

Zn-FREE HYDRAULIC OIL COMPOSITIONS COMPRISING GUERBET ALCOHOLS TO IMPROVE THE STORAGE STABILITY

FIELD OF THE INVENTION

- 5 **[0001]** The disclosed technology relates to the use of Guerbet alcohols to improve the storage stability of Zn-free hydraulic fluids at both high and low temperatures. These improvements are particularly relevant to synthetic lubricants, such as those made with isoparaffinic hydrocarbon oils, such as polyalphaolefin (PAO) base oils.

BACKGROUND OF THE INVENTION

- 10 **[0002]** Hydraulic systems rely on a hydraulic fluid under pressure to create motion in machine components. Pumps are used to create the combination of flow and pressure in hydraulic systems. Hydraulic fluids are useful in such systems to provide the pressurized fluid. While the primary purpose of a hydraulic fluid is to transmit energy (power) from the source (pump) to the end use (motor, cylinder, etc.), the hydraulic fluid provides lubrication, helping to minimize wear, reduce friction, provide cooling, inhibit corrosion, and minimize deposits, thereby extending the lifetime and efficiency of the system.

- 15 **[0003]** Some hydraulic applications require high purity, synthetic hydrocarbon base oils. Further, there is increasing interest in hydraulic oil compositions that contain ashless additives due to environmental concerns and potential toxicity issues. In some applications, the use of antiwear additives such as ZDDP is being reduced in favor of other ashless additives. One of the challenges of using high purity, synthetic hydrocarbon base oils is the poor solubility of additives, for example zinc-free antiwear additives, in the very non-polar medium. This poor solubility can often result in drop-out, haze, flocculation, and sedimentation when the finished fluids are stored under a variety of conditions. Initial studies of Zn-free antiwear additives in finished hydraulic fluids made with isoparaffinic hydrocarbon base oils gave poor storage stability results. Therefore, there is a need for improved isoparaffinic hydrocarbon-based hydraulic oils with Zn-free antiwear additives that are stable under multiple storage conditions.

SUMMARY OF THE INVENTION

- 30 **[0004]** It was found that the addition of Guerbet alcohols can help improve the storage stability at a wide range of temperatures when Zn-free antiwear additives are blended in a highly pure, hydrocarbon base oil. The addition of Guerbet alcohols to the formulations resulted in improved storage stability at both high and low temperatures.

The disclosed technology, therefore, solves the problem of improving the stability of Zn-free antiwear additives in isoparaffinic hydrocarbon oil-based hydraulic fluids.

[0005] Accordingly, hydraulic oil compositions comprising: 60 to 97 wt% of an isoparaffinic hydrocarbon base oil; 0.5 to 5 wt% of a hydraulic oil additive package comprising at least one zinc-free antiwear additive; and 2 to 20 wt% (or 5 to 20 wt%, or 10 to 20 wt%) of at least one compatibilizer that is a Guerbet alcohol are disclosed. The zinc-free antiwear additive may comprise at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof.

[0006] The at least one Guerbet alcohol may have the structure: $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is a alkylene group containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon atoms. In some embodiments, the at least one Guerbet alcohol may be a β -branched saturated alcohol containing from 16 to 28 carbon atoms, for example, 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, or mixtures thereof.

[0007] In some embodiments, the treat rate of the at least one zinc-free antiwear additive in the hydraulic oil composition ranges from 50 ppm to 10,000 ppm (or 100 ppm to 5,000 ppm or 7,500 ppm) by mass. In yet other embodiments, the hydraulic oil additive package may comprise at least two zinc-free antiwear additives, for example, at least one dithiophosphate ester, at least one alkyl dithiocarbamate, at least one phosphoric acid ester, at least one amine phosphate, or combinations thereof. In some embodiments the at least two zinc-free antiwear additives may comprise at least one dithiophosphate ester and at least one alkyl dithiocarbamate. In yet other embodiments, the at least two zinc-free antiwear additives may comprise at least one phosphoric acid ester and at least one amine phosphate.

[0008] In some embodiments, the hydraulic oil composition may further comprise 2 to 10 wt% of viscosity modifier. Exemplary viscosity modifiers include, but are not limited to, ethylene-olefin co-polymers (especially ethylene-propylene); maleic anhydride-styrene alternating copolymers and esters thereof, poly(alkylmethacrylates) (including random, block, linear, radial and star architectures), hydrogenated styrene-butadiene block copolymers, hydrogenated styrene-isoprene radial and/or block copolymers, or mixtures thereof.

[0009] In some embodiments, the hydraulic oil additive package further comprises at least one rust and/or corrosion inhibitor, foam inhibitors, friction modifiers, antioxidant, demulsifier, surfactant, dispersant, or combinations thereof.

[0010] In some embodiments, the isoparaffinic hydrocarbon base oil may have a viscosity grade of 2 to 10 cSt at 100°C. In some embodiments, the isoparaffinic hydrocarbon base oil may be a polyalphaolefin (PAO) and may comprise oligomers of 1-octene, 1-decene, 1-dodecene, 1-tetradecene 1-octadecene, 1-hexadecane, or mixtures thereof.

[0011] Methods of improving the storage stability and/or seals compatibility of a hydraulic oil composition are also disclosed. The methods may comprise adding to the hydraulic oil composition 2 to 20 wt% (or 5 to 20 wt%, or 10 to 20 wt%) of at least one compatibilizer that is a Guerbet alcohol, based on a total weight of the hydraulic oil composition. In some embodiments, the hydraulic oil composition may comprise: 60 to 97 wt% of an isoparaffinic hydrocarbon base oil; and 0.5 to 20 wt% of a hydraulic oil additive package comprising at least one zinc-free antiwear additive. The zinc-free antiwear additive may comprise at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof.

[0012] In some method embodiments, the at least one Guerbet alcohol may have the structure: $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is an alkylene group containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon atoms. In some embodiments, the at least one Guerbet alcohol may be a β -branched saturated alcohol containing from 16 to 28 carbon atoms, for example, 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, or mixtures thereof.

[0013] In some method embodiments, the storage stability may be improved when the hydraulic oil composition is stored from 0 to -20 °C.

[0014] In some embodiments, uses of a compatibilizer that is a Guerbet alcohol to improve the storage stability and/or seals compatibility of a hydraulic oil composition are disclosed. Suitable Guerbet alcohols include those as described above. The uses may result in improved storage stability when the hydraulic oil composition is stored at 0 to -20 °C.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Various preferred features and embodiments will be described below by way of non-limiting illustration. Isoparaffinic hydrocarbon-based hydraulic fluids comprising Guerbet alcohols and having improved storage stability at both high and low temperatures

are disclosed. These compositions remain stable, even in the presence of Zn-free antiwear additives. In some embodiments, the hydraulic oil compositions may comprise: 60 to 97 wt% of an isoparaffinic hydrocarbon base oil; 0.5 to 5 wt% of a hydraulic oil additive package comprising at least one zinc-free antiwear additive; and 2 to 20 wt% (or 5 to 20 wt%, or 10 to 20 wt%) of at least one compatibilizer that is a Guerbet alcohol. The zinc-free antiwear additive may comprise at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof.

The Isoparaffinic Hydrocarbon Base Oil

[0016] Isoparaffins (or isoparaffinic oils) are saturated hydrocarbon compounds containing at least one hydrocarbyl branch, sufficient to provide fluidity to both very low and high temperatures. Isoparaffins of the invention include those produced by isomerization of predominantly linear hydrocarbons to produce branched hydrocarbons. Linear hydrocarbons may be naturally sourced, synthetically prepared, or derived from Fischer-Tropsch reactions or similar processes. Isoparaffins may be derived from hydro-isomerized wax and typically may be hydro-isomerized Fischer-Tropsch hydrocarbons or waxes. In one embodiment isoparaffinic oils may be prepared by a Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid oils.

[0017] Suitable isoparaffins may also be obtained from natural, renewable, sources. Natural (or bio-derived) oils refer to materials derived from a renewable biological resource, organism, or entity, distinct from materials derived from petroleum or equivalent raw materials. Natural sources of hydrocarbon oil include fatty acid triglycerides, hydrolyzed or partially hydrolyzed triglycerides, or transesterified triglyceride esters, such as fatty acid methyl ester (or FAME). Suitable triglycerides include, but are not limited to, palm oil, soybean oil, sunflower oil, rapeseed oil, olive oil, linseed oil, and related materials. Other sources of triglycerides include, but are not limited to algae, animal tallow, and zooplankton. Linear and branched hydrocarbons may be rendered or extracted from vegetable oils and hydro-refined and/or hydro-isomerized in a manner similar to the processes to produce isoparaffins, for example, the Fischer-Tropsch or other processes as described above.

[0018] Another class of isoparaffinic oils includes polyalphaolefins (PAO). Polyolefins are well known in the art. In one embodiment, the polyolefin may be derivable (or derived) from olefins with 2 to 24 carbon atoms. By derivable or derived, it is meant the polyolefin is polymerized from the starting polymerizable olefin monomers having the noted number of carbon atoms or mixtures thereof. In embodiments, the polyolefin may

be derivable (or derived) from olefins with 3 to 24 carbon atoms. In some embodiments, the polyolefin may be derivable (or derived) from olefins with 4 to 24 carbon atoms. In further embodiments, the polyolefin may be derivable (or derived) from olefins with 5 to 20 carbon atoms. In still further embodiments, the polyolefin may be derivable (or derived) from olefins with 6 to 18 carbon atoms. In still further embodiments, the polyolefin may be derivable (or derived) from olefins with 8 to 14 carbon atoms. In alternate embodiments, the polyolefin may be derivable (or derived) from olefins with 8 to 12 carbon atoms.

[0019] The hydraulic oil compositions include a major amount of an isoparaffinic hydrocarbon base oil. The base oil may be further defined as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines. Generally, the base oil may be in API Group IV (all polyalphaolefins, or PAO, such as PAO-2, PAO-4, PAO-5, PAO-6, PAO-7 or PAO-8, PAO-40, PAO-100, or any combination thereof), or it may be an API Group III base oil. API Group III base oils include high viscosity index (“VI”) paraffinic hydrocarbon oils that may be produced by several synthetic processes, such as gas to liquid (GTL) Fischer-Tropsch processes and hydroisomerization of linear paraffins. In some embodiments, the base oil may be a blend of base oils of different viscosities to obtain the desired viscosity for a particular lubrication application.

[0020] In a fully formulated hydraulic oil, the isoparaffinic base oil is generally present in a major amount (i.e., an amount greater than 50 percent by weight). Typically, the oil of lubricating viscosity is present in an amount of 75 to 98 percent by weight, and often greater than 80 percent by weight of the overall composition. In one embodiment, the hydraulic oil composition may comprise 60 to 97 wt% of an isoparaffinic hydrocarbon base oil.

[0021] In some embodiments, additional oils of lubricating viscosity, may also be present. These include other synthetic base oils besides the oils described above. Synthetic oils of lubricating viscosity include hydrocarbon oils such as polymerized and interpolymerised olefins (e.g., polybutylenes, polypropylenes, propyleneisobutylene copolymers); poly(1-hexenes), poly(1-octenes), poly(1-decenes), and mixtures thereof; alkyl-benzenes (e.g., dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di-(2-ethylhexyl)-benzenes); polyphenyls (e.g., biphenyls, terphenyls, alkylated polyphenyls); alkylated biphenyl ethers and alkylated biphenyl sulfides and the derivatives, analogs and homologs thereof or mixtures thereof.

[0022] Another synthetic oil of lubricating viscosity includes polyol esters other than the hydrocarbyl-capped polyoxyalkylene polyol as disclosed herein, dicarboxylic esters, liquid esters of phosphorus-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, and the diethyl ester of decane phosphonic acid), or polymeric tetrahydrofurans.

5 Synthetic conventional oil of lubricating viscosity also includes those produced by Fischer-Tropsch reactions and typically may be hydroisomerised Fischer-Tropsch hydrocarbons or waxes. In one embodiment, the oil of lubricating viscosity may be prepared by a Fischer-Tropsch gas-to-liquid synthetic procedure as well as other gas-to-liquid oils.

10 **[0023]** As used herein, the term “hydrocarbyl” refers to a group having a carbon atom directly attached to the remainder of the molecule, where the group includes at least carbon and hydrogen atoms. If the hydrocarbyl group comprises more than one carbon atom, then those carbons need not necessarily be linked to each other. For example, at least two of the carbons may be linked via a suitable element or group. In various
15 embodiments, the term “hydrocarbyl” refers to a group having a carbon atom directly attached to the remainder of the molecule, where the group consists of carbon, hydrogen, optionally one or more heteroatoms provided the heteroatoms do not alter the predominantly hydrocarbon nature of the substituent. The heteroatom may link at least two of the carbons in the hydrocarbyl group, and optionally no more than two non-hydrocarbon
20 substituents. Suitable heteroatoms will be apparent to those skilled in the art and include, for instance, sulphur, nitrogen, oxygen, phosphorus and silicon. Where the hydrocarbyl contains heteroatoms, optionally, no more than two heteroatoms will be present for every ten carbon atoms in the hydrocarbyl group. Suitable non-hydrocarbon substituents will also be apparent to those skilled in the art and include, for instance, halo, hydroxy,
25 alkoxy, mercapto, alkylmercapto, nitro, nitroso, and sulphony.

[0024] Examples of hydrocarbyls within the context of the present technology therefore include:

- (i) hydrocarbon groups selected from aliphatic (e.g. alkyl or alkenyl), alicyclic (e.g. cycloalkyl, cycloalkenyl, cycloalkadienyl), and aromatic groups;
- 30 (ii) substituted hydrocarbon groups, selected from hydrocarbon groups defined in (i) substituted with no more than two non-hydrocarbon substituents and/or one or more hydrocarbon substituents, the non-hydrocarbon substituents being selected from the group consisting of halo, hydroxy, alkoxy, mercapto, alkylmercapto, nitro, nitroso, and sulphony;

- (iii) hetero-containing hydrocarbon groups, selected from hydrocarbon groups defined in (i) containing one or more heteroatom in the ring or chain, provided that the group has no more than two heteroatoms present for every ten carbon atoms in the group, the heteroatoms being selected from sulphur, nitrogen, oxygen, phosphorus and silicon. The hetero-containing hydrocarbon groups may be substituted with no more than two non-hydrocarbon substituents and/or one or more hydrocarbon substituents.

[0025] In some embodiments, the term “hydrocarbyl” refers to a group having a carbon atom directly attached to the remainder of the molecule, where the group consists of carbon and hydrogen atoms.

[0026] In some embodiments, the additional oils of lubricating viscosity may include one or more non-synthetic base oils from the following API groups: Group I (sulfur content >0.03 percent by weight, and/or <90 percent by weight saturates, viscosity index 80-120); Group II (sulfur content ≤ 0.03 percent by weight and ≥ 90 percent by weight saturates, viscosity index 80-120); Group III (sulfur content ≤ 0.03 percent by weight and ≥ 90 percent by weight saturates, viscosity index ≥ 120).

[0027] In yet other embodiments, hydraulic oil may include additional oils of lubricating viscosity- that are not isoparaffinic, which may be in API Group V (which encompasses “all others”). The non-isoparaffinic base oils, if present will be present in a minor amount, such as 20, 10, 5, or even 1 percent by weight, of the total hydraulic oil composition. These additional oils of lubricating viscosity will generally not be present in amounts that significantly impact the properties or performance of the overall composition.

[0028] In still other embodiments, the total amount of the isoparaffinic base oil and any other non-isoparaffinic base oils, if present, may be from 60 to 97, or from 80 to 97, or even from 85 to 97 percent by weight. In some embodiments, the isoparaffinic base oil may have a viscosity grade of 2 to 10 cSt at 100°C. In some embodiments, the isoparaffinic hydrocarbon base oil may be a polyalphaolefin (PAO) and may comprise oligomers of 1-octene, 1-decene, 1-dodecene, 1-tetradecene 1-octadecene, 1- hexadecane, or mixtures thereof. In some embodiments, the hydraulic oil may comprise an API Group I, Group II, Group III base oil, or mixtures thereof, in addition to the isoparaffinic base oil, for example the base oil may comprise a PAO base oil in combination with a Group II base oil.

The Compatibilizer

[0029] The hydraulic oil compositions of the invention include a compatibilizer which includes one or more saturated alcohols. Suitable compatibilizers include linear and branched saturated alcohols, however in some embodiments the compatibilizer includes one or more branched saturated alcohols. In some embodiments, the compatibilizer is essentially free or, or even completely free of, linear saturated alcohols.

[0030] In some embodiments, the compatibilizer includes a branched, primary, saturated alcohol. In some embodiments, the compatibilizer is essentially free or, or even completely free of, unsaturated alcohols. In some embodiments, the compatibilizer is essentially free or, or even completely free of, secondary alcohols.

[0031] In some embodiments, the compatibilizer includes one or more a Guerbet alcohols. Guerbet alcohols may be described as alcohols made via the Guerbet reaction, which was named after Marcel Guerbet. In a Guerbet reaction, a primary aliphatic alcohol is converted to its β -alkylated dimer alcohol (i.e., a branched, primary, saturated alcohol).

[0032] Accordingly, in some embodiments, the hydraulic oil compositions disclosed herein have a compatibilizer comprising at least one Guerbet alcohol. The at least one Guerbet alcohol may have the structure: $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is a alkylene group containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon atoms. In some embodiments, n is zero, and R^2 and R^3 are alkyl groups, and R^4 is hydrogen. In such embodiments, R^2 and R^3 may contain from 4 to 14, or even from 6 to 12 carbon atoms. In still further embodiments, R^2 and R^3 contain 6 and 8, or 10 and 12 carbon atoms.

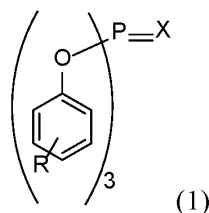
[0033] Suitable examples of the compatibilizers useful in the invention include 2-ethylhexanol, 2-butyloctanol, 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, or any combination thereof. These types of alcohols are commercially available from Sasol and marketed as ISOFOL[®] alcohols. In some embodiments, the at least one Guerbet alcohol may be a β -branched saturated alcohol containing from 16 to 28 carbon atoms, for example, 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, or mixtures thereof.

[0034] The compatibilizer may be present in the hydraulic oil composition at 2 percent by weight or more. In some embodiments, the compatibilizer is present from 2 to 20 or even 2 to 10 percent by weight in the hydraulic oil composition.

The Zinc-Free Antiwear Additive

[0035] In some embodiments, the treat rate of the at least one zinc-free antiwear additive in the hydraulic oil composition ranges from 50 ppm to 10,000 ppm (or 100 ppm to 5,000 ppm or 7,500 ppm) by mass. Suitable zinc-free antiwear additives may include any known phosphorous and/or sulfur based antiwear additive, for example, tartrates, tartrimides, oil soluble amine salts of phosphorus compounds, sulfurized olefins, phosphites (such as dibutyl or dioleoyl phosphite), phosphonates, thiocarbamate-containing compounds, such as thiocarbamate esters, thiocarbamate amides, thiocarbamic ethers, alkylene-coupled thiocarbamates, bis(S-alkyldithiocarbamyl) disulfides, and oil soluble phosphorus amine salts. In one embodiment, the metal-free phosphorous anti-wear agent comprises or consists of a (thio)phosphate ester. As used herein, the term (thio)phosphate ester should be understood to include phosphate esters, thiophosphate esters or mixtures thereof.

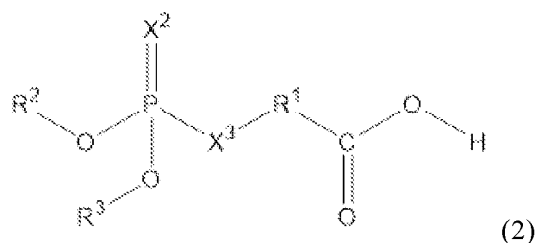
[0036] Phosphorus compounds usable in the present invention may include triaryl phosphate or triaryl thiophosphate represented by a formula (1) below:



[0037] In the formula (1), R is a hydrogen atom or an alkyl group having 3 to 9 carbon atoms, for example 3, 4, 5, 6, 7, 8, 9, or combinations thereof of carbon atoms and X is an oxygen atom or a sulfur atom. In the formula (1), the three R groups may be mutually the same or different. Examples of the alkyl group having 4 or less carbon atoms include a methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, isobutyl group and tertiary butyl group.

[0038] Examples of the phosphorus compound represented by the formula (1) include triphenyl phosphate, tricresyl phosphate, triphenyl thiophosphate, tricresyl thiophosphate, and butylated triphenyl phosphorothionate.

[0039] Another example of a phosphorous compound useful in the present invention is represented by a formula (2) below.



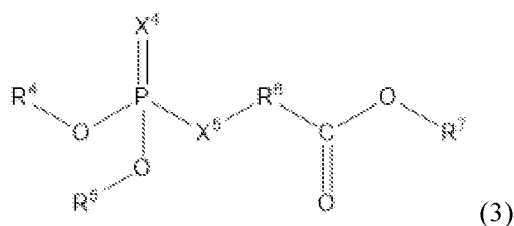
[0040] In the formula (2), R¹ represents a linear or branched alkylene group having 1 to 8 carbon atoms, R² and R³ each represent a hydrocarbon group having 3 to 20 carbon atoms, and X² and X³ each, independently, represent an oxygen atom or sulfur atom.

5 [0041] In one embodiment, R¹ may be a linear or branched alkylene group having 1 to 8 carbon atoms, more preferably a linear or branched alkylene group having 2 to 4 carbon atoms, and further preferably a branched alkylene group. Specifically, R¹ is preferably, for instance, —CH₂CH₂—, —CH₂CH(CH₃)—, —CH₂CH(CH₂CH₃)— or —CH₂CH(CH₂CH₂CH₃)—, and more preferably —CH₂CH(CH₃)— or —CH₂CH(CH₃)CH₂—.

10 [0042] In one embodiment, R² to R³ each preferably represent a linear or branched alkyl group having 3 to 8 carbon atoms, and more preferably a linear or branched alkyl group having 4 to 6 carbon atoms. Specifically, R² to R³ is each preferably selected from the group consisting of propyl, isopropyl, butyl, isobutyl, pentyl, isopentyl, hexyl, 2-ethylbutyl, 1-methylpentyl, 1,3-dimethylbutyl and 2-ethylhexyl groups.

[0043] In one embodiment, both X² and X³ represent oxygen atoms. In another embodiment, both X² and X³ represent sulfur atoms. In another embodiment, X² is oxygen and X³ is sulfur, and in another embodiment, X² is sulfur and X³ is oxygen.

20 [0044] Another phosphorous compound which may be useful in the present invention comprises a thiophosphate compound represented by a formula (3) below.



25 [0045] In the formula (3), R⁴, R⁵ and R⁷ are each independently a linear or branched saturated or unsaturated aliphatic hydrocarbon group having 1 to 18 carbon atoms or a branched or unbranched saturated or unsaturated cyclic hydrocarbon group having 5 to 18 carbon atoms. R⁶ is a linear or branched alkylene group having 1 to 8 carbon atoms,

X⁴ and X⁵ are each independently an oxygen atom or sulfur atom. In one embodiment of formula (3), at least one sulfur atom exists.

[0046] In one embodiment, both X⁴ and X⁵ represent oxygen atoms. In another embodiment, both X⁴ and X⁵ represent sulfur atoms. In another embodiment, X⁴ is oxygen and X⁵ is sulfur, and in another embodiment, X⁴ is sulfur and X⁵ is oxygen.

[0047] In one embodiment, the Zn-free anti-wear agent of the present invention may be selected from Methyl 3-((dialkoxyphosphorothioyl)thio)propanoate with mixed C4/C5 alkoxy groups, 3-((diisobutoxyphosphorothioyl)thio)-2-methylpropanoic acid, and mixtures thereof.

[0048] In some embodiments, the zinc-free antiwear additive may comprise at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof. In yet other embodiments, the hydraulic oil additive package may comprise at least two zinc-free antiwear additives, for example, at least one dithiophosphate ester, at least one alkyl dithiocarbamate, at least one phosphoric acid ester, at least one amine phosphate, or combinations thereof. In some embodiments the at least two zinc-free antiwear additives may comprise at least one dithiophosphate ester and at least one alkyl dithiocarbamate. In yet other embodiments, the at least two zinc-free antiwear additives may comprise at least one phosphoric acid ester and at least one amine phosphate.

Viscosity Modifier

[0049] The hydraulic fluid may also contain one or more viscosity modifiers. Any known viscosity modifier may be used. In one embodiment, the lubricating composition of the present invention is substantially free of or totally free of poly(meth)acrylates as viscosity modifiers. Viscosity modifiers (often referred to as viscosity index improvers) suitable for use in the invention include, but are not limited to, ethylene-olefin co-polymers (especially ethylene-propylene); maleic anhydride-styrene alternating copolymers and esters thereof, poly(alkylmethacrylates) (including random, block, linear, radial and star architectures), hydrogenated styrene-butadiene block copolymers hydrogenated styrene-isoprene radial and/or block copolymers, or mixtures thereof. Commercially available viscosity modifiers include EO/PO copolymers sold by The Lubrizol Corporation under the tradename LUCANT™ and a methacrylate polymer sold by The Lubrizol Corporation under the tradename Lubrizol® 7773.

[0050] The viscosity modifier may be present in the hydraulic oil composition at 0 to 10wt%, 0.5 wt % to 8 wt %, and 1 wt % to 6 wt % of the composition. In some embodiments, the viscosity modifier may be present in the hydraulic oil composition at 2 to 10 wt%, based on a total weight of the hydraulic oil composition.

5 Additional Hydraulic Oil Additives

[0051] The hydraulic fluid composition of the present invention may be in the form of a concentrate and/or a fully formulated lubricant. If the hydraulic fluid of the invention (comprising the additives disclosed herein) is in the form of a concentrate (which may be combined with additional oil to form, in whole or in part, a finished lubricant), the ratio of the of these
10 additives to the oil of lubricating viscosity and/or to diluent oil include the ranges of 1:99 to 99:1 by weight, or 80:20 to 10:90 by weight.

[0052] In addition to the specific additives described above, the hydraulic fluid compositions may also contain one or more additional other additives. In some embodiments the additional additives may include corrosion inhibitors, rust inhibitors, foam inhibitors, surfac-
15 tants, dispersants, demulsifiers, metal deactivators, friction modifiers, emulsifiers, extreme pressure agents, pour point depressants, viscosity modifiers, or any combination thereof.

[0053] In one embodiment, the fluid of the present invention contains a surfactant. In one embodiment, the surfactant is an ashless surfactant. Suitable surfactant may include substituted polyisobutenyl compounds. For examples, useful surfactants may include (i) polyeth-
20 eramines; (ii) succinimide dispersants; (iii) Mannich reaction products of a dialkylamine, an aldehyde and a hydrocarbyl substituted phenol; or any combination thereof. In some embodiments the surfactant may be present at 0 wt % or 0.01 wt % to 2.0 wt%, 0.025 wt% to 1.5 wt %, or 0.05 wt % to 1 wt %, or 0.05 wt % to 0.5 wt % of the overall composition. In one exemplary embodiment, the hydraulic fluid contains 0.025 wt % to 0.075 wt% of the surfac-
25 tant.

[0054] The surfactant used in the present invention may also comprise one or more dispersants. Dispersants which may be included in the composition include those with an oil soluble polymeric hydrocarbon backbone and having functional groups that are capable of associating with particles to be dispersed. The polymeric hydrocarbon backbone may have a
30 weight average molecular weight ranging from 750 to 1500 Daltons. Exemplary functional groups include amines, alcohols, amides, and ester polar moieties which are attached to the polymer backbone, often via a bridging group. Example dispersants include Mannich dispersants, described in U.S. Patent Nos. 3,697,574 and 3,736,357; ashless succinimide dispersants described in U.S. Patent Nos. 4,234,435 and 4,636,322; amine dispersants described in U.S.

Patent Nos. 3,219,666, 3,565,804, and 5,633,326; Koch dispersants, described in U.S. Patent Nos. 5,936,041, 5,643,859, and 5,627,259, and polyalkylene succinimide dispersants, described in U.S. Patent Nos. 5,851,965, 5,853,434, and 5,792,729.

5 [0055] In one embodiment, the surfactant comprises a polyisobutenyl succinimide, a polyisobutenyl succinimide derived from aromatic polyamine, or mixtures thereof.

[0056] Anti-foam agents, also known as foam inhibitors, are known in the art and include organic silicones and non-silicon foam inhibitors. Examples of organic silicones include dimethyl silicone and polysiloxanes. Examples of non-silicone foam inhibitors include copolymers of ethyl acrylate and 2-ethylhexylacrylate, copolymers of ethyl acrylate, 2-ethylhexylacrylate and vinyl acetate, polyethers, polyacrylates and mixtures thereof. In some embodiments the anti-foam is a polyacrylate. Antifoams may be present in the composition from 10 0.001 wt % to 0.012 wt % or 0.004 wt % or even 0.001 wt % to 0.003 wt %.

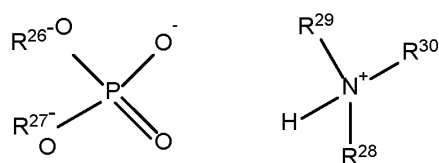
[0057] Demulsifiers are known in the art and include derivatives of propylene oxide, ethylene oxide, polyoxyalkylene alcohols, alkyl amines, amino alcohols, diamines or polyamines reacted sequentially with ethylene oxide or substituted ethylene oxides or mixtures thereof. 15 Examples of demulsifiers include polyethylene glycols, polyethylene oxides, polypropylene oxides, (ethylene oxide-propylene oxide) polymers and mixtures thereof. In some embodiments the demulsifiers is a polyether. In one embodiment, the demulsifier may be an oxyalkylated phenolic resin blend. Such a blend may comprise formaldehyde polymers with 4-nonylphenol, ethylene oxide and propylene oxide and formaldehyde polymers with 4-nonylphenol ethylene oxide. Demulsifier may be present in the composition from 20 0.002 wt % to 0.012 wt %.

[0058] Pour point depressants are known in the art and include esters of maleic anhydride-styrene copolymers, polymethacrylates; polyacrylates; polyacrylamides; condensation products of haloparaffin waxes and aromatic compounds; vinyl carboxylate polymers; and terpolymers of dialkyl fumarates, vinyl esters of fatty acids, ethylene-vinyl acetate copolymers, alkyl phenol formaldehyde condensation resins, alkyl vinyl ethers and mixtures thereof. 25

[0059] As used herein, the term "condensation product" is intended to encompass esters, amides, imides and other such materials that may be prepared by a condensation reaction of an acid or a reactive equivalent of an acid (e.g., an acid halide, anhydride, or ester) with an alcohol or amine, irrespective of whether a condensation reaction is actually performed to lead directly to the product. Thus, for example, a particular ester may be prepared by a transesterification reaction rather than directly by a condensation reaction. 30 The resulting product is still considered a condensation product.

[0060] The hydraulic fluid composition may also include a rust inhibitor. Suitable rust inhibitors include hydrocarbyl amine salts of alkylphosphoric acid, hydrocarbyl amine salts of dialkyldithiophosphoric acid, hydrocarbyl amine salts of hydrocarbyl aryl sulfonic acid, fatty carboxylic acids or esters thereof, an ester of a nitrogen-containing carboxylic acid, an ammonium sulfonate, an imidazoline, alkylated succinic acid derivatives reacted with alcohols or ethers, or any combination thereof, or mixtures thereof.

[0061] Suitable hydrocarbyl amine salts of alkylphosphoric acid may be represented by the following formula:



wherein R^{26} and R^{27} are independently hydrogen, alkyl chains or hydrocarbyl, typically at least one of R^{26} and R^{27} are hydrocarbyl. R^{26} and R^{27} contain 4 to 30, or 8 to 25, or 10 to 20, or 13 to 19 carbon atoms. R^{28} , R^{29} and R^{30} are independently hydrogen, alkyl branched or linear alkyl chains with 1 to 30, or 4 to 24, or 6 to 20, or 10 to 16 carbon atoms. R^{28} , R^{29} and R^{30} are independently hydrogen, alkyl branched or linear alkyl chains, or at least one, or two of R^{28} , R^{29} and R^{30} are hydrogen.

[0062] Examples of alkyl groups suitable for R^{28} , R^{29} and R^{30} include butyl, sec butyl, isobutyl, tert-butyl, pentyl, n-hexyl, sec hexyl, n-octyl, 2-ethyl, hexyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, octadecenyl, nonadecyl, eicosyl or mixtures thereof.

[0063] In one embodiment, the hydrocarbyl amine salt of an alkylphosphoric acid is the reaction product of a C_{14} to C_{18} alkylated phosphoric acid with Primene® 81R (produced and sold by Rohm & Haas) which is a mixture of C_{11} to C_{14} tertiary alkyl primary amines.

[0064] Hydrocarbyl amine salts of dialkyldithiophosphoric acid may include a rust inhibitor such as a hydrocarbyl amine salt of dialkyldithiophosphoric acid. These may be a reaction product of heptyl or octyl or nonyl dithiophosphoric acids with ethylene diamine, morpholine or Primene® 81R or mixtures thereof.

[0065] The hydrocarbyl amine salts of hydrocarbyl aryl sulfonic acid may include ethylene diamine salt of dinonyl naphthalene sulfonic acid.

[0066] Examples of suitable fatty carboxylic acids or esters thereof include glycerol monooleate and oleic acid.

[0067] The rust inhibitors may be present in the range from 0 or 0.02 wt % to 0.2 wt %, from 0.03 wt % to 0.15 wt %, from 0.04 wt % to 0.12 wt %, or from 0.05 wt % to 0.1 wt % of the lubricating oil composition. The rust inhibitors may be used alone or in mixtures thereof.

5 [0068] The hydraulic fluid may also contain a metal deactivator. Metal deactivators may be chosen from derivatives of benzotriazole, 1,2,4-triazole, benzimidazole, 2-alkyldithiobenzimidazole, 2-alkyldithiobenzothiazole, or dimercaptothiadiazone. Examples of such derivatives include 2,5-dimercapto-1,3,4-thiadiazone, or oligomers thereof, a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazone, a hydrocarbylthio-substituted 2,5-dimercapto-1,3,4-thiadiazone, or oligomers thereof. The oligomers of hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazone typically form by forming a sulfur-sulfur bond between 2,5-dimercapto-1,3,4-thiadiazone units to form oligomers of two or more of said thiadiazone units. Examples of a suitable thiadiazone compound include at least one of a dimercaptothiadiazone, 2,5-dimercapto-[1,3,4]-thiadiazone, 3,5-dimercapto-[1,2,4]-thiadiazone, 3,4-dimercapto-[1,2,5]-thiadiazone, or 4-5-dimercapto-[1,2,3]-thiadiazone. Typically, readily available materials such as 2,5-dimercapto-1,3,4-thiadiazone or a hydrocarbyl-substituted 2,5-dimercapto-1,3,4-thiadiazone or a hydrocarbylthio-substituted 2,5-dimercapto-1,3,4-thiadiazone are commonly utilized. In different embodiments the number of carbon atoms on the hydrocarbyl-substituent group includes 1 to 30, 2 to 25, 4 to 20, 6 to 16, or 8 to 10. The 2,5-dimercapto-1,3,4-thiadiazone may be 2,5-dioctyl dithio-1,3,4-thiadiazone, or 2,5-dinonyl dithio-1,3,4-thiadiazone. The metal deactivators may also be described as corrosion inhibitors.

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[0069] The metal deactivators may be present in the range from 0 or 0.001 wt % to 0.1 wt %, from 0.01 wt % to 0.04 wt % or from 0.015 wt % to 0.03 wt % of the lubricating oil composition. Metal deactivators may also be present in the composition from 0.002 wt % or 0.004 wt % to 0.02 wt %.

25

[0070] In one embodiment, the hydraulic fluid disclosed herein may contain at least one friction modifier. The friction modifier may be present at 0 wt % to 3 wt %, or 0.02 wt % to 2 wt %, or 0.05 wt % to 1 wt %, of the lubricant composition.

[0071] As used herein the term “fatty alkyl” or “fatty” in relation to friction modifiers means a carbon chain having 8 to 22 carbon atoms, typically a straight carbon chain. Alternatively, the fatty alkyl may be a mono branched alkyl group, with branching typically at the β -position. Examples of mono branched alkyl groups include 2-ethylhexyl, 2-propylheptyl or 2-octyldodecyl.

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[0072] Examples of suitable friction modifiers 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 phosphonates; fatty phosphites; borated phospholipids, borated fatty epoxides; glycerol esters; borated glycerol esters; fatty amines; alkoxylated fatty amines; borated alkoxylated fatty amines; hydroxyl and polyhydroxy fatty amines; hydroxy alkyl amides; metal salts of fatty acids; metal salts of alkyl salicylates; fatty oxazolines; fatty ethoxylated 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.

[0073] Accordingly, in some embodiments, the hydraulic oil additive package further comprises at least one rust and/or corrosion inhibitor, foam inhibitors, friction modifiers, antioxidant, demulsifier, surfactant, dispersant, or combinations thereof. In one embodiment, all of the additives used in the lubricating composition may be ashless. In another embodiment, the lubricating composition may be free of additives that contain transition metals. In still another embodiment, the lubricating composition may contain additives where calcium is the only metal.

Industrial Application

[0074] In accordance with one aspect of the exemplary embodiment, the hydraulic fluid is for use in a hydraulic system, turbine system or other circulating oil system. The hydraulic system may be a device or apparatus in which the hydraulic fluid transmits energy to different parts of the system by hydraulic force. A turbine lubricant is typically used to lubricate the gears or other moving parts of a turbine (or turbine system), such as a steam turbine or a gas turbine. A circulating oil is typically used to distribute heat to or through a device or apparatus through which it is circulated.

[0075] Viscosity grades generally suitable for hydraulic oils are ISO 10, 15, 22, 32, 46, 68, 100 and 150 (cSt). The viscosity of each grade is the kinematic viscosity at 40 °C +/-10% as measured by ASTM D445 or ISO 3104. As such, an ISO 46 is 46cSt at 40 °C may have a kinematic viscosity of 41.4 – 50.6 cSt at 40 °C. The ISO viscosity classification system is defined in ISO 3448. Exemplary viscosity grades are listed in the table below:

Viscosity grade (ISO 3448)	...	VG 10	VG 15	VG 22	VG 32	VG 46	VG 68	VG 100	VG 150
Kinematic viscosity at 40 °C: minimum/maximum	mm ² /s	9.00 ~ 11.0	13.5 ~ 16.5	19.8 ~ 24.2	28.8 ~ 35.2	41.4 ~ 50.6	61.2 ~ 74.8	90.0 ~ 110	135 ~ 165

[0076] Accordingly, in some embodiments, the lubricating composition may have an ISO viscosity grade (VG) of 10, 15, 22, 32, 46, 68, 100 or 150 (cSt) grade lubricant. In yet other embodiments, the lubricating composition may have an ISO VG of 22 cSt, 32 cSt, 46 cSt, or 68 cSt.

5 [0077] Methods of improving the storage stability and/or seals compatibility of a hydraulic oil composition are also disclosed. The methods may comprise adding to the hydraulic oil composition 2 to 20 wt% (or 5 to 20 wt%, or 10 to 20 wt%) of at least one compatibilizer that is a Guerbet alcohol, based on a total weight of the hydraulic oil composition. In some embodiments, the hydraulic oil composition may comprise: 60 to
10 97 wt% of an isoparaffinic hydrocarbon base oil; and 0.5 to 20 wt% of a hydraulic oil additive package comprising at least one zinc-free antiwear additive. The zinc-free antiwear additive may comprise at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof.

[0078] In some method embodiments, the at least one Guerbet alcohol may have the
15 structure: $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is a alkylene group containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon atoms. In some embodiments, the at least one Guerbet alcohol may be a β -branched saturated alcohol containing from 16 to 28 carbon atoms, for example, 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-
20 dodecylhexadecanol, or mixtures thereof.

[0079] In some method embodiments, the storage stability may be improved when the hydraulic oil composition is stored from 0 to -20 °C.

[0080] In some embodiments, uses of a compatibilizer that is a Guerbet alcohol to improve the storage stability and/or seals compatibility of a hydraulic oil composition are
25 disclosed. Suitable Guerbet alcohols include those as described above. The uses may result in improved storage stability when the hydraulic oil composition is stored at 0 to -20 °C.

[0081] 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. However, unless other-
30 wise indicated, each 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.

[0082] It is known that some of the materials described above may interact in the 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. 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.

[0083] The compositions disclosed herein are useful as hydraulic oils and have improved storage stability in the presence of Zn-free antiwear additives, which may be better understood with reference to the following examples.

EXAMPLES

[0084] Two different additive packages, Package A and Package B, suitable for use in a hydraulic oil were prepared. The additive package compositions are provided in Table 1 below.

Table 1

Functional Type	Chemistry Type	Package A (wt%)	Package B (wt%)
Diluent Oil	Mineral oil	1.35	-
	Synthetic Ester	-	1.37
Antiwear	Dithiophosphate Ester Blend	7.06	-
	Alkyl Dithiocarbamate	5.88	-
	Phosphoric Acid Ester	-	40
	Amine Phosphate	-	0.8
Friction Modifier	Glycerol monooleate	11.77	-
Other Additives*	See note	73.94	57.83

* Both additive packages had one or more antioxidants, antifoams, demulsifiers, and corrosion or rust inhibitors. Package A also had a surfactant/filterability aid and a dispersant.

[0085] The additive packages were then blended with isoparaffinic base oils and other lubricant components to make a finished hydraulic oil. Some of the finished hydraulic oils also contained a Guerbet alcohol (2-octyldodecanol) available as ISO FOL 20 from Sasol, South Africa. All the finished hydraulic oils were evaluated for stability. The stability evaluation is a visual assessment of the clarity of the hydraulic oil. The assessment is made by placing a sample of the hydraulic oil in a clear glass test tube and holding the

test tube in front of a clear tubular light bulb (40 Watts, Sylvania 40T10 or equivalent). A lack of clarity indicates that various components are unstable in the hydraulic oil and not staying in solution.

[0086] For the stability tests, approximately 30mL of each sample is added to four different test tubes (60mL EPA sample vials with a screw top available from VWR International or equivalent) for storage at different temperatures. One test tube is measured immediately for stability and kept at room temperature (RT). The remaining three test tubes are placed in a temperature-controlled environment and maintained at 65°C, 0°C, and -18°C respectively. The stability of the test tubes maintained at RT, 0°C, and -18°C samples is visually assessed at 1, 2, 3, and 4 weeks. The test tubes of the 0°C, and -18°C and the 65°C samples are allowed to come to room temperature for 2 hours before making the visual assessment. After the assessment, they're placed back in the temperature-controlled environment for storage. The test tube maintained at 65°C is visually assessed at 1, 2, and 3 weeks and placed back into the temperature-controlled environment after the assessments at weeks 1 and 2. After the assessment at week 3, the test tube is maintained at room temperature and then visually assessed at week 4.

[0087] First, the bottoms of the test tubes are checked for sediment. If there is no apparent sediment visible on the bottom, the tube is inverted slightly past horizontal for approximately 15 seconds and the bottom of the tube is inspected again. The clarity of the tests tubes is visually rated and recorded in coded form. The codes, description and definitions of the clarity ratings are provided in Table 2 below.

Table 2 - Storage Stability Rating Table

Code	Description	Definition
C	Clear	The filament of the light bulb can be seen through the sample with no distortion of the filament. No signs of instability.
Z1	Slightly Hazy	Slight distortion of light filament.
Z2	Hazy	Light is able to pass through the sample, the filament may be visible (glow stick appearance).
S1	Slight trace	Sediment only becomes visible after inversion i.e. ghosting effect.
S2	Trace sediment	This is any amount of sediment that is visible on the tube bottom without fully covering the bottom. The tube may need to be inverted due to clarity/color/viscosity of the sample.
S4	Heavy sediment	Sediment over 1/16 inch (2mm)
N1	Fine Suspension	Fine particles can be seen throughout the sample or when tilted/inverted.
N2	Suspension	More obvious larger particles can be seen throughout the sample.

X	Crystallized	Crystals of any size are observed suspended in the fluid or on the tube bottom. They are jaggy and have an ice-like appearance.
G1	Light gel	A portion of the sample has gel or jelly like appearance and texture. The gel may be dispersed throughout the sample as fine globules, present at the bottom of tube or cling to the walls.
G2	Gel	Clumpy, jelly like appearance and texture, sometimes dry and crackly when inverted. (Tends to stretch or break off after inversion).
DM	Solid	More than half of the sample does not flow within 30 seconds of being inverted.
F	Flocculent	Contains cloud like or cotton ball (wool) particles which are randomly suspended in the sample.

[0088] The hydraulic oil compositions with Package A and their storage stability results are provided in Table 2 below.

5 Table 2

Formula (wt%)	EX 1	EX 2	EX 3	EX 4	EX 5	EX 6	EX 7	EX 8	EX 9	EX 10
Base Oil A ¹	82.15	72.15	97.15	95.15	92.15	87.15	-	-	96.15	86.15
Base Oil B ²	-	-	-	-	-	-	97.15	87.15	-	-
Group II oil	17	17	-	-	-	-	-	-	-	-
VM A ³	-	-	2	2	2	2	2	2	-	-
VM B ⁴	-	-	-	-	-	-	-	-	3	3
Guerbet alcohol	-	10	-	2	5	10	-	10	-	10
Package A	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Stability										
RT (initial)	C	C	C	C	C	C	C	C	C	C
1 week										
65°C	C	C	C	C/S1	C/S1	C	C/S1	C	C/S1	C
RT	C	C	C	C	C	C	C	C	C	C
0°C	C/F	C	C/S1	C	C	C	C	C	C	C
-18°C	S1/F	C	C	C	C	C	C	C	C	C
2 weeks										
65°C	C	C	C	C/S1	C/S1	C	C/S1	C	C/S1	C
RT	C	C	C	C	C	C	C/S1/ F	C	C/S1	C
0°C	Z1/F	C	C/S2	C	C	C	C/F	C	C	C
-18°C	Z1/F	C	C/S1	C	C	C	C	C	C/S1	C
3 weeks										
65°C	-	C	C	C/S1	C/S1	C	C/S1	C	C/S1	C
RT	-	C	C	C	C	C	C/S1/ F	C	C/S1	C
0°C	-	C	C/S2/ F	C	C	C	C/F	C	C/S1	C
-18°C	-	C	C/S1	C	C	C	C/S1/ N1	C	C/S1	C
4 weeks										
65°C	C	C	C	C/S1	C/S1	C	C/S1	C	C/S1	C
RT	C	C	C	C	C/S1	C/S1	C/S1/ F	C	C/S1	C

0°C	Z1/F	C	C/S2/ F	C	C	C	C/S1/ F	C	C/S1/ F	C
-18°C	Z1/F	C	C/S1	C	C	C	C/S1/ N1	C	C/S1	C

1 – Base Oil A is an isoparaffinic hydrocarbon base oil manufactured from renewable materials with a kinematic viscosity of 5.4 at 100°C, available as Novvi EL 26 from Novvi, LLC.

2 – Base Oil B is a polydecene (PAO) with a kinematic viscosity of 6.0 at 100°C, available from Chevron.

5 3 – VM A is a viscosity modifier that is an EO/PO copolymer sold by The Lubrizol Corporation under the tradename LUCANT™.

4 – VM B is a viscosity modifier that is methacrylate polymer sold by The Lubrizol Corporation under the tradename LUBRIZOL® 7773.

10 **[0089]** As shown in Table 2 above, the addition of a Guerbet alcohol improves the storage stability of the lubricant compositions at all temperatures. This improvement can be seen even at 2 wt% of the Guerbet alcohol. Further, the addition of viscosity modifiers may also contribute to instability of the finished lubricant, but the Guerbet alcohol improves the stability of the lubricant compositions, even when a viscosity modifier is present.

[0090] The hydraulic oil compositions with Package B are provided in Table 3 below.

Table 3

Component (wt%)	EX 11	EX 12	EX 13	EX 14
Base Oil A ¹	96.75	94.75	91.75	86.75
VM A ³	2	2	2	2
Guerbet alcohol	-	2	5	10
Package B	1.25	1.25	1.25	1.25
Stability				
RT (initial)	Z1	C	C	C
1 week				
65°C	Z1	C	C	C
RT	Z1	C	C	C
0°C	Z1/S1	C	C	C
-18°C	Z1	C	C	C
2 weeks				
65°C	Z2	C	C	C
RT	Z1	C	C	C
0°C	Z1/S1	C	C	C
-18°C	Z1/S1	C	C	C
3 weeks				
65°C	Z2	C	C	C
RT	Z1	C	C	C
0°C	Z1/S1	C	C	C
-18°C	Z1/S1	C	C	C
4 weeks				
65°C	Z2	C/S1	C	C
RT	Z1	C	C	C
0°C	Z1/S2	C	C	C
-18°C	Z1/S1	C	C	C

1 – Base Oil A is an isoparaffinic hydrocarbon base oil manufactured from renewable materials with a kinematic viscosity of 5.4 at 100°C, available as Novvi EL 26 from Novvi, LLC.

3 – VM A is a viscosity modifier that is an EO/PO copolymer sold by The Lubrizol Corporation under the tradename LUCANT™.

5 [0091] As shown in Table 3 above, the addition of a Guerbet alcohol improves the storage stability of the lubricant compositions at all temperatures. This improvement can be seen even at 2 wt% of the Guerbet alcohol. The Guerbet alcohol improves the stability of the lubricant compositions even when a viscosity modifier is present.

10 [0092] Each of the documents referred to above is incorporated herein by reference, including any prior applications, whether or not specifically listed 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
15 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 amounts for each element of the invention can be used together with ranges or amounts for any of the other elements.

[0093] As used herein, the transitional term "comprising," which is synonymous with
20 "including," "containing," or "characterized by," is inclusive or open-ended and does not exclude additional, un-recited elements or method steps. However, in each recitation of "comprising" herein, it is intended that the term also encompass, as alternative embodiments, the phrases "consisting essentially of" and "consisting of," where "consisting of" excludes any element or step not specified and "consisting essentially of" permits
25 the inclusion of additional un-recited elements or steps that do not materially affect the basic and novel characteristics of the composition or method under consideration.

[0094] While certain representative embodiments and details have been shown for the purpose of illustrating the subject invention, it will be apparent to those skilled in this art that various changes and modifications can be made therein without departing
30 from the scope of the subject invention. In this regard, the scope of the invention is to be limited only by the following claims.

1. A hydraulic oil composition comprising:
 - a. 60 to 97 wt% of an isoparaffinic hydrocarbon base oil;
 - b. 0.5 to 5 wt% of a hydraulic oil additive package comprising at least one
5 zinc-free antiwear additive;
 - c. 2 to 20 wt% (or 5 to 20 wt%, or 10 to 20 wt%) of at least one compati-
bilizer that is a Guerbet alcohol; andwherein the zinc-free antiwear additive comprises at least one dithiophosphate
10 ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mix-
tures thereof.
2. The hydraulic oil composition of claim 1, wherein the at least one Guerbet al-
cohol has the structure: $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is a alkylene group
containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and
15 R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon
atoms.
3. The hydraulic oil composition of claim 1 or 2, wherein the at least one Guerbet
alcohol is a β -branched saturated alcohol containing from 16 to 28 carbon at-
oms.
4. The hydraulic oil composition of any of the above claims, wherein the at least
20 one Guerbet alcohol is 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol,
2-dodecylhexadecanol, or mixtures thereof.
5. The hydraulic oil composition of any of the above claims, wherein the treat rate
of the at least one zinc-free antiwear additive in the hydraulic oil composition
ranges from 50 ppm to 10,000 ppm (or 100 ppm to 5,000 ppm or 7,500 ppm) by
25 mass of the total weight of the hydraulic oil composition.
6. The hydraulic oil composition of any of the above claims, wherein the hydrau-
lic oil additive package comprises at least two zinc-free antiwear additives, for
example, at least one dithiophosphate ester, at least one alkyl dithiocarbamate,
at least one phosphoric acid ester, at least one amine phosphate, or combina-
30 tions thereof.

7. The hydraulic oil composition of claim 6, wherein the hydraulic oil additive package comprises at least one dithiophosphate ester and at least one alkyl dithiocarbamate.
8. The hydraulic oil composition of claim 6, wherein the hydraulic oil additive package comprises at least one phosphoric acid ester and at least one amine phosphate.
9. The hydraulic oil composition of any of the above claims, further comprising 2 to 10 wt% of viscosity modifier.
10. The hydraulic oil composition of any of the above claims, wherein the viscosity modifier comprises at least one ethylene-olefin co-polymer (especially ethylene-propylene); maleic anhydride-styrene alternating copolymers and esters thereof, poly(alkylmethacrylates) (including random, block, linear, radial and star architectures), hydrogenated styrene-butadiene block copolymers, hydrogenated styrene-isoprene radial and/or block copolymers, or mixtures thereof.
11. The hydraulic oil composition of any of the above claims, wherein the hydraulic oil additive package further comprises at least one rust and/or corrosion inhibitor, foam inhibitors, friction modifiers, antioxidant, demulsifier, surfactant, dispersant, or combinations thereof.
12. The hydraulic oil composition of any of the above claims, wherein the isoparaffinic hydrocarbon base oil has a viscosity grade of 2 to 10 cSt at 100°C.
13. The hydraulic oil composition of any of the above claims, wherein the isoparaffinic hydrocarbon base oil comprises a polyalphaolefin (PAO) derived from 1-octene, 1-decene, 1-dodecene, 1-tetradecene, 1-octadecene, 1-hexadecane, or mixtures thereof.
14. The hydraulic oil composition of any of the above claims, wherein the isoparaffinic hydrocarbon based oil comprises an isoparaffin obtained from fatty acid triglycerides, hydrolyzed or partially hydrolyzed triglycerides, transesterified triglyceride esters, such as fatty acid methyl ester, or mixtures thereof.
15. The hydraulic oil composition of any of the above claims, further comprising an API Group I, Group II, Group III base oil, or mixtures thereof.

16. A method of improving the storage stability and/or seals compatibility of a hydraulic oil composition, wherein the hydraulic oil composition comprises:
- a. 60 to 97 wt% of an isoparaffinic hydrocarbon base oil;
 - b. 0.5 to 20 wt% of a hydraulic oil additive package comprising at least one zinc-free antiwear additive;
- wherein the zinc-free antiwear additive comprises at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof;
- wherein the method comprises adding to the hydraulic oil composition 2 to 20 wt% (or 5 to 20 wt%, or 10 to 20 wt%) of at least one compatibilizer that is a Guerbet alcohol, based on a total weight of the hydraulic oil composition.
17. The method of claim 16, wherein the at least one Guerbet alcohol has the structure: $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is a alkylene group containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon atoms.
18. The method of claim 16 or 17, wherein the at least one Guerbet alcohol is a β -branched saturated alcohol containing from 16 to 28 carbon atoms.
19. The method of any claim 16 to 18, wherein the at least one Guerbet alcohol is 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, or mixtures thereof.
20. The method of any claim 16 to 19, wherein the storage stability is improved when the hydraulic oil composition is stored from 0 to -20 °C.
21. The use of a compatibilizer that is a Guerbet alcohol to improve the storage stability and/or seals compatibility of a hydraulic oil composition, wherein the hydraulic oil composition comprises:
- a. 60 to 97 wt% of an isoparaffinic hydrocarbon base oil;
 - b. 0.5 to 20 wt% of a hydraulic oil additive package comprising at least one zinc-free antiwear additive;
- wherein the zinc-free antiwear additive comprises at least one dithiophosphate ester, alkyl dithiocarbamate, phosphoric acid ester, amine phosphate, or mixtures thereof.

22. The use of claim 21, wherein the at least one Guerbet alcohol has the structure:
 $\text{HO-CH}_2\text{-(R}^1\text{)}_n\text{-CR}^2\text{R}^3\text{R}^4$ where R^1 is a alkylene group containing from 1 to 20 carbon atoms, n is either 0 or 1, and each of R^2 , R^3 and R^4 are independently hydrogen or alkyl groups containing from 1 to 20 carbon atoms.
- 5 23. The use of claim 21 or 22, wherein the at least one Guerbet alcohol is a β -branched saturated alcohol containing from 16 to 28 carbon atoms.
24. The use of any claim 21 to 23, wherein the at least one Guerbet alcohol is 2-hexyldecanol, 2-octyldodecanol, 2-decyltetradecanol, 2-dodecylhexadecanol, or mixtures thereof.
- 10 25. The use of any claim 21 to 24, wherein the storage stability is improved when the hydraulic oil composition is stored at 0 to -20 °C.