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Wu et al.(10) **Pub. No.: US 2012/0264665 A1**(43) **Pub. Date: Oct. 18, 2012**(54) **LUBRICANT BLENDS WITH PAO-BASED
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COMPANY**, Annandale, NJ (US)(21) Appl. No.: **13/444,208**(22) Filed: **Apr. 11, 2012****Related U.S. Application Data**(60) Provisional application No. 61/474,912, filed on Apr.
13, 2011.**Publication Classification**(51) **Int. Cl.****C10M 149/22** (2006.01)**C10M 145/22** (2006.01)(52) **U.S. Cl. 508/277; 508/287; 508/551; 508/463;
508/269**

(57)

ABSTRACT

Provided is a lubricant blend including one or more lubricant base stocks and one or more dispersants. The dispersant is chosen from a polyalphaolefin succinimide, a polyalphaolefin succinamide, a polyalphaolefin acid ester, a polyalphaolefin oxazoline, a polyalphaolefin imidazoline, a polyalphaolefin succinamide imidazoline, and combinations thereof. The one or more dispersants are present at 2 to 20 wt % based on the total weight of the blend. The one or more dispersants and the one or more lubricant base stocks are together present at 8 wt % or more of the total weight of the blend. Provided is also a process for making the lubricant blend and a method for the service life of a lubricant.

LUBRICANT BLENDS WITH PAO-BASED DISPERSANTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is a non-provisional application that claims priority to U.S. Provisional Patent Application No. 61/474,912 filed on Apr. 13, 2011, herein incorporated by reference in its entirety.

FIELD

[0002] The present disclosure relates to lubricant blends including dispersants. The present disclosure further relates to lubricant blends exhibiting desirable viscosity properties.

BACKGROUND

[0003] Dispersants have been employed in lubricant and fuel formulations to provide protection against and to stabilize dirt and sludge that accumulate in the formulations during ordinary use. Dispersants typically have hydrophilic heads and hydrophobic tails and exhibit the properties of surfactants. The hydrophilic heads have an affinity for dirt and sludge, while the hydrophobic tails have an affinity for the base stocks of the lubricant and fuel formulations.

[0004] Conventional dispersants most often used in lubricant or fuel formulations have been the type prepared by functionalizing polyisobutylene (PIB) of varying molecular weights with maleic anhydride followed by reaction with polyamines [Lubricant additives, Chemistry and Applications, by L. R. Rudnick, 2003 Marcel Dekker, Inc. New York, NJ 10016]. These dispersants work well for conventional lubricant and fuel formulations. In many automotive engine lubricant formulations, 3 to 10 wt % of dispersant has typically been used, the highest amount of all additives used in such formulations.

[0005] New lubricants are needed to meet higher automobile fuel economy standards, longer oil drain intervals, and greater operating severity. This need may require the use of even higher levels of dispersants and/or lower lubricant base stock viscosity. The use of higher levels of PIB-based dispersants, however, may significantly increase the viscosity of lubricant formulations and render it difficult to attain lower motor oil viscosity grades, e.g., 0W20 and 0W30. Lower viscosity grades for motor oil are particularly important in meeting fuel economy guidelines.

[0006] An alternative to increasing dispersant levels is to use lower viscosity base stocks. However, the use of such lower viscosity base stocks can result in higher volatility (loss of oil) and reduced lubricant oil film and wear protection on internal engine surfaces.

[0007] Thus, there is a need for a dispersant that provides lubricant formulations with effective protection against the effects of dirt and sludge accumulation. There is also a need for a dispersant that provides lubricant formulations with such protection without significant increase in a required amount of dispersant and/or formulation viscosity.

SUMMARY

[0008] According to the present disclosure, there is provided a lubricant blend. The blend has one or more lubricant base stocks and a dispersant. The dispersant is selected from the group consisting of a polyalphaolefin succinimide, a polyalphaolefin succinamide, a polyalphaolefin acid ester, a poly-

alphaolefin oxazoline, a polyalphaolefin imidazoline, a polyalphaolefin succinamide imidazoline, and combinations thereof. The one or more dispersants are present at 2 to 20 wt % based on the total weight of the blend. The one or more dispersants and the one or more lubricant base stocks are together present at 85 wt % or more of the total weight of the blend.

[0009] Further according to the present disclosure, there is provided a process for making a lubricant blend. The process has the step of admixing an amount of the one or more lubricant base stocks and the amount of the dispersant described above in the proportions described above.

[0010] Still further according to the present disclosure, there is provided a method for lengthening the service life of a lubricant. The method has the steps of admixing with an amount of the one or more lubricant base stocks and the amount of the dispersant described above in the proportions described above, and utilizing the lubricant formulation as an oil or grease in a device or apparatus requiring lubrication of moving and/or interacting mechanical parts, components, or surfaces.

[0011] According to the present disclosure, there is provided a lubricant blend provided by a process. The blend is produced by admixing one or more lubricant base stocks with a dispersant produced by a process of reacting (A) a polyalphaolefin with a polyamine to yield a polyalphaolefin succinimide and/or a polyalphaolefin succinamide and/or polyalphaolefin succinamide-imidazoline, or (B) a polyalphaolefin with an alcohol or polyol to yield a succinic acid ester or (C) a polyalphaolefin with an amino alcohol to yield a polyalphaolefin amide-oxazoline. The dispersant is 2 to 20 wt % based on the total weight of the blend. The dispersant and the one or more lubricant base stocks are together present at 85 wt % or more of the total weight of the blend.

DETAILED DESCRIPTION

[0012] All numerical values within the detailed description and the claims herein are modified by "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

[0013] The polyalphaolefin succinimide (PAO-imide), polyalphaolefin succinamide (PAO-amide), and/or polyalphaolefin succinic acid ester (PAO-ester), polyalphaolefin oxazoline, and polyalphaolefin imidazoline dispersant disclosed herein provides lubricant formulations with effective and enhanced protection against dirt and sludge such that automobile oil drain intervals can be lengthened and severe operation maintained. The dispersant provides enhanced protection without need for substantial increase in amount employed. The dispersant provides enhanced stabilization of dirt and sludge without substantial increase in viscosity, including without substantial increase in kinematic viscosity at 40° C. and 100° C. The dispersant provides improved low temperature properties, such as improvement of CCS performance at -15° C. to -40° C. and improvement of low temperature kinematic viscosities at less than -15° C.

[0014] The dispersants can be synthesized to have similar amounts of nitrogen content and similar degree of dispersancy as conventional PIB-imide, PIB-amide and PIB-ester dispersants. The dispersants provide an easier and broader formulation window to reach fuel-efficient viscosity grades and/or the use of more conventional base stocks of higher viscosity and provide in better overall performance. PAO also

reacts faster with maleic anhydride than does PIB and affords a greater degree of functionalization.

[0015] Polyalphaolefins (PAO) useful as feedstock in forming the dispersants are those derived from oligomerization or polymerization of ethylene, propylene, and α -olefins. Suitable α -olefins include 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tetradecene, and 1-octadecene. Feedstocks containing a mixture of two or more of the foregoing monomers as well as other hydrocarbons are typically employed when manufacturing PAOs commercially. The PAO may take the form of dimers, trimers, tetramers, polymers, and the like.

[0016] The PAO used to prepare PAO-based dispersants may have a M_w (weight-average molecular weight) of 450 to 24,000, preferably 600 to 20,000, preferably 600 to 18,000, preferably 600 to 16,000, preferably 600 to 14,000, preferably 600 to 7,500, and most preferably 600 to 4,000. The PAO may have a M_n (number-average molecular weight) of 280 to 12,000, preferably 400 to 10,000, preferably 500 to 9,000, preferably 500 to 7,500, preferably 500 to 6,000, preferably 500 to 4,400, preferably 400 to 1,000, and most preferably 400 to 800. The PAO may have a M_w/M_n or molecular weight distribution of 1.1 to 3.0, preferably 1.2 to 2.5, and most preferably 1.3 to 2.2. The molecular weights of the PAO were measured by a gel permeation chromatograph equipped with universal column and calibrated with commercial polystyrene GPC standard of very narrow molecular weight distribution. The PAO may have a 100° C. kinematic viscosity measured of 2 cSt to 1,000 cSt, preferably 3 cSt to 800 cSt, preferably 4 cSt to 600 cSt, preferably 5 cSt to 450 cSt, preferably 5 cSt to 300 cSt, preferably 5 cSt to 150 cSt, preferably 4 cSt to 40 cSt, and preferably 4 cSt to 20 cSt. The PAO may have a 40° C. kinematic viscosity measured of 4 cSt to 12,000 cSt, preferably 10 cSt to 1,000 cSt, preferably 20 cSt to 8,000 cSt, preferably 20 cSt to 6,000 cSt, preferably 20 cSt to 4,000 cSt, preferably 20 cSt to 2,000 cSt, and most preferably 4 cSt to 250 cSt. The PAO may have a viscosity index of 70 to 350, preferably 80 to 300, preferably above 100, preferably above 150, preferably above 170, preferably above 200, and most preferably 120 to 300. The PAO may have a pour point as measured by ASTM D97 method or equivalent method of less than 0° C., or preferably less than -15° C., or less than -25° C., or less than -35° C., or less than -40° C. Usually, it is preferred to use PAO that has low pour point and high VI as starting material for the synthesis of dispersant to ensure a final product with optimum viscometric properties.

[0017] The PAO is preferably prepared by oligomerization or polymerization in the presence of an activated metallocene catalyst. Manufacture of PAO in the presence of metallocene catalysts is disclosed, for example, in WO 2007/011462 A1, WO 2007/011459 A1, and WO 2007/011973 A1, all of which are incorporated herein by reference.

[0018] The PAO can be prepared from any one or two or more alpha-olefins containing 3 to 24 carbons. When a single alpha-olefin is used as a feed, it is preferred to select a feed olefin from C_3 to C_{18} linear alpha-olefin (LAO), or preferably from C_4 to C_{16} -LAO, or preferably from C_6 to C_{14} -LAO, or preferably from C_6 to C_{12} -LAO, or preferably from C_6 to C_{10} -LAO, or preferably C_8 to C_{12} -LAO, or preferably C_6 or C_8 or C_{10} LAO. When a mixture of alpha-olefins containing two or more linear alpha-olefins is used as the feed, the mixed alpha-olefins can be selected from any C_3 to C_{24} -LAO, or preferably C_4 to C_{20} -LAO, or preferably C_6 to C_{20} -LAO, or

preferably C_6 to C_{18} -LAO, or preferably C_4 to C_{18} -LAO, or preferably C_6 to C_{14} -LAO, or preferably C_6 to C_{12} -LAO, or most preferably C_8 to C_{12} -LAO. When a mixture of alpha-olefins containing two or more linear alpha-olefins is used as the feed, the preferred composition of the feed LAOs should have an average carbon length of greater than 4. For example, a feed containing 50 wt % 1-butene and 50 wt % 1-pentene has an average carbon length of 4.4. A feed containing 50 wt % 1-butene and 50 wt % 1-hexene has an average carbon length of 4.8. A feed containing 50 wt % 1-butene and 50 wt % 1-octene has an average carbon length of 5.3. A feed containing 50 wt % 1-butene and 50 wt % 1-decene has an average carbon length of 5.7. A feed containing 50 wt % 1-butene and 50 wt % 1-dodecene has an average carbon length of 6. A feed containing 50 wt % 1-butene and 50 wt % 1-tetradecene has an average carbon length of 6.2. A feed containing 50 wt % 1-hexene and 50 wt % 1-octene has an average carbon length of 6.9. A feed containing 33.3 wt % 1-hexene and 66.7 wt % 1-dodecene has an average carbon length of 9.0. A feed containing 33.3 wt % 1-hexene, 33.3 wt % 1-octene, and 33.3 wt % 1-dodecene has an average carbon length of 8. Other combinations of mixed linear alpha-olefins, such as C_6/C_{14} , $C_6/C_8/C_{10}/C_{12}$, $C_6/C_{10}/C_{14}$, $C_8/C_{10}/C_{12}$, C_8/C_{14} , and the like can also be used. The choice of linear alpha-olefins typically depends on availability. Usually, it is most preferred to choose the linear alpha-olefins mixture such that the average carbon number of the mixture is greater than 4, or alternatively greater than 4.5, alternatively greater than 5, alternatively greater than 5.5, alternatively greater than 6, and most alternatively greater than 6.5. In all cases, it is also preferred to have the average carbon length no larger than 14, preferably no larger than 12, preferably no larger than 11, preferably no larger than 10.5, and most preferably no larger than 10. Usually, the larger the average carbon length of the feed olefins, the higher VI for the liquid PAO product. Higher VI is usually more beneficial. However, when the average carbon number of the feed olefins is much above 11 or 12, the long chain hydrocarbon portion of the PAO may cause severe low temperature viscosity increase due to partial gel formation or partial crystallization, which is undesirable. Therefore, a preferred average carbon length for the feed olefins is between 4.5 and 11.5 and most preferably 4.5 to 10.5.

[0019] In a preferred process, feed olefins, usually linear-alpha-olefins, are polymerized in the presence of activated metallocene catalysts, which results in a PAO containing only un-isomerized branches. More preferred PAO usually contains branches of two or more carbons. Examples of the branches are ethyl, propyl, n-butyl, n-pentyl, n-hexyl, n-heptyl, n-octyl, n-nonyl, n-decyl, n-dodecyl, n-tetradecyl, n-hexadecyl, or mixture of any of them. More preferred branches are ethyl, n-butyl, n-hexyl, n-octyl, n-decyl, n-tetradecyl, or mixture of them. Dispersants derived from these PAO with linear branches are more desirable than the dispersants prepared from polyolefins prepared from branched olefins, such as iso-butylene.

[0020] The PAO is reacted with maleic anhydride (MA) to form the polyalphaolefin succinic anhydride (PAO-SA) and subsequently the anhydride is reacted with one or more of polyamines, aminoalcohols, and alcohols/polyols to form polyalphaolefin succinimide, polyalphaolefin succinamide, polyalphaolefin succinic acid ester, polyalphaolefin oxazoline, polyalphaolefin imidazoline, polyalphaolefin-succinamide-imidazoline, and mixtures thereof as represented by the following reaction sequences:

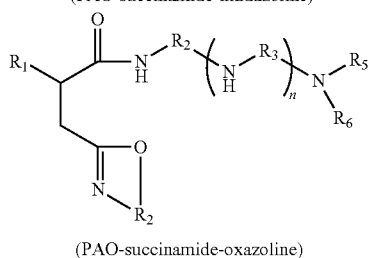
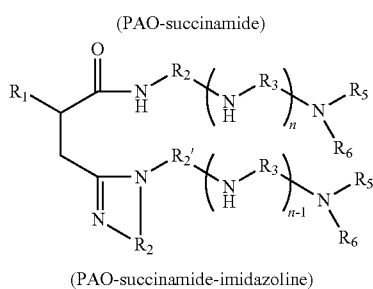
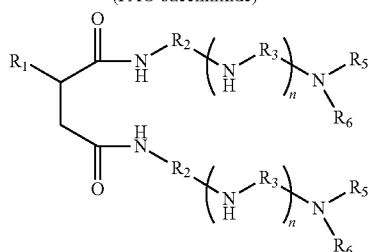
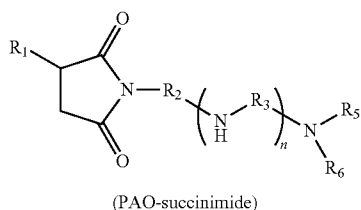
PAO (unhydrogenated)+maleic anhydride→PAO-SA
(succinic anhydride)

PAO-SA+polyamine→PAO-imide and PAO-amide
and PAO-amide-imidazoline

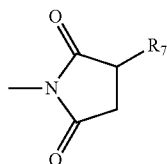
PAO-SA+alcohol/polyol→PAO-acid ester

PAO-SA+amino alcohol→PAO-amide-oxazoline

[0021] Some reaction products are depicted below:



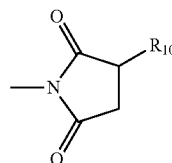
wherein R_1 is a branched C_{20} - C_{200} alkyl or alkenyl group derived from poly alpha-olefins; R_2 and R_3 are independently a C_1 - C_{10} branched or straight chained alkylene group; n is an integer from 1 to 10; R_5 and R_6 are H or R_5 and R_6 together along with the N atom bound thereto form the group:



wherein R_7 is a branched or straight-chained C_{20} - C_{200} alkyl or alkenyl group derived from polyalphaolefins; wherein the N atom bound to the R_2 and R_3 groups above is optionally substituted in one or more places with the following group:



wherein R_8 is a C_1 - C_{10} branched or straight chained alkylene group; and R_9 is NH_2 or

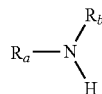


[0022] wherein R_{10} is a branched or straight-chained C_{20} - C_{200} alkyl or alkenyl group; and wherein the R_2-NH-R_3 group is optionally interrupted in one or more places by a heterocyclic or homocyclic cycloalkyl group, and wherein one or more of R_1 , R_7 and R_{10} groups is a substituted or unsubstituted poly-alpha-olefin. For example, one or more of R_1 , R_7 and R_{10} can be independently selected from poly(1-pentene) (POP), poly(1-decene) (POD), or other poly-alpha-olefins in which each repeat unit contains 5-18 carbon atoms, i.e., poly(1-pentene), poly(1-hexene), poly(1-heptene), poly(1-octene), poly(1-nonene), poly(1-undecene), poly(1-dodecene), or poly-alpha-olefins prepared from mixture of C_3 to C_{24} linear-alpha-olefins. The poly-alpha-olefins can have from 20 to 200 carbon atoms in the polymer.

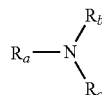
[0023] Based on the bonding environment, the nitrogen atom in the above-mentioned mixtures or combinations of compounds can have any of several different types of bonding. The types of bonding are illustrated in the following structures:



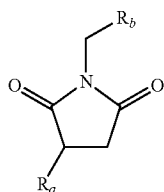
Primary amine (two hydrogen atoms bonded with nitrogen atom)



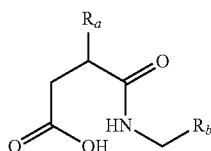
Secondary amine (one hydrogen atom bonded with nitrogen atom). R_a and R_b can be the same or different.



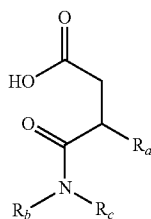
Tertiary amine (no hydrogen atom bonded with nitrogen atom. R_a , R_b and R_c can be the same or can be complete different.



Imide (nitrogen atom bonded in the succinyl anhydride ring, ring is closed). R_a and R_b can be the same or can be different.

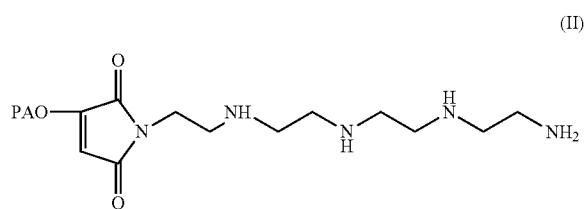
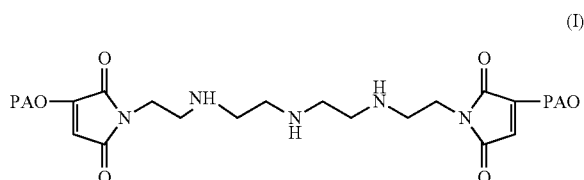


Secondary Amide (nitrogen atom bonded with a carbonyl group and have one hydrogen atom bonded to nitrogen atom). R_a and R_b can be the same or can be different.

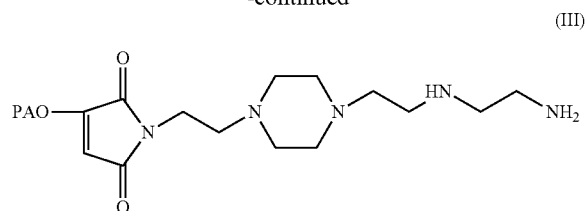


Tertiary Amide (nitrogen atom bonded with a carbonyl group and have no hydrogen atom bonded to nitrogen atom. R_a , R_b and R_c can be the same or different.

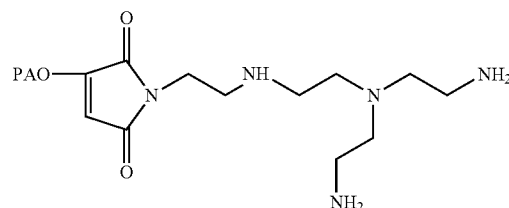
[0024] In some embodiments, at least one of R_1 , R_7 and R_{10} , as defined above, is poly-1-decene (POD). In one embodiment, the additive is selected from



-continued



(III)



(IV)

[0025] It will be understood by persons of ordinary skill in the art that various chemical structures as shown above shall have very different ratios of their functional groups (i.e. amine (primary-secondary/tertiary)/amide/imide). For example, the amine to imide ratio in structure (I) is 3:2 while the ratio in structure (II) is 4:1. To be more specific, although the amine to imide ratio is the same in structure (III) as in structure (II), the tertiary amine to primary amine ratio is 1:1 in structure (III) but at 0:4 in structure (II). The relative amine/amide/imide ratios can be important as their performance levels could be very different.

[0026] The PAO-MA maleination reaction is carried out at a temperature of 120 to 280° C., preferably 150° C. to 250° C., and most preferably 170° C. to 220° C. The reaction can be carried out at a pressure of 2 psi to 100 psi, preferably sub-atmospheric pressure to 50 psi, and most preferably atmospheric pressure to 30 psi. The reaction is carried out (reaction time) for 1 hour to 48 hours, preferably 2 hours to 24 hours, and most preferably 4 hours to 12 hours. Analogous procedures for maleination of polyisobutylene (PIB) are disclosed, for example, in U.S. Pat. Nos. 6,051,537, 6,355,074, 6,355,603, 3,284,410 and 3,948,800. Excess molar quantity of maleic anhydride can be used to increase conversion rates. However, since unhydrogenated PAO has higher reactivity than typical polyisobutylene, a lower reaction temperature can be employed. For example, most PIB-maleic anhydride reaction temperature is 190° C. or more, while in the case of PAO-maleic anhydride, reasonable conversion can be achieved at 140° C. or more.

[0027] The synthesis of PAO-succinic anhydride can be carried out through a thermal process (without catalyst) at relatively high temperature or a chlorine catalyzed process at much lower reaction temperature. A typical set of process conditions can be described by the batch reactor conditions as follows. A CSTR reactor equipped with cooling tower, mechanical agitator, gas inlet and outlet can be employed. The system was flushed with nitrogen to avoid oxidation and the mixture (PAO and maleic anhydride) was heated to 110° C., then to 140° C. with vigorous stirring for an adequate amount of reaction time. The unreacted maleic anhydride was stripped by heating under nitrogen stream at 190° C. The residue is the desired polyalphaolefin-substituted succinic anhydride having an appropriate saponification equivalent

number as determined by ASTM procedure D94. If chlorine process is chosen, excess amount of gaseous chlorine is added beneath the surface to achieve the best catalytic effect and the reaction temperature can be as low as 130° C. to 140° C. range. The subsequent reaction from polyalphaolefin succinic anhydride to polyalphaolefin succinimide and/or succinamide can be carried out with a commercial mixture of alkylene polyamines having from 3 to 10 nitrogen atoms per molecule and the presence of some mineral oil to reduce viscosity. The reaction mixture is heated to 135° C. to 155° C. and stripped by blowing with nitrogen. The reaction mixture is filtered to yield the filtrate as an oil solution of the desired product. Polyalphaolefin amide imidazoline can be prepared by reacting a polyalphaolefin succinamide with a stoichiometric excess of a polyamine and extra reaction time.

[0028] It is advantageous to use the PAO described above for the synthesis of the dispersant. These PAOs usually have higher reactivity because the olefin composition is rich in vinylidene or 1,2-disubstituted olefins and low in tri- or tetra-substituted olefins. Vinylidene and 1,2-disubstituted olefins have higher reactivity with maleic anhydride. Typically, the total amount of vinylidene and 1,2-di-substituted olefin content is great than 50% of the total olefins, preferably greater than 60%, preferably greater than 70%, preferably greater than 80%, preferably greater than 90%. The most preferred range is from 60 to 85%. The PAOs produced in this method has less impurities than many of the traditional polymeric olefins such as poly-isobutylene (PIB). Some of the impurities, such as fluorides or aluminum, may act as inhibitor for the reaction with maleic anhydride. The PAOs produced in this method have much better thermal stability than PIB. Thus, it will not decompose under high reaction temperatures usually required for maleic anhydride reaction. As a result, the adduct has more uniform molecular size, which provides better dispersancy. In contrast, PIB decomposes at high temperature, resulting in reduced product yields and lower product quality.

[0029] The dispersants are admixed with lubricant base stocks to form the lubricant blends of the present disclosure. Any known base stock may be employed, including those of Group I, Group II, Group+, Group III, Group III+, Group IV, and Group V. Gas-to-liquid (GTL) base stocks, which are sometimes classified as Group III+ base stocks, are also useful. Combinations of the foregoing base stocks may also be employed. These base stocks may be obtained from either synthetic or natural/renewable sources.

[0030] The lubricating oil base oil can be any oil boiling in the lube oil boiling range, typically between 100° C. to 450° C. In the present specification and claims the terms base oil(s) and base stock(s) are used interchangeably.

[0031] A wide range of lubricating base oils is known in the art. Lubricating base oils include natural oils and synthetic oils. Natural and synthetic oils (or mixtures thereof) can be used as unrefined, refined, or rerefined (the latter is also known as reclaimed or reprocessed oil). Unrefined oils are those obtained directly from a natural or synthetic source and used without added purification. These include shale oil obtained directly from retorting operations, petroleum oil obtained directly from primary distillation, and ester oil obtained directly from an esterification process. Refined oils are similar to the oils discussed for unrefined oils except refined oils are subjected to one or more purification steps to improve at least one lubricating oil property. Purification processes known in the art include solvent extraction, sec-

ondary distillation, acid extraction, base extraction, filtration, and percolation. Rerefined oils are obtained by processes analogous to refined oils but using an oil that has been previously used as feed stock.

[0032] Groups I, II, III, IV and V are broad categories of base oil stocks developed and defined by the American Petroleum Institute (API Publication 1509; www.API.org) to create guidelines for lubricant base oils. Group I base stocks generally have a viscosity index of 80 to 120 and contain greater than 0.03% sulfur and less than 90% saturates. Group II base stocks generally have a viscosity index of 80 to 120, and contain less than or equal to 0.03% sulfur and greater than or equal to 90% saturates. Group III stocks generally have a viscosity index greater than 120 and contain less than or equal to 0.03% sulfur and greater than 90% saturates. Group IV includes polyalphaolefins (PAO). Group V base stock includes base stocks not included in Groups I-IV. The table below summarizes properties of each of these five groups.

	Base Oil Properties		
	Saturates	Sulfur	Viscosity Index
Group I	<90 and/or	>0.03% and	≥80 and <120
Group II	≥90 and	≤0.03% and	≥80 and <120
Group III	≥90 and	≤0.03% and	≥120
Group IV	Includes polyalphaolefins (PAO) and GTL products		
Group V	All other base oil stocks not included in Groups I, II, III or IV		

[0033] Useful lubricant base stocks preferably exhibit a pour point of less than 10° C., more preferably less than 0° C., and most preferably less than -10° C. according to ASTM D 97. The lubricant base stocks preferably exhibit a kinematic viscosity at 40° C. from 4 to 80,000 centi-Stokes (cSt) and more preferably from 5 cSt to 50,000 cSt at 40° C. according to ASTM D445. The lubricant base stocks preferably exhibit a kinematic viscosity at 100° C. of 1.5 to 5,000 cSt, more preferably 2 cSt to 3,000 cSt, and most preferably 3 cSt to 500 cSt. Low viscosity lubricant base stocks are particularly useful in automotive motor oil applications, namely those with kinematic viscosities at 100° C. from 3 cSt to 15 cSt and more typically 3 cSt to 8 cSt. Low viscosity lubricant base stocks are particularly useful for 0W20 and 0W30 motor oils.

[0034] Lubricant blends of the present disclosure may optionally include other conventional lubricant additives, such as detergents, antioxidants, anti-wear additives, pour point depressants, viscosity index modifiers, friction modifiers, defoaming agents, corrosion inhibitors, wetting agents, rust inhibitors, seal swell agents and the like. The additives may be incorporated to make a finished lubricant product that has desired viscosity and physical properties. Typical additives used in lubricant formulation can be found in the book "Lubricant Additives, Chemistry and Applications", Ed. L. R. Rudnick, Marcel Dekker, Inc. 270 Madison Ave. New York, N.J. 10016, 2003.

[0035] Lubricant blends of the present disclosure are useful as oils or greases for any device or apparatus requiring lubrication of moving and/or interacting mechanical parts, components, or surfaces. Useful apparatuses include engines and machines. The lubricant blends are most suitable for use in the formulation of automotive crank-case lubricants, automotive gear oils, transmission oils, many industrial lubricants includ-

ing circulation lubricant, industrial gear lubricants, grease, compressor oil, pump oils, refrigeration lubricants, hydraulic lubricants, metal working fluids. Lubricant blends of the present disclosure are particularly useful in automotive applications as crank-case oil, i.e., motor oil.

[0036] Preferred lubricant blends with PAO-based dispersants preferably exhibit lower viscosities than PIB-based dispersants at equal amounts and at comparable molecular weights and more preferably do so across a temperature range of -40°C. to 100°C. Comparative viscosities can be measured by ASTM method D665-3 for Kv 40, by D665-5 for Kv 100, and ASTM D5293 for Cold Crank Simulation (CCS).

[0037] The following are examples of the present disclosure and are not to be construed as limiting.

EXAMPLES

[0038] Lubricant blends containing PAO-based succinimide (PAO-imide) of the present disclosure were prepared and compared for viscosity properties with respect to conventional blends containing PIB-based succinimide (PIB-imide).

[0039] A poly-alpha-olefin (PAO) with M_n of 1160 was synthesized according to substantially the same procedures set forth in Example 10 of WO 2007011973, herein incorporated by reference, at 90°C. and with H_2 feed rate of 5 scc/minute. The polymer fraction was isolated from the crude product by distillation at $180^{\circ}\text{C.}/0.1$ millitorr vacuum to remove any light boiling fraction. This PAO exhibited the same degree of unsaturation as measured by bromine number as a 900 molecular weight PIB used for the synthesis of commercial dispersant. The PIB has bromine number of 16.6 and the PAO has bromine number of 16.

[0040] A PAO-imide dispersant, Example 1, was synthesized according to the following procedures and compared with the analogous PIB-imide dispersant, Example 2, of equal molecular weight (Table 1). The resulting succinimide dispersants had very similar overall N (nitrogen) levels (3.9 and 4.1 wt % N for PIB-imide and PAO-imide). It is surprising to note that although the starting PIB and PAO have the same molecular weight and same bromine number, the PAO-imide has much lower Kv 100°C. and Kv 40°C. than PIB-imide. Generally, it is preferred to have an oil-diluted dispersant of Kv 100°C. much less than 200 cS and Kv 40°C. of much less than 10,000 cS. A lower viscosity dispersant allows broader formulation space for low viscosity, fuel efficient engine lubricants.

[0041] The dispersants of Example 1 and 2 were blended with a 4 cS Gr III+ base stock at 10 wt % based on the total weight of the blend. The PAO-imide blend of Example 3 had a lower Kv at 40°C. and 100°C. than the PIB-imide blend of Example 4. The lower viscosity is particularly beneficial for formulating into 0W20 and 0W30 lubricants and motor oils.

[0042] The calculated viscosities at -15°C. , -30°C. and -40°C. for the PAO-imide blend of Example 3 also are significantly lower than for the PIB-imide blend of Example 4. The viscosities were calculated according to the extrapolation of VI calculation by ASTM D2270 method. The lower viscosity for the blends is particularly beneficial for formulation of low-vis grade-finished lubricants.

TABLE 1

	Example No.	
	1	2*
Dispersant Type	PAO-imide	PIB-imide
Kv 100°C. , cS	36.50	224.50
Kv 40°C. , cS	425.60	10,046.40
VI (viscosity index)	120	99
	Example No.	
	3	4
Blend Properties		
Wt % SI in Blend	10	10
Blend Properties		
Kv 100°C. , cS	4.55	4.95
Kv 40°C. , cS	19.32	21.91
VI	158	159
Calculated Low Temperature		
Kv at -15°C. , cS	314.2	387.9
Kv at -30°C. , cS	1141.5	1464
Kv at -40°C. , cS	3338.0	4413
% Less Kv Increase compared to Example 4		
100°C. Kv reduction	7.8	Control
40°C. Kv reduction	13.4	Control
-15°C. Kv reduction	23.5	Control
-30°C. Kv reduction	28.3	Control
-40°C. Kv reduction	32.2	Control

*not an example of the present disclosure

[0043] The two dispersants used in the blends of Example 5 and 6 were synthesized in the same manner as the dispersants used in Example 1 and 2 except no diluent oil was added to the final step for the succinimide synthesis. The PAO-imide blend of Example 5 and the PIB-imide blend of Example 6 were prepared with a 4 cS Gr III+ base stock. The properties of the blends of Example 7 and 8, and the dispersants PAO-imide and PIB-imide are summarized in Table 2. Similar reduction of viscosity was observed with the PAO-imide blend (Example 5). This example further demonstrated the advantages of PAO-imide dispersants in that the blend exhibited very low viscosity and good VI compared to the blend having PTB-imide. Because of low viscosity, the PAO-imide is easy to handle during synthesis and no diluent oil was needed at the end of the synthesis to cut down oil viscosity. It is desirable to avoid use of diluent oil as it allows for better control of base stock purity in the final formulation. Generally, it is preferred to have pure dispersant of Kv 100°C. less than 700 cS and a Kv 40°C. of less than 60,000 cS. A lower viscosity dispersant without diluent oil affords broader formulation tolerance in low viscosity, fuel efficient, engine lubricants.

TABLE 2

	Example No.	
	5	6*
Dispersant Type	PAO-imide	PIB-imide
Kv 100°C. , cS	96.77	788.67
Kv 40°C. , cS	1,344.00	60,985.31
VI	156	134

TABLE 2-continued

	Example No.	
	7	8
Wt % SI in Blend	10	10
Blend Properties		
Kv 100° C., cS	4.65	5.08
Kv 40° C., cS	19.90	23.15
VI	159	155
Calculated Low Temperature		
Kv at -15° C., cS	328.1	441.1
Kv at -30° C., cS	1198.1	1729.8
Kv at -40° C., cS	3516.6	5392.5
% Kv Reduction Compared to PIB-imide blend		
%100° C. Kv reduction	8.2	control
% 40° C. Kv reduction	16.3	control
% -15° C. Kv reduction	34.4	control
% -30° C. Kv reduction	44.4	control
% -40° C. Kv reduction	53.3	control

*not an example of the present disclosure

Synthesis Procedures:

Synthesis of PAO-imide (poly-alpha-olefin succinimide, Example 1)

[0044] A PAO (as described above, 75 g) was added to a round-bottom flask equipped with N₂ inlet, stirrer, and condenser together with crushed maleic anhydride (15 g, 2 eq). The system was flushed with nitrogen and the mixture heated to 142° C. with vigorous stirring for 6 hours. The unreacted maleic anhydride was stripped by heating under nitrogen stream at 200° C. The saponification number of the product, PAO-succinic anhydride (PAO-SA), was 79.6.

[0045] A four-necked flask equipped with Dean Stark trap, condenser, thermometer, stirrer and nitrogen inlet was charged with mPAO-SA (50 g, 1 eq), a commercial mixture of ethylene polyamines (tetraethylenepentamine or TEPA**, 9.4 g, 1 eq) and diluent oil (100 sec Solvent dewaxed, paraffinic neutral, 25 g). The mixture was heated to 138° C. and stirred for 4 hours. The warm product was filtered. IR analysis confirmed complete reaction. Yield: 80.0 g of a clear, brown fluid.

Synthesis of PIB-imide (polyisobutylene succinimide, Example 2)

[0046] PIB (Aldrich product no 388696, 125 g) was added to a round-bottom flask equipped with N₂ inlet, stirrer, and condenser, together with crushed maleic anhydride (26.6 g, 2 eq based on 900 M_n of PIB). The system was flushed with nitrogen and the mixture heated to 110° C. with vigorous stirring for 30 minutes. The reaction mixture was heated at 207° C.-234° C. and stirred for 5.5 hours. Remaining maleic anhydride was stripped by heating under nitrogen stream at 200° C. The saponification number of the product, PIB-succinic anhydride (PIB-SA) was 80.3.

[0047] A four-necked flask equipped with Dean-Stark trap, condenser, thermometer, stirrer and nitrogen inlet was charged with mPIB-SA (94 g, 1 eq), a commercial mixture of ethylene polyamines (tetraethylenepentamine or TEPA**, 17.7 g, 1 eq) and diluent oil (100 sec Solvent dewaxed, paraffinic neutral, 50 g). The mixture was heated to 138° C. and begin stirred for 4 hours. The warm product was filtered. IR

analysis confirmed complete reaction. Yield: 148.0 clear, viscous, brown fluid.

*The saponification test method was similar to ASTM D94 method. It was used to measure the amount of anhydride functionality in the succinic anhydride product.

**TEPA is mixture of mostly triethylenetetraamines, tetraethylenepentamine, pentaethylenhexamine and was obtained from The Dow Chemical Company.

What is claimed is:

1. A lubricant blend comprising one or more lubricant base stocks and a dispersant chosen from:

a polyalphaolefin succinimide,
a polyalphaolefin succinamide,
a polyalphaolefin acid ester,
a polyalphaolefin oxazoline,
a polyalphaolefin imidazoline,
a polyalphaolefin succinamide imidazoline, and
combinations thereof,

wherein the one or more dispersants are present at 2 to 20 wt % based on the total weight of the blend, and wherein the one or more dispersants and the one or more lubricant base stocks are together present at 85 wt % or more of the total weight of the blend.

2. The blend of claim 1, wherein the one or more dispersants and the one or more lubricant base stocks are together present at 90 wt % or more of the total weight of the blend.

3. The blend of claim 1, wherein the one or more dispersants and the one or more lubricant base stocks are together present at 95 wt % or more of the total weight of the blend.

4. The blend of claim 1, wherein the one or more dispersants are present at 5 to 15 wt % based on the total weight of the blend.

5. The blend of claim 1, wherein the one or more dispersants are present at 5 to 10 wt % based on the total weight of the blend.

6. The blend of claim 1, wherein the one or more lubricant base stocks is chosen from a Group I, Group II, Group II+, Group III, Group III+, Group IV, Group V, and combinations thereof.

7. The blend of claim 1, wherein the one or more lubricant base stocks includes a Group III+ base stock.

8. The blend of claim 1, wherein the dispersant exhibits a kinematic viscosity at 100° C. of less than 700 cS, a kinematic viscosity at 40° C. of less than 50,000 cS, and a viscosity index of greater than 135.

9. The blend of claim 1, wherein the dispersant diluted with up to 35 wt % mineral oil exhibits a kinematic viscosity at 100° C. of less than 200 cS, a kinematic viscosity at 40° C. of less than 10,000 cS, and a viscosity index of greater than 100, from 100 to 200.

10. The blend of claim 1, wherein the dispersant is a polyalphaolefin succinimide.

11. The blend of claim 1, wherein the dispersant is a polyalphaolefin succinamide.

12. The blend of claim 1, wherein the dispersant is a polyalphaolefin acid ester.

13. The blend of claim 1, wherein the dispersant is a polyalphaolefin oxazoline.

14. The blend of claim 1, wherein the dispersant is a polyalphaolefin imidazoline.

15. The blend of claim 1, wherein the dispersant is a polyalphaolefin succinamide.

16. A process for making a lubricant blend comprising: admixing an amount of one or more lubricant base stocks and an amount of a dispersant chosen from:

- a polyalphaolefin succinimide,
- a polyalphaolefin succinamide,
- a polyalphaolefin acid ester,
- a polyalphaolefin oxazoline,
- a polyalphaolefin imidazoline,
- a polyalphaolefin succinamide imidazoline, and
- combinations thereof,

wherein the one or more dispersants are present at 2 to 20 wt % based on the total weight of the blend, and wherein the one or more dispersants and the one or more lubricant base stocks are together present at 85 wt % or more of the total weight of the blend.

17. The process of claim 16, wherein the one or more lubricant base stocks is chosen from a Group I, Group II, Group II+, Group III, Group III+, Group IV, Group V, and combinations thereof.

18. The process of claim 16, wherein the dispersant exhibits a kinematic viscosity at 100° C. of less than 700 cS, a kinematic viscosity at 40° C. of less than 50,000 cS, and a viscosity index of greater than 135.

19. The process of claim 16, wherein the dispersant diluted with up to 35 wt % mineral oil exhibits a kinematic viscosity at 100° C. of less than 200 cS, a kinematic viscosity at 40° C. of less than 10,000 cS, and a viscosity index of greater than 100, from 100 to 200.

20. A method for lengthening the service life of a lubricant formulation comprising: admixing with one or more lubricant base stocks an amount of a dispersant chosen from:

- a polyalphaolefin succinimide,
- a polyalphaolefin succinamide,
- a polyalphaolefin acid ester,
- a polyalphaolefin oxazoline,
- a polyalphaolefin imidazoline,
- a polyalphaolefin succinamide imidazoline, and
- combinations thereof, and

utilizing the lubricant formulation as an oil or grease in a device or apparatus requiring lubrication of moving and/or interacting mechanical parts, components, or surfaces,

wherein the one or more dispersants are present at 2 to 20 wt % based on the total weight of the blend, and wherein

the one or more dispersants and the one or more lubricant base stocks are together present at 85 wt % or more of the total weight of the blend.

21. The method of claim 20, wherein the one or more lubricant base stocks is chosen from a Group I, Group II, Group II+, Group III, Group III+, Group IV, Group V, and combinations thereof.

22. The method of claim 20, wherein the dispersant exhibits a kinematic viscosity at 100° C. of less than 700 cS, a kinematic viscosity at 40° C. of less than 50,000 cS, and a viscosity index of greater than 135.

23. The method of claim 20, wherein the dispersant diluted with up to 35 wt % mineral oil exhibits a kinematic viscosity at 100° C. of less than 200 cS, a kinematic viscosity at 40° C. of less than 10,000 cS, and a viscosity index of greater than 100, from 100 to 200.

24. A lubricant formulation prepared by the process comprising: admixing with one or more lubricant base stocks an amount of a dispersant chosen from:

- a polyalphaolefin succinimide prepared by reacting an unhydrogenated polyalphaolefin with maleic anhydride to form a polyalphaolefin anhydride followed by reacting the polyalphaolefin anhydride with a polyamine,
- a polyalphaolefin succinamide prepared by reacting an unhydrogenated polyalphaolefin with maleic anhydride to form a polyalphaolefin anhydride followed by reacting the polyalphaolefin anhydride with a polyamine,
- a polyalphaolefin acid ester prepared by reacting an unhydrogenated polyalphaolefin with maleic anhydride to form a polyalphaolefin anhydride followed by reacting the polyalphaolefin anhydride with a polyamine,
- a polyalphaolefin oxazoline prepared by reacting an unhydrogenated polyalphaolefin with maleic anhydride to form a polyalphaolefin anhydride followed by reacting the polyalphaolefin anhydride with an aminoalcohol,
- a polyalphaolefin amide-imidazoline prepared by reacting a polyalphaolefin succinamide with a polyamine, and
- combinations of two or more of the foregoing,

wherein the one or more dispersants are present at 2 to 20 wt % based on the total weight of the blend, and wherein the one or more dispersants and the one or more lubricant base stocks are together present at 85 wt % or more of the total weight of the blend.

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