i) a low overbased sulfonate detergent;
 - (ii) a high overbased sulfonate detergent; and
 - (iii) a high overbased phenate detergent having an alkyl group derived from an isomerized normal alpha olefin having from about 10 to about 40 carbon atoms per molecule.
8. The method of claim 7, wherein the high overbased phenate detergent is a calcium phenate detergent.

9. The method of claim 8, wherein the calcium phenate detergent is derived from C20 to C24 isomerized olefins.
10. The method of claim 7, wherein the composition comprises from 0.005 to 0.08 wt.% Ca from the high overbased phenate detergent.
11. The method of claim 10, wherein the composition comprises from 0.01 to 0.06 wt.% Ca from the high overbased phenate detergent.
12. The method of claim 7, wherein the composition comprises a zinc dialkyl dithiophosphate detergent.