



(51) International Patent Classification:

C10M 105/34 (2006.01) C07C 69/614 (2006.01)
C10M 129/70 (2006.01) C10M 111/02 (2006.01)
C07C 69/612 (2006.01) C10M 129/95 (2006.01)

(21) International Application Number:

PCT/US2016/067962

(22) International Filing Date:

21 December 2016 (21.12.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/271,513 28 December 2015 (28.12.2015) US
15/384,471 20 December 2016 (20.12.2016) US

(71) Applicant: EXXONMOBIL RESEARCH AND ENGINEERING COMPANY [US/US]; 1545 Route 22 East, P.O. Box 900, Annandale, NJ 08801-0900 (US).

(72) Inventors: NG, Man, Kit; 51 Liberty Ridge Road, Basking Ridge, NJ 07920 (US). OUMAR-MAHAMAT, Halou; 501 Township Line Road, Belle Mead, NJ 08502 (US). CHENG, Hong; 9 Wendover Place, Bridgewater, NJ 08807 (US). BLAIN, David, A.; 423 Coolidge Road, Cherry Hill, NJ 08002 (US).

(74) Agents: MIGLIORINI, Robert, A. et al.; Exxonmobil Research and Engineering Company, 1545 Route 22 East, P.O. Box 900, Annandale, NJ 08801-0900 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

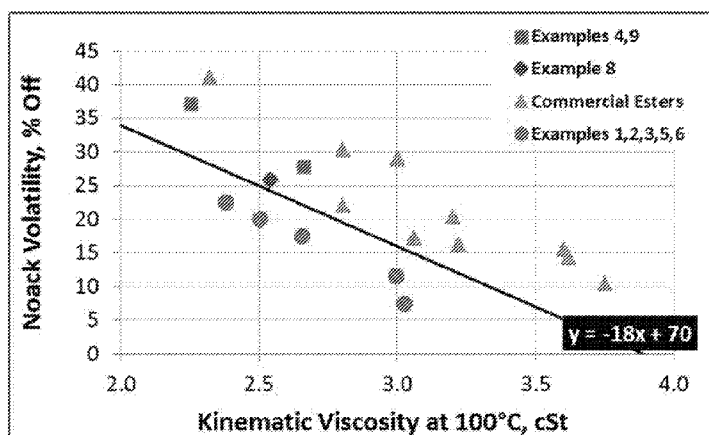
Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

(54) Title: LOW VISCOSITY LOW VOLATILITY LUBRICATING OIL BASE STOCKS AND METHODS OF USE THEREOF

Fig. 2



(57) Abstract: A composition including one or more aromatic alkanoate monoester compounds represented by the formulae (I) and (II) as defined herein. The composition has a viscosity (Kv_{100}) from about 1 cSt to about 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800. A process for producing the composition, a lubricating oil base stock and lubricating oil containing the composition, and a method for improving one or more of thermal and oxidative stability, solubility and dispersancy of polar additives, deposit control and traction control in a lubricating oil by using as the lubricating oil a formulated oil containing the composition.



- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- Published:**
 - *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

LOW VISCOSITY LOW VOLATILITY LUBRICATING OIL
BASE STOCKS AND METHODS OF USE THEREOF

FIELD

[0001] This disclosure relates to low viscosity, low volatility compositions that include one or more aromatic alkanoate monoesters, a process for producing the compositions, a lubricating oil base stock and lubricating oil containing the composition, and a method for improving one or more of thermal and oxidative stability, solubility and dispersancy of polar additives, deposit control and traction control in a lubricating oil by using as the lubricating oil a formulated oil containing the composition.

BACKGROUND

[0002] Lubricants in commercial use today are prepared from a variety of natural and synthetic base stocks admixed with various additive packages and solvents depending upon their intended application. The base stocks typically include mineral oils, polyalphaolefins (PAO), gas-to-liquid base oils (GTL), silicone oils, phosphate esters, diesters, polyol esters, and the like.

[0003] A major trend for passenger car engine oils (PCEOs) is an overall improvement in quality as higher quality base stocks become more readily available. Typically the highest quality PCEO products are formulated with base stocks such as PAOs or GTL stocks admixed with various additive packages.

[0004] For improving fuel economy, base oil viscosity is very important. Substantial improved fuel economy (>2%) requires breakthrough in: (1) base oil volatility (2) durability and (3) friction. Friction losses occur between the moving components within the engine. Models developed to date indicate that fuel economy is heavily influenced by the lubricant properties at high shear. The base stock contributes a greater proportion of the total viscosity under high shear conditions than under low shear. Lowering base stock viscosity is likely to have the largest impact on future fuel economy gains.

[0005] Current commercial PAO fluids (e.g., SpectraSyn™ 2) based on hydrocarbon and commercial esters (e.g., 2-ethylhexyl adipate, di-2-ethylhexyl azelate, Esterex™ A32, Esterex™ A34) do not adequately allow formulation of ultra-low viscosity lubricant while still meeting API specification (e.g., Noack volatility of 15% or less). In order to formulate ultra-low viscosity lubricant for fuel economy benefit, it is desirable to have low viscosity and low volatility properties co-exist in the same base stock, for meeting volatility requirement. In addition, the base stock should also possess adequate thermal and oxidative stability at high temperature to prevent or

- 2 -

minimize deposit formation. Good compatibility with additives commonly used in lubricant formulations (PVL – Passenger Vehicle Lubricants, CVL – Commercial Vehicle Lubricants, industrial lubricants), good low temperature properties, and acceptable viscosity indices are also necessary for the base stocks.

[0006] Poly- α -olefins (PAOs) are important lube base stocks with many excellent lubricant properties, including high viscosity index (VI), low volatility and are available in various viscosity range (K_{V100} 2-300 cSt). However, PAOs are paraffinic hydrocarbons with low polarity. This low polarity leads to low solubility and dispersancy for polar additives or sludge generated during service. To compensate for this low polarity, lube formulators usually add one or multiple polar cobase stocks. Ester or alkylated naphthalene (AN) is usually present at 1 wt. % to 50 wt. % levels in many finished lubricant formulations to increase the fluid polarity which improves the solubility of polar additives and sludge.

[0007] Therefore, there is a need for polar cobase fluids that provide appropriate solubility and dispersibility for polar additives or sludge generated during service of lubricating oils.

[0008] Future automotive and industrial trend suggest that there will be a need for advanced additive technology and synthetic base stocks with substantially better thermal and oxidative stability. This is primarily because of smaller sump sizes that will have more thermal and oxidative stresses on the lubricants. Performance requirements have become more stringent in the past 10 to 20 years and the demand for longer drain intervals has grown steadily. Also, the use of Group II, III and IV base oils is becoming more widespread. Such base oils have very little sulfur content since natural sulfur-containing antioxidants are either absent or removed during the severe refining process.

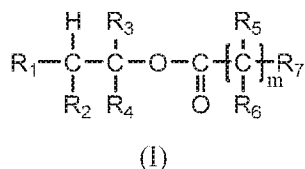
[0009] It is known that lubricant oils used in internal combustion engines and transmission of automobile engines or trucks are subjected to demanding environments during use. These environments result in the lubricant suffering oxidation catalyzed by the presence of impurities in the oil, such as iron (wear) compounds and elevated temperatures. The oxidation manifests itself by increase in acid or viscosity and deposit formation or any combination of these symptoms. These are controlled to some extent by the use of antioxidants which can extend the useful life of the lubricating oil, particularly by reducing or preventing unacceptable viscosity increases. Besides oxidation inhibition, other parameters such as rust and wear control are also important.

[0010] A major challenge in engine oil formulation is simultaneously achieving improved fuel economy while also achieving appropriate solubility and dispersibility for polar additives or sludge generated during service of lubricating oils and oxidative stability.

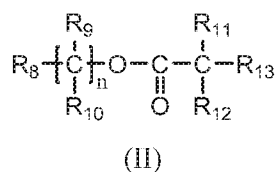
- 6 -

wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, \underline{m} is a value from about 1 to about 10, and \underline{n} is a value greater than or equal to 1. The composition has a viscosity (K_{V100}) from about 1cSt to about 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800.

[0018] This disclosure also relates in part to a method for improving one or more of thermal and oxidative stability, solubility and dispersancy of polar additives, deposit control and traction control in a lubricating oil by using as the lubricating oil a formulated oil comprising a lubricating oil base stock as a major component, and a monoester cobase stock as a minor component; wherein said monoester cobase stock comprises one or more compounds represented by the formula selected from the group consisting of



and



wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, \underline{m} is a value from about 1 to about 10, and \underline{n} is a value greater than or equal to 1. The composition has a viscosity (K_{V100}) from about 1cSt to about 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800.

- 7 -

[0019] It has been surprisingly found that outstanding low viscosity low volatility properties, good high-temperature thermal and oxidative stability, good solvency for polar additives, deposit control, and traction benefits, can be attained in an engine lubricated with a lubricating oil by using as the lubricating oil a formulated oil in accordance with this disclosure. In particular, a lubricating oil base stock comprising one or more aromatic alkanooate monoesters exhibits low viscosity, low volatility, desired solvency for polar additives, superior oxidative stability, desired deposit control and traction benefits, which helps to prolong the useful life of lubricants and significantly improve the durability and resistance of lubricants when exposed to high temperatures.

[0020] The lubricating oils of this disclosure are particularly advantageous as passenger vehicle engine oil (PVEO) products, more specifically SAE 0WX, SAE 5WX, or SAE 10WX, (where X = 4, 8, 12, 16, 20, 30, 40, or 50), and similar oil formulations, especially oil formulations exhibiting lowered volatility when blended with the components of this invention. Furthermore, the esters of this invention can be used in low ash, low metals, low phosphorus oils, preferably formulated with ZDDP derived in part from secondary alcohols, with metallic detergents, such as salicylates, phenates and/or sulfonates, preferably magnesium and/or calcium, with succinimide dispersants or with boron-containing detergents or dispersants.

[0021] Further objects, features and advantages of the present disclosure will be understood by reference to the following drawings and detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Fig. 1 shows lube properties including kinematic viscosities, viscosity indices (VI) and volatility of selected base stocks of this disclosure and commercially available ester base stocks in accordance with Example 10.

[0023] Fig. 2 graphically shows kinematic viscosity (100°C) versus volatility (Noack) for selected base stocks of this disclosure and commercially available ester base stocks based on data in Fig. 1 and in accordance with Example 10.

[0024] Fig. 3 shows high temperature high shear (HTHS) viscosity ASTM D4683, Noack volatility ASTM D5800 and TEOST ASTM D6335 (thermo-oxidation engine oil determination of high temperature piston deposits) results for low-viscosity engine oils formulated with base stocks of this disclosure and commercially available ester base stocks in accordance with Example 11.

[0025] Fig. 4 shows MTM traction curves from selected ester fluids of this disclosure and commercial esters in MTM (mini-traction machine) traction test at 100°C and 1.00 GPa in accordance with Example 11.

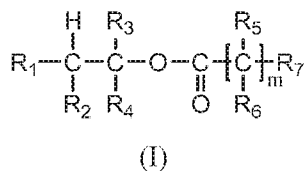
DETAILED DESCRIPTION

[0026] 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.

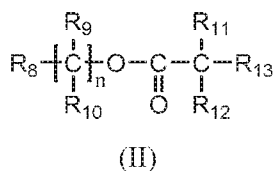
[0027] The compositions of this disclosure are aromatic alkanooate monoesters. These compositions exhibit (1) outstanding low viscosity low volatility properties, (2) good high-temperature thermal and oxidative stability, (3) good solvency for polar additives, (4) good deposit control, and (5) traction benefits, which make them attractive as Group V synthetic base stocks in high performance, fuel economy lubricant applications.

[0028] Low viscosity base stocks (e.g., kinematic viscosity at 100°C, 2-3 cSt) currently available in the marketplace are too volatile (Noack > 15-20%) to be used for formulating next-generation ultra-low viscosity engine oils (i.e., xxW-4 → xxW-16). These base stocks (e.g., SpectraSyn™ 2, QHVI™ 3, bis-(2-ethylhexyl) adipate, di-2-ethylhexyl azelate, Esterex™ A32) are unable to provide formulated engine oils that also meet current volatility API specification. In addition, current Group V ester base stocks generally have poor high temperature oxidation stability which can cause operational problems in engine, potentially causing high deposit formation. The present disclosure identifies aromatic alkanooate monoesters that have desirable low viscosity and low volatility properties while exhibiting traction benefits, good deposit control behavior and good high-temperature thermal-oxidative stability, hence provides a solution to achieve enhanced fuel economy and energy efficiency. In addition, good solvency for commonly used polar additives and potentially good hydrolytic stability are other advantages of these compounds in base stock applications.

[0029] As indicated above, the compositions of this disclosure include, for example, one or more aromatic alkanooate monoester compounds represented by the formula selected from the group consisting of



and



- 9 -

wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from about 1 to about 10, and n is a value greater than or equal to 1. The composition has a viscosity (K_{V100}) from about 1cSt to about 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800.

[0030] Preferred compositions of this disclosure include, for example, those wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₂₀); R₃, R₄, R₅, R₆, R₉, R₁₀, R₁₁, R₁₂ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₂₀), alkenyl group (C₁-C₂₀), or alkoxy group (C₁-C₂₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₁-C₂₀), heteroaryl group (C₁-C₂₀), or arylalkyl group (C₁-C₂₀), and m and n are independently a value from about 1 to about 8.

[0031] Other preferred compositions of this disclosure include, for example, those wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₁₀); R₃, R₄, R₅, R₆, R₉, R₁₀, R₁₁, R₁₂ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₁₀), alkenyl group (C₁-C₁₀), or alkoxy group (C₁-C₁₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₁₀), heteroaryl group (C₄-C₁₀), or arylalkyl group (C₅-C₁₀), and m and n are independently a value from about 2 to about 8.

[0032] Illustrative aromatic alkanooate monoester compositions of this disclosure have a viscosity (K_{V100}) from about 1cSt to about 8 cSt, more preferably from about 2 cSt to about 6 cSt, at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300, more preferably from about 0 to about 200, even more preferably from about 25 to about 150, as determined by ASTM D2270, a Noack volatility of no greater than 25 percent, more preferably no greater than 20 percent, even more preferably no greater than 15 percent, as determined by ASTM D5800, and a high temperature high shear (HTHS) viscosity of less than about 2.5 cP, more preferably less than about 2.25 cP, even more preferably less than about 2.0 cP, as determined by ASTM D4683.

[0033] Preferred aromatic alkanooate monoester compositions of this disclosure have a high temperature high shear (HTHS) viscosity of less than about 1.7 cP as determined by ASTM D4683, and Noack volatility from about 15 percent to about 30 percent as determined by ASTM D5800.

- 10 -

[0034] Illustrative aromatic alkanooate monoester compositions of this disclosure include, for example, 2-hexyl-1-decyl benzoate, 2-hexyl-1-decyl phenylacetate, 2-hexyl-1-decyl 3-phenylpropionate, 2-octyl-1-dodecyl phenylacetate, 2-butyl-1-octyl 4-phenylbutyrate, 2-hexyl-1-decyl 4-methoxyphenylacetate, 2-hexyl-1-decyl m-tolylacetate, 2-hexyl-1-decyl p-tolylacetate, 2-phenylethyl 2-hexyldecanoate, and the like.

[0035] Illustrative aromatic alkanooate monoester compositions of formula (I) include, for example, 2-ethylhexyl phenylacetate, 2-heptylundecyl phenylacetate, 2-octyldecyl phenylacetate, 2-octyldodecyl phenylacetate, 2-decyldodecyl phenylacetate, 2-decyltetradecyl phenylacetate, 2-hexyldecyl phenylacetate, 2-butyloctyl phenylacetate, isopropyl phenylacetate, 2-methylbutyl phenylacetate, 2-methylpentyl phenylacetate, isotridecyl phenylacetate, isodecyl phenylacetate, isononyl phenylacetate, isooctyl phenylacetate, 2-ethylhexyl phenylpropionate, 2-heptylundecyl phenylpropionate, 2-octyldecyl phenylpropionate, 2-octyldodecyl phenylpropionate, 2-decyldodecyl phenylpropionate, 2-decyltetradecyl phenylpropionate, 2-hexyldecyl phenylpropionate, 2-butyloctyl phenylpropionate isopropyl phenylpropionate, 2-methylbutyl phenylpropionate, 2-methylpentyl phenylpropionate, isotridecyl phenylpropionate, isodecyl phenylpropionate, isononyl phenylpropionate, isooctyl phenylpropionate, 2-ethylhexyl tolylacetate, 2-heptylundecyl tolylacetate, 2-octyldecyl tolylacetate, 2-octyldodecyl tolylacetate, 2-decyldodecyl tolylacetate, 2-decyltetradecyl tolylacetate, 2-hexyldecyl tolylacetate, 2-butyloctyl tolylacetate, isopropyl tolylacetate, 2-methylbutyl tolylacetate, 2-methylpentyl tolylacetate, isotridecyl tolylacetate, isodecyl tolylacetate, isononyl tolylacetate, isooctyl tolylacetate, 2-ethylhexyl tolylpropionate, 2-heptylundecyl tolylpropionate, 2-octyldecyl tolylpropionate, 2-octyldodecyl tolylpropionate, 2-decyldodecyl tolylpropionate, 2-decyltetradecyl tolylpropionate, 2-hexyldecyl tolylpropionate, 2-butyloctyl tolylpropionate, isopropyl tolylpropionate, 2-methylbutyl tolylpropionate, 2-methylpentyl tolylpropionate, isotridecyl tolylpropionate, isodecyl tolylpropionate, isononyl tolylpropionate, isooctyl tolylpropionate, 2-ethylhexyl xylylacetate, 2-heptylundecyl xylylacetate, 2-octyldecyl xylylacetate, 2-octyldodecyl xylylacetate, 2-decyldodecyl xylylacetate, 2-decyltetradecyl xylylacetate, 2-hexyldecyl xylylacetate, 2-butyloctyl xylylacetate, isopropyl xylylacetate, 2-methylbutyl xylylacetate, 2-methylpentyl xylylacetate, isotridecyl xylylacetate, isodecyl xylylacetate, isononyl xylylacetate, isooctyl xylylacetate, 2-ethylhexyl xylylpropionate, 2-heptylundecyl xylylpropionate, 2-octyldecyl xylylpropionate, 2-octyldodecyl xylylpropionate, 2-decyldodecyl xylylpropionate, 2-decyltetradecyl xylylpropionate, 2-hexyldecyl xylylpropionate, 2-butyloctyl xylylpropionate, isopropyl xylylpropionate, 2-methylbutyl xylylpropionate, 2-methylpentyl xylylpropionate, isotridecyl xylylpropionate, isodecyl xylylpropionate, isononyl xylylpropionate, isooctyl xylylpropionate, 2-ethylhexyl

- 11 -

methoxyphenylacetate, 2-heptylundecyl methoxyphenylacetate, 2-octyldecyl methoxyphenylacetate, 2-octyldodecyl methoxyphenylacetate, 2-decyltetradecyl methoxyphenylacetate, 2-hexyldecyl methoxyphenylacetate, 2-butyloctyl methoxyphenylacetate, isopropyl methoxyphenylacetate, 2-methylbutyl methoxyphenylacetate, 2-methylpentyl methoxyphenylacetate, isotridecyl methoxyphenylacetate, isodecyl methoxyphenylacetate, isononyl methoxyphenylacetate, isooctyl methoxyphenylacetate, 2-ethylhexyl methoxyphenylpropionate, 2-heptylundecyl methoxyphenylpropionate, 2-octyldecyl methoxyphenylpropionate, 2-octyldodecyl methoxyphenylpropionate, 2-decyltetradecyl methoxyphenylpropionate, 2-hexyldecyl methoxyphenylpropionate, 2-butyloctyl methoxyphenylpropionate, isopropyl methoxyphenylpropionate, 2-methylbutyl methoxyphenylpropionate, 2-methylpentyl methoxyphenylpropionate, isotridecyl methoxyphenylpropionate, isodecyl methoxyphenylpropionate, isononyl methoxyphenylpropionate, isooctyl methoxyphenylpropionate, 2-ethylhexyl phenylbutyrate, 2-heptylundecyl phenylbutyrate, 2-octyldecyl phenylbutyrate, 2-octyldodecyl phenylbutyrate, 2-decyltetradecyl phenylbutyrate, 2-hexyldecyl phenylbutyrate, 2-butyloctyl phenylbutyrate, isopropyl phenylbutyrate, 2-methylbutyl phenylbutyrate, 2-methylpentyl phenylbutyrate, isotridecyl phenylbutyrate, isodecyl phenylbutyrate, isononyl phenylbutyrate, isooctyl phenylbutyrate, and the like.

[0036] Illustrative aromatic alkanoate monoester compositions of formula (II) include, for example, benzyl 2-butyloctanoate, benzyl 2-hexyloctanoate, benzyl 2-hexyldecanoate, benzyl 2-heptylundecanoate, benzyl 2-octyldecanoate, benzyl 2-octyldodecanoate, benzyl 2-decyldecanoate, benzyl 2-decyltetradecanoate, phenylethyl 2-butyloctanoate, phenylethyl 2-hexyloctanoate, phenylethyl 2-hexyldecanoate, phenylethyl 2-heptylundecanoate, phenylethyl 2-octyldecanoate, phenylethyl 2-octyldodecanoate, phenylethyl 2-decyldecanoate, phenylethyl 2-decyltetradecanoate, phenylpropyl 2-butyloctanoate, phenylpropyl 2-hexyloctanoate, phenylpropyl 2-hexyldecanoate, phenylpropyl 2-heptylundecanoate, phenylpropyl 2-octyldecanoate, phenylpropyl 2-octyldodecanoate, phenylpropyl 2-decyldecanoate, phenylpropyl 2-decyltetradecanoate, phenylbutyl 2-butyloctanoate, phenylbutyl 2-hexyloctanoate, phenylbutyl 2-hexyldecanoate, phenylbutyl 2-heptylundecanoate, phenylbutyl 2-octyldecanoate, phenylbutyl 2-octyldodecanoate, phenylbutyl 2-decyldecanoate, phenylbutyl 2-decyltetradecanoate, phenylpentyl 2-butyloctanoate, phenylpentyl 2-hexyloctanoate, phenylpentyl 2-hexyldecanoate, phenylpentyl 2-heptylundecanoate, phenylpentyl 2-octyldecanoate,

- 12 -

phenylpentyl 2-octyldodecanoate, phenylpentyl 2-decyldodecanoate, phenylpentyl 2-decyltetradecanoate, and the like.

[0037] The aromatic alkanooate monoester compositions of formula (I) of the present disclosure can be prepared by a process (I) that involves reacting a substituted or unsubstituted alcohol with a substituted or unsubstituted aromatic alkanooic acid, optionally in the presence of a catalyst, under reaction conditions sufficient to produce one or more alkanooate monoester compositions of formula (I).

[0038] Illustrative alcohols useful in the process (I) of this disclosure include, for example, 2-heptyl-1-undecanol, 2-hexyl-1-octanol, 2-hexyl-1-decanol, 2-octyl-1-decanol, 2-octyl-1-dodecanol, 2-butyl-1-octanol, 2-decyl-1-dodecanol, 2-decyl-1-tetradecanol, 2-ethyl-1-hexanol, 2-butyl-1-hexanol, isopropanol, 2-methylbutanol, 2-methyl-1-pentanol, isotridecanol, isodecanol, isononanol, isooctanol, alcohols obtained from hydroformylation of terminal monosubstituted alkenes, 1,1-disubstituted alkenes, cis- or trans-1,2-disubstituted alkenes using carbon monoxide, hydrogen and a suitable transition metal catalyst, followed by hydrogenation (commonly known as oxo alcohols), and the like. Examples of commercially available oxo alcohols are, but not limited to, Exxal™ alcohols manufactured and marketed by ExxonMobil Corporation).

[0039] Illustrative aromatic alkanooic acids useful in the process (I) of this disclosure include, for example, benzoic acid, phenylacetic acid, phenylpropionic acid, phenylbutyric acid, methoxyphenylacetic acid, tolylacetic acid, nitrophenylacetic acid, xylylacetic acid, tolylpropionic acid, xylylpropionic acid, methoxyphenylpropionic acid, methoxyphenylbutyric acid, nitrophenylpropionic acid, nitrophenylbutyric acid, xylylbutyric acid, tolylbutyric acid, and the like.

[0040] Reaction conditions for the reaction of the alcohol with the aromatic or alkanooic acid, such as temperature, pressure and contact time, may also vary greatly and any suitable combination of such conditions may be employed herein. The reaction temperature may range between about 25°C to about 300°C, and preferably between about 50°C to about 250°C, and more preferably between about 100°C to about 200°C. Normally the reaction is carried out under ambient pressure and the contact time may vary from a matter of seconds or minutes to a few hours or greater. The reactants can be added to the reaction mixture or combined in any order. The reaction residence time employed can range from about 30 seconds to about 48 hours, preferably from about 5 minutes to 36 hours, and more preferably from about 1 hour to 24 hours.

[0041] The aromatic alkanooate monoester compositions of formula (II) of the present disclosure can be prepared by a process (II) that involves reacting a substituted or unsubstituted aromatic alkanol with a substituted or unsubstituted carboxylic acid, optionally in the presence of

- 13 -

a catalyst, under reaction conditions sufficient to produce aromatic alkanooate monoester compositions of formula (II).

[0042] Illustrative aromatic alkanols useful in the process (II) of this disclosure include, for example, benzyl alcohol, phenylethanol, phenylpropanol, phenylbutanol, phenylpentanol, tolylethanol, phenylbenzyl alcohol, and the like.

[0043] Illustrative carboxylic acids useful in the process (II) of this disclosure include, for example, 2-hexyldecanoic acid, 2-heptylundecanoic acid, 2-hexyloctanoic acid, 2-butylhexanoic acid, 2-octyldecanoic acid, 2-butyldecanoic acid, 2-hexyldecanoic acid, 2-butyldecanoic acid, 2-ethylhexanoic acid, 2-butyldecanoic acid, 2-hexyldecanoic acid, 2-octyldecanoic acid, 2-decyldecanoic acid, 2-decyltetradecanoic acid, isotridecanoic acid, isononanoic acid, and the like.

[0044] Reaction conditions for the reaction of the aromatic alkanol with the carboxylic acid, such as temperature, pressure and contact time, may also vary greatly and any suitable combination of such conditions may be employed herein. The reaction temperature may range between about 25°C to about 300°C, and preferably between about 50°C to about 250°C, and more preferably between about 100°C to about 200°C. Normally the reaction is carried out under ambient pressure and the contact time may vary from a matter of seconds or minutes to a few hours or greater. The reactants can be added to the reaction mixture or combined in any order. The stir time employed can range from about 30 seconds to about 48 hours, preferably from about 5 minutes to 36 hours, and more preferably from about 1 hour to 24 hours.

[0045] As shown in the Examples herein, the aromatic alkanooate monoester compositions of formulae (I) and (II) have more desirable viscosity-volatility characteristics when compared to commercially available low viscosity Group IV PAO synthetic base stocks (e.g., SpectraSyn™ 2, SpectraSyn™ 4) or Group V ester base stocks (e.g., 2-ethylhexyl oleate, 2-ethylhexyl adipate, isodecyl adipate, 2-ethylhexyl phthalate, nC8/nC10 neopentyl glycol esters, nC7 trimethylpropane ester, and the like). As shown in the Examples herein, the aromatic alkanooate monoester compositions of formulae (I) and (II) of the present disclosure have lower viscosities than commercially available esters at similar volatility. Additionally, the aromatic alkanooate monoester compositions of formulae (I) and (II) have lower volatility than commercially available esters at comparable viscosities.

[0046] Surprisingly, as shown in the Examples herein, it has been discovered that formulated engine oils employing these aromatic alkanooate monoester compositions of formulae (I) and (II) as a major component possess unexpectedly high thermal and oxidative stability along with good deposit control benefit, as confirmed by their consistently low deposit formation from the Thermo-

- 14 -

Oxidation Engine Oil Simulation Test (TEOST 33C ASTM D6335) conducted at high temperature. In comparison, the same formulation based on commercially available ester base stocks (e.g., diisooctyl adipate) show high deposit formation in the same test. This finding is surprising based on conventional belief that ester base stocks derived from alcohol with beta hydrogen atoms can readily undergo beta elimination to form carboxylic acid and olefin at temperature $>275^{\circ}\text{C}$, which can potentially contribute to deposit formation through further reactions (e.g., oxidation, polymerization, etc.).

[0047] Furthermore, it has been found that these aromatic alkanoate monoester compositions of formulae (I) and (II) also show high solvency for the typical additive components (e.g., antiwear additives, friction modifiers, dispersants, detergents, antioxidants, viscosity modifiers, pour point depressants, antifoaming agent, etc.) employed in the formulation of PVL (Passenger Vehicles Lubricants), CVL (Commercial Vehicles Lubricants), as well as industrial applications.

[0048] Examples of techniques that can be employed to characterize the compositions formed by the process described above include, but are not limited to, analytical gas chromatography, nuclear magnetic resonance, thermogravimetric analysis (TGA), inductively coupled plasma mass spectrometry, differential scanning calorimetry (DSC), volatility and viscosity measurements.

[0049] This disclosure provides lubricating oils useful as engine oils and in other applications characterized by excellent oxidative stability. The lubricating oils are based on high quality base stocks including a major portion of a hydrocarbon base fluid such as a PAO or GTL with a secondary cobase stock component which is a monoester as described herein. The lubricating oil base stock can be any oil boiling in the lube oil boiling range, typically between about 100 to 450°C . In the present specification and claims, the terms base oil(s) and base stock(s) are used interchangeably.

[0050] The viscosity-temperature relationship of a lubricating oil is one of the critical criteria which must be considered when selecting a lubricant for a particular application. Viscosity Index (VI) is an empirical, unitless number which indicates the rate of change in the viscosity of an oil within a given temperature range. Fluids exhibiting a relatively large change in viscosity with temperature are said to have a low viscosity index. A low VI oil, for example, will thin out at elevated temperatures faster than a high VI oil. Usually, the high VI oil is more desirable because it has higher viscosity at higher temperature, which translates into better or thicker lubrication film and better protection of the contacting machine elements.

[0051] In another aspect, as the oil operating temperature decreases, the viscosity of a high VI oil will not increase as much as the viscosity of a low VI oil. This is advantageous because the excessive high viscosity of the low VI oil will decrease the efficiency of the operating machine.

Thus high VI (HVI) oil has performance advantages in both high and low temperature operation. VI is determined according to ASTM D2270. VI is related to kinematic viscosities measured at 40°C and 100°C using ASTM D445.

Lubricating Oil Base Stocks

[0052] A wide range of lubricating oils is known in the art. Lubricating oils that are useful in the present disclosure are both natural oils and synthetic oils. Natural and synthetic oils (or mixtures thereof) can be used 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 the at least one lubricating oil property. One skilled in the art is familiar with many purification processes. These processes include solvent extraction, secondary 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 a feed stock.

[0053] 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 between about 80 to 120 and contain greater than about 0.03% sulfur and less than about 90% saturates. Group II base stocks generally have a viscosity index of between about 80 to 120, and contain less than or equal to about 0.03% sulfur and greater than or equal to about 90% saturates. Group III stock generally has a viscosity index greater than about 120 and contains less than or equal to about 0.03% sulfur and greater than about 90% saturates. Group IV includes polyalphaolefins (PAO). Group V base stocks include 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) products		
Group V	All other base oil stocks not included in Groups I, II, III or IV		

- 16 -

[0054] Natural oils include animal oils, vegetable oils (castor oil and lard oil, for example), and mineral oils. Animal and vegetable oils possessing favorable thermal oxidative stability can be used. Of the natural oils, mineral oils are preferred. Mineral oils vary widely as to their crude source, for example, as to whether they are paraffinic, naphthenic, or mixed paraffinic-naphthenic. Oils derived from coal or shale are also useful in the present disclosure. Natural oils vary also as to the method used for their production and purification, for example, their distillation range and whether they are straight run or cracked, hydrorefined, or solvent extracted.

[0055] Group II and/or Group III hydroprocessed or hydrocracked base stocks, as well as synthetic oils such as polyalphaolefins, alkyl aromatics and synthetic esters, i.e. Group IV and Group V oils are also well known base stock oils.

[0056] Synthetic oils include hydrocarbon oil such as polymerized and interpolymerized olefins (polybutylenes, polypropylenes, propylene isobutylene copolymers, ethylene-olefin copolymers, and ethylene-alphaolefin copolymers, for example). Polyalphaolefin (PAO) oil base stocks, the Group IV API base stocks, are a commonly used synthetic hydrocarbon oil. By way of example, PAOs derived from C₈, C₁₀, C₁₂, C₁₄ olefins or mixtures thereof may be utilized. See U.S. Patent Nos. 4,956,122; 4,827,064; and 4,827,073, which are incorporated herein by reference in their entirety. Group IV oils, that is, the PAO base stocks have viscosity indices preferably greater than 130, more preferably greater than 135, still more preferably greater than 140.

[0057] Esters may be useful in the lubricating oils of this disclosure. Additive solvency and seal compatibility characteristics may be secured by the use of esters such as the esters of dibasic acids with monoalkanols and the polyol esters of monocarboxylic acids. Esters of the former type include, for example, the esters of dicarboxylic acids such as phthalic acid, succinic acid, sebacic acid, fumaric acid, adipic acid, linoleic acid dimer, malonic acid, alkyl malonic acid, alkenyl malonic acid, etc., with a variety of alcohols such as butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, etc. Specific examples of these types of esters include dibutyl adipate, di(2-ethylhexyl) sebacate, di-n-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, etc.

[0058] Particularly useful synthetic esters are those which are obtained by reacting one or more polyhydric alcohols, preferably the hindered polyols such as the neopentyl polyols; e.g., neopentyl glycol, trimethylol ethane, 2-methyl-2-propyl-1,3-propanediol, trimethylol propane, pentaerythritol and dipentaerythritol with alkanolic acids containing at least about 4 carbon atoms, preferably C₅ to C₃₀ acids such as saturated straight chain fatty acids including caprylic acid, capric acids, lauric acid, myristic acid, palmitic acid, stearic acid, arachic acid, and behenic acid, or the

corresponding branched chain fatty acids or unsaturated fatty acids such as oleic acid, or mixtures of any of these materials.

[0059] Esters should be used in an amount such that the improved wear and corrosion resistance provided by the lubricating oils of this disclosure are not adversely affected.

[0060] Non-conventional or unconventional base stocks and/or base oils include one or a mixture of base stock(s) and/or base oil(s) derived from: (1) one or more Gas-to-Liquids (GTL) materials, as well as (2) hydrodewaxed, or hydroisomerized/cat (and/or solvent) dewaxed base stock(s) and/or base oils derived from synthetic wax, natural wax or waxy feeds, mineral and/or non-mineral oil waxy feed stocks such as gas oils, slack waxes (derived from the solvent dewaxing of natural oils, mineral oils or synthetic oils; e.g., Fischer-Tropsch feed stocks), natural waxes, and waxy stocks such as gas oils, waxy fuels hydrocracker bottoms, waxy raffinate, hydrocrackate, thermal crackates, foots oil or other mineral, mineral oil, or even non-petroleum oil derived waxy materials such as waxy materials recovered from coal liquefaction or shale oil, linear or branched hydrocarbyl compounds with carbon number of about 20 or greater, preferably about 30 or greater and mixtures of such base stocks and/or base oils.

[0061] GTL materials are materials that are derived via one or more synthesis, combination, transformation, rearrangement, and/or degradation/deconstructive processes from gaseous carbon-containing compounds, hydrogen-containing compounds and/or elements as feed stocks such as hydrogen, carbon dioxide, carbon monoxide, water, methane, ethane, ethylene, acetylene, propane, propylene, propyne, butane, butylenes, and butynes. GTL base stocks and/or base oils are GTL materials of lubricating viscosity that are generally derived from hydrocarbons; for example, waxy synthesized hydrocarbons, that are themselves derived from simpler gaseous carbon-containing compounds, hydrogen-containing compounds and/or elements as feed stocks. GTL base stock(s) and/or base oil(s) include oils boiling in the lube oil boiling range (1) separated/fractionated from synthesized GTL materials such as, for example, by distillation and subsequently subjected to a final wax processing step which involves either or both of a catalytic dewaxing process, or a solvent dewaxing process, to produce lube oils of reduced/low pour point; (2) synthesized wax isomerates, comprising, for example, hydrodewaxed or hydroisomerized cat and/or solvent dewaxed synthesized wax or waxy hydrocarbons; (3) hydrodewaxed or hydroisomerized cat and/or solvent dewaxed Fischer-Tropsch (F-T) material (i.e., hydrocarbons, waxy hydrocarbons, waxes and possible analogous oxygenates); preferably hydrodewaxed or hydroisomerized/ followed by cat and/or solvent dewaxing dewaxed F-T waxy hydrocarbons, or hydrodewaxed or hydroisomerized/ followed by cat (or solvent) dewaxing dewaxed, F-T waxes, or mixtures thereof.

- 18 -

[0062] GTL base stock(s) and/or base oil(s) derived from GTL materials, especially, hydrodewaxed or hydroisomerized/ followed by cat and/or solvent dewaxed wax or waxy feed, preferably F-T material derived base stock(s) and/or base oil(s), are characterized typically as having kinematic viscosities at 100°C of from about 2 mm²/s to about 50 mm²/s (ASTM D445). They are further characterized typically as having pour points of -5°C to about -40°C or lower (ASTM D97). They are also characterized typically as having viscosity indices of about 80 to about 140 or greater (ASTM D2270).

[0063] In addition, the GTL base stock(s) and/or base oil(s) are typically highly paraffinic (>90% saturates), and may contain mixtures of monocycloparaffins and multicycloparaffins in combination with non-cyclic isoparaffins. The ratio of the naphthenic (i.e., cycloparaffin) content in such combinations varies with the catalyst and temperature used. Further, GTL base stock(s) and/or base oil(s) typically have very low sulfur and nitrogen content, generally containing less than about 10 ppm, and more typically less than about 5 ppm of each of these elements. The sulfur and nitrogen content of GTL base stock(s) and/or base oil(s) obtained from F-T material, especially F-T wax, is essentially nil. In addition, the absence of phosphorous and aromatics make this material especially suitable for the formulation of low SAP products.

[0064] The term GTL base stock and/or base oil and/or wax isomerate base stock and/or base oil is to be understood as embracing individual fractions of such materials of wide viscosity range as recovered in the production process, mixtures of two or more of such fractions, as well as mixtures of one or two or more low viscosity fractions with one, two or more higher viscosity fractions to produce a blend wherein the blend exhibits a target kinematic viscosity.

[0065] The GTL material, from which the GTL base stock(s) and/or base oil(s) is/are derived is preferably an F-T material (i.e., hydrocarbons, waxy hydrocarbons, wax).

[0066] Base oils for use in the formulated lubricating oils useful in the present disclosure are any of the variety of oils corresponding to API Group I, Group II, Group III, Group IV, Group V and Group VI oils and mixtures thereof, preferably API Group II, Group III, Group IV, Group V and Group VI oils and mixtures thereof, more preferably the Group III to Group VI base oils due to their exceptional volatility, stability, viscometric and cleanliness features. Minor quantities of Group I stock, such as the amount used to dilute additives for blending into formulated lube oil products, can be tolerated but should be kept to a minimum, i.e. amounts only associated with their use as diluent/carrier oil for additives used on an "as received" basis. Even in regard to the Group II stocks, it is preferred that the Group II stock be in the higher quality range associated with that stock, i.e. a Group II stock having a viscosity index in the range $100 < VI < 120$.

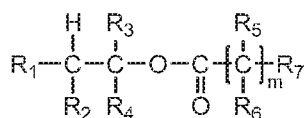
- 19 -

[0067] In addition, the GTL base stock(s) and/or base oil(s) are typically highly paraffinic (>90% saturates), and may contain mixtures of monocycloparaffins and multicycloparaffins in combination with non-cyclic isoparaffins. The ratio of the naphthenic (i.e., cycloparaffin) content in such combinations varies with the catalyst and temperature used. Further, GTL base stock(s) and/or base oil(s) and hydrodewaxed, or hydroisomerized/cat (and/or solvent) dewaxed base stock(s) and/or base oil(s) typically have very low sulfur and nitrogen content, generally containing less than about 10 ppm, and more typically less than about 5 ppm of each of these elements. The sulfur and nitrogen content of GTL base stock(s) and/or base oil(s) obtained from F-T material, especially F-T wax, is essentially nil. In addition, the absence of phosphorous and aromatics make this material especially suitable for the formulation of low sulfur, sulfated ash, and phosphorus (low SAP) products.

[0068] The base stock component of the present lubricating oils will typically be from 1 to 99 weight percent of the total composition (all proportions and percentages set out in this specification are by weight unless the contrary is stated) and more preferably in the range of 10 to 99 weight percent, or more preferably from 15 to 80 percent, or more preferably from 20 to 70 percent, or more preferably from 25 to 60 percent, or more preferably from 30 to 50 percent.

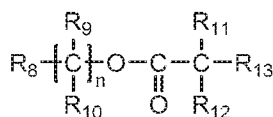
Aromatic Alkanoate Monoester Base Stock and Cobase Stock Components

[0069] Aromatic alkanoate monoester base stock and cobase stock components useful in this disclosure include, for example, compositions containing one or more compounds represented by the formula selected from the group consisting of



(I)

and



(II)

wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆,

- 20 -

R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from about 1 to about 10, and n is a value greater than or equal to 1. The composition has a viscosity (K_{V100}) from about 1cSt to about 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800.

[0070] Preferred aromatic alkanooate monoester base stock and cobase stock components of this disclosure include, for example, those wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₂₀); R₃, R₄, R₅, R₆, R₉, R₁₀, R₁₁, R₁₂ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₂₀), alkenyl group (C₁-C₂₀), or alkoxy group (C₁-C₂₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₂₀), heteroaryl group (C₄-C₂₀), or arylalkyl group (C₅-C₂₀), and m and n are independently a value from about 1 to about 8.

[0071] Other preferred aromatic alkanooate monoester base stock and cobase stock components of this disclosure include, for example, those wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₁₀); R₃, R₄, R₅, R₆, R₉, R₁₀, R₁₁, R₁₂ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₁₀), alkenyl group (C₁-C₁₀), or alkoxy group (C₁-C₁₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₁₀), heteroaryl group (C₄-C₁₀), or arylalkyl group (C₅-C₁₀), and m and n are independently a value from about 2 to about 8.

[0072] Illustrative aromatic alkanooate monoester base stock and cobase stock components of this disclosure have a viscosity (K_{V100}) from about 1 cSt to about 8 cSt, more preferably from about 2 cSt to about 6 cSt, at 100°C as determined by ASTM D445, a viscosity index (VI) from about -100 to about 300, more preferably from about 0 to about 200, even more preferably from about 25 to about 150, as determined by ASTM D2270, a Noack volatility of no greater than 25 percent, more preferably no greater than 20 percent, even more preferably no greater than 15 percent, as determined by ASTM D5800, and a high temperature high shear (HTHS) viscosity of less than about 2.5 cP, more preferably less than about 2.25 cP, even more preferably less than about 2.0 cP, as determined by ASTM D4683.

[0073] Preferred aromatic alkanooate monoester base stock and cobase stock components of this disclosure have a high temperature high shear (HTHS) viscosity of less than about 1.7 cP as determined by ASTM D4683, and a Noack volatility from about 15 percent to about 30 percent as determined by ASTM D5800.

[0074] Illustrative aromatic alkanooate monoester base stock and cobase stock components of this disclosure include, for example, 2-hexyl-1-decyl benzoate, 2-hexyl-1-decyl phenylacetate, 2-

- 21 -

hexyl-1-decyl 3-phenylpropionate, 2-octyl-1-dodecyl phenylacetate, 2-butyl-1-octyl 4-phenylbutyrate, 2-hexyl-1-decyl 4-methoxyphenylacetate, 2-hexyl-1-decyl m-tolylacetate, 2-hexyl-1-decyl p-tolylacetate, 2-phenylethyl 2-hexyldecanoate, and the like.

[0075] Illustrative aromatic alkanoate monoester base stock and cobase stock components of formula (I) include, for example, 2-ethylhexyl phenylacetate, 2-heptylundecyl phenylacetate, 2-octyldecyl phenylacetate, 2-octyldodecyl phenylacetate, 2-decyldodecyl phenylacetate, 2-decyltetradecyl phenylacetate, 2-hexyldecyl phenylacetate, 2-butyloctyl phenylacetate, isopropyl phenylacetate, 2-methylbutyl phenylacetate, 2-methylpentyl phenylacetate, isotridecyl phenylacetate, isodecyl phenylacetate, isononyl phenylacetate, isooctyl phenylacetate, 2-ethylhexyl phenylpropionate, 2-heptylundecyl phenylpropionate, 2-octyldecyl phenylpropionate, 2-octyldodecyl phenylpropionate, 2-decyldodecyl phenylpropionate, 2-decyltetradecyl phenylpropionate, 2-hexyldecyl phenylpropionate, 2-butyloctyl phenylpropionate, isopropyl phenylpropionate, 2-methylbutyl phenylpropionate, 2-methylpentyl phenylpropionate, isotridecyl phenylpropionate, isodecyl phenylpropionate, isononyl phenylpropionate, isooctyl phenylpropionate, 2-ethylhexyl tolylacetate, 2-heptylundecyl tolylacetate, 2-octyldecyl tolylacetate, 2-octyldodecyl tolylacetate, 2-decyldodecyl tolylacetate, 2-decyltetradecyl tolylacetate, 2-hexyldecyl tolylacetate, 2-butyloctyl tolylacetate, isopropyl tolylacetate, 2-methylbutyl tolylacetate, 2-methylpentyl tolylacetate, isotridecyl tolylacetate, isodecyl tolylacetate, isononyl tolylacetate, isooctyl tolylacetate, 2-ethylhexyl tolylpropionate, 2-heptylundecyl tolylpropionate, 2-octyldecyl tolylpropionate, 2-octyldodecyl tolylpropionate, 2-decyldodecyl tolylpropionate, 2-decyltetradecyl tolylpropionate, 2-hexyldecyl tolylpropionate, 2-butyloctyl tolylpropionate, isopropyl tolylpropionate, 2-methylbutyl tolylpropionate, 2-methylpentyl tolylpropionate, isotridecyl tolylpropionate, isodecyl tolylpropionate, isononyl tolylpropionate, isooctyl tolylpropionate, 2-ethylhexyl xylylacetate, 2-heptylundecyl xylylacetate, 2-octyldecyl xylylacetate, 2-octyldodecyl xylylacetate, 2-decyldodecyl xylylacetate, 2-decyltetradecyl xylylacetate, 2-hexyldecyl xylylacetate, 2-butyloctyl xylylacetate, isopropyl xylylacetate, 2-methylbutyl xylylacetate, 2-methylpentyl xylylacetate, isotridecyl xylylacetate, isodecyl xylylacetate, isononyl xylylacetate, isooctyl xylylacetate, 2-ethylhexyl xylylpropionate, 2-heptylundecyl xylylpropionate, 2-octyldecyl xylylpropionate, 2-octyldodecyl xylylpropionate, 2-decyldodecyl xylylpropionate, 2-decyltetradecyl xylylpropionate, 2-hexyldecyl xylylpropionate, 2-butyloctyl xylylpropionate, isopropyl xylylpropionate, 2-methylbutyl xylylpropionate, 2-methylpentyl xylylpropionate, isotridecyl xylylpropionate, isodecyl xylylpropionate, isononyl xylylpropionate, isooctyl xylylpropionate, 2-ethylhexyl methoxyphenylacetate, 2-heptylundecyl methoxyphenylacetate, 2-octyldecyl methoxyphenylacetate, 2-octyldodecyl

- 22 -

methoxyphenylacetate, 2-decyldodecyl methoxyphenylacetate, 2-decyltetradecyl methoxyphenylacetate, 2-hexyldecyl methoxyphenylacetate, 2-butyloctyl methoxyphenylacetate, isopropyl methoxyphenylacetate, 2-methylbutyl methoxyphenylacetate, 2-methylpentyl methoxyphenylacetate, isotridecyl methoxyphenylacetate, isodecyl methoxyphenylacetate, isononyl methoxyphenylacetate, isooctyl methoxyphenylacetate, 2-ethylhexyl methoxyphenylpropionate, 2-heptylundecyl methoxyphenylpropionate, 2-octyldecyl methoxyphenylpropionate, 2-octyldodecyl methoxyphenylpropionate, 2-decyldodecyl methoxyphenylpropionate, 2-decyltetradecyl methoxyphenylpropionate, 2-hexyldecyl methoxyphenylpropionate, 2-butyloctyl methoxyphenylpropionate, isopropyl methoxyphenylpropionate, 2-methylbutyl methoxyphenylpropionate, 2-methylpentyl methoxyphenylpropionate, isotridecyl methoxyphenylpropionate, isodecyl methoxyphenylpropionate, isononyl methoxyphenylpropionate, isooctyl methoxyphenylpropionate, 2-ethylhexyl phenylbutyrate, 2-heptylundecyl phenylbutyrate, 2-octyldecyl phenylbutyrate, 2-octyldodecyl phenylbutyrate, 2-decyldodecyl phenylbutyrate, 2-decyltetradecyl phenylbutyrate, 2-hexyldecyl phenylbutyrate, 2-butyloctyl phenylbutyrate, isopropyl phenylbutyrate, 2-methylbutyl phenylbutyrate, 2-methylpentyl phenylbutyrate, isotridecyl phenylbutyrate, isodecyl phenylbutyrate, isononyl phenylbutyrate, isooctyl phenylbutyrate, and the like.

[0076] Illustrative aromatic alkanoate monoester base stock and cobase stock components of formula (II) include, for example, benzyl 2-butyloctanoate, benzyl 2-hexyloctanoate, benzyl 2-hexyldecanoate, benzyl 2-heptylundecanoate, benzyl 2-octyldecanoate, benzyl 2-octyldodecanoate, benzyl 2-decyldodecanoate, benzyl 2-decyltetradecanoate, phenylethyl 2-butyloctanoate, phenylethyl 2-hexyloctanoate, phenylethyl 2-hexyldecanoate, phenylethyl 2-heptylundecanoate, phenylethyl 2-octyldecanoate, phenylethyl 2-octyldodecanoate, phenylethyl 2-decyldodecanoate, phenylethyl 2-decyltetradecanoate, phenylpropyl 2-butyloctanoate, phenylpropyl 2-hexyloctanoate, phenylpropyl 2-hexyldecanoate, phenylpropyl 2-heptylundecanoate, phenylpropyl 2-octyldecanoate, phenylpropyl 2-octyldodecanoate, phenylpropyl 2-decyldodecanoate, phenylpropyl 2-decyltetradecanoate, phenylbutyl 2-butyloctanoate, phenylbutyl 2-hexyloctanoate, phenylbutyl 2-hexyldecanoate, phenylbutyl 2-heptylundecanoate, phenylbutyl 2-octyldecanoate, phenylbutyl 2-octyldodecanoate, phenylbutyl 2-decyldodecanoate, phenylbutyl 2-decyltetradecanoate, phenylpentyl 2-butyloctanoate, phenylpentyl 2-hexyloctanoate, phenylpentyl 2-hexyldecanoate, phenylpentyl 2-heptylundecanoate, phenylpentyl 2-octyldecanoate, phenylpentyl 2-octyldodecanoate, phenylpentyl 2-decyldodecanoate, phenylpentyl 2-decyltetradecanoate, and the like.

- 23 -

[0077] The aromatic alkanooate monoester base stock and cobase stock components of formula (I) of the present disclosure can be prepared by a process (I) that involves reacting a substituted or unsubstituted alcohol with a substituted or unsubstituted aromatic alkanooic acid, optionally in the presence of a catalyst, under reaction conditions sufficient to produce one or more aromatic alkanooate monoester base stock and cobase stock components of formula (I).

[0078] Illustrative alcohols useful in the process (I) of this disclosure include, for example, 2-heptyl-1-undecanol, 2-hexyl-1-octanol, 2-hexyl-1-decanol, 2-octyl-1-decanol, 2-octyl-1-dodecanol, 2-butyl-1-octanol, 2-decyl-1-dodecanol, 2-decyl-1-tetradecanol, 2-ethyl-1-hexanol, 2-butyl-1-hexanol, isopropanol, 2-methylbutanol, 2-methyl-1-pentanol, isotridecanol, isodecanol, isononanol, isooctanol, alcohols obtained from hydroformylation-hydrogenation of terminal monosubstituted alkenes, 1,1-disubstituted alkenes, cis- or trans-1,2-disubstituted alkenes (commonly known as oxo alcohols). Examples of commercially available oxo alcohols are, but not limited to, Exxal™ alcohols manufactured and marketed by ExxonMobil Corporation), and the like.

[0079] Illustrative aromatic alkanooic acids useful in the process (I) of this disclosure include, for example, benzoic acid, phenylacetic acid, phenylpropionic acid, phenylbutyric acid, methoxyphenylacetic acid, tolylacetic acid, nitrophenylacetic acid, xylylacetic acid, tolylpropionic acid, xylylpropionic acid, methoxyphenylpropionic acid, methoxyphenylbutyric acid, nitrophenylpropionic acid, nitrophenylbutyric acid, xylylbutyric acid, tolylbutyric acid, and the like.

[0080] Reaction conditions for the reaction of the alcohol with the aromatic or alkanooic acid, such as temperature, pressure and contact time, may also vary greatly and any suitable combination of such conditions may be employed herein. The reaction temperature may range between about 25°C to about 300°C, and preferably between about 50°C to about 250°C, and more preferably between about 100°C to about 200°C. Normally the reaction is carried out under ambient pressure and the contact time may vary from a matter of seconds or minutes to a few hours or greater. The reactants can be added to the reaction mixture or combined in any order. The reaction residence time employed can range from about 30 seconds to about 48 hours, preferably from about 5 minutes to 36 hours, and more preferably from about 1 hour to 24 hours.

[0081] The aromatic alkanooate monoester base stock and cobase stock components of formula (II) of the present disclosure can be prepared by a process (II) that involves reacting a substituted or unsubstituted aromatic alkanol with a substituted or unsubstituted carboxylic acid, optionally in the presence of a catalyst, under reaction conditions sufficient to produce aromatic alkanooate monoester base stock and cobase stock components of formula (II).

- 24 -

[0082] Illustrative aromatic alkanols useful in the process (II) of this disclosure include, for example, benzyl alcohol, phenylethanol, phenylpropanol, phenylbutanol, phenylpentanol, tolylethanol, phenylbenzyl alcohol, and the like.

[0083] Illustrative carboxylic acids useful in the process (II) of this disclosure include, for example, 2-hexyldecanoic acid, 2-hexyloctanoic acid, 2-heptylundecanoic acid, 2-butylhexanoic acid, 2-octyldecanoic acid, 2-butyldecanoic acid, 2-butyl octanoic acid, 2-ethylhexanoic acid, 2-butyl dodecanoic acid, 2-hexyl dodecanoic acid, 2-octyl dodecanoic acid, 2-decyl dodecanoic acid, 2-decyl tetradecanoic acid, isotridecanoic acid, isononanoic acid, and the like.

[0084] Reaction conditions for the reaction of the aromatic alkanol with the carboxylic acid, such as temperature, pressure and contact time, may also vary greatly and any suitable combination of such conditions may be employed herein. The reaction temperature may range between about 25°C to about 300°C, and preferably between about 50°C to about 250°C, and more preferably between about 100°C to about 200°C. Normally the reaction is carried out under ambient pressure and the contact time may vary from a matter of seconds or minutes to a few hours or greater. The reactants can be added to the reaction mixture or combined in any order. The reaction residence time employed can range from about 30 seconds to about 48 hours, preferably from about 5 minutes to 36 hours, and more preferably from about 1 hour to 24 hours.

[0085] The monoester base stock component is preferably present in an amount sufficient for providing oxidative stability in the lubricating oil. The monoester base stock component can be present as the major base stock in the lubricating oils of this disclosure. Accordingly, the monoester can be present in an amount from about 1 to about 99 weight percent, preferably from about 5 to about 99 weight percent, and more preferably from about 10 to about 99 weight percent, or more preferably from about 40 to about 90 weight percent, or more preferably from about 50 to about 80 weight percent, or more preferably from about 60 to about 80 weight percent.

[0086] The monoester base stock component can also be present as a minor co-base stock in the lubricating oils of this disclosure. Accordingly, the monoester co-base stock component of the present lubricating oils will typically be present from 1 to 50 weight, or more preferably from 5 to 50 percent, or more preferably from 10 to 40 percent, or more preferably from 20 to 30 percent.

Other Additives

[0087] The formulated lubricating oil useful in the present disclosure may additionally contain one or more of the other commonly used lubricating oil performance additives including but not limited to dispersants, other detergents, corrosion inhibitors, rust inhibitors, metal deactivators, other anti-wear agents and/or extreme pressure additives, anti-seizure agents, wax modifiers, viscosity index improvers, viscosity modifiers, fluid-loss additives, seal compatibility agents, other

- 25 -

friction modifiers, lubricity agents, anti-staining agents, chromophoric agents, defoamants, demulsifiers, emulsifiers, densifiers, wetting agents, gelling agents, tackiness agents, colorants, and others. For a review of many commonly used additives, see Klamann in Lubricants and Related Products, Verlag Chemie, Deerfield Beach, FL; ISBN 0-89573-177-0. Reference is also made to "Lubricant Additives Chemistry and Applications" edited by Leslie R. Rudnick, Marcel Dekker, Inc. New York, 2003 ISBN: 0-8247-0857-1.

[0088] All of the additives described below can be used alone or in combination. The total treat rates for the additives can range from 1 to 30 percent, or more preferably from 2 to 25 percent, or more preferably from 3 to 20 percent, or more preferably from 4 to 15 percent, or more preferably from 5 to 10 percent. Particularly preferred compositions have additive levels between 15 and 20 percent.

[0089] The types and quantities of performance additives used in combination with the instant disclosure in lubricant compositions are not limited by the examples shown herein as illustrations.

Viscosity Modifiers

[0090] Viscosity modifiers (also known as viscosity index improvers - VI improvers - and viscosity improvers) can be included in the lubricant compositions of this disclosure.

[0091] Viscosity modifiers provide lubricants with high and low temperature operability. These additives impart shear stability at elevated temperatures and acceptable viscosity at low temperatures.

[0092] Suitable viscosity modifiers include high molecular weight hydrocarbons, polyesters and viscosity modifier dispersants that function as both a viscosity modifier and a dispersant. Typical molecular weights of these polymers are between about 10,000 to 1,500,000, more typically about 20,000 to 1,200,000, and even more typically between about 50,000 and 1,000,000.

[0093] Examples of suitable viscosity modifiers are linear or star-shaped polymers and copolymers of methacrylate, butadiene, olefins, or alkylated styrenes. Polyisobutylene is a commonly used viscosity modifier. Another suitable viscosity modifier is polymethacrylate (copolymers of various chain length alkyl methacrylates, for example), some formulations of which also serve as pour point depressants. Other suitable viscosity modifiers include copolymers of ethylene and propylene, hydrogenated block copolymers of styrene and isoprene, and polyacrylates (copolymers of various chain length acrylates, for example). Specific examples include styrene-isoprene or styrene-butadiene based polymers of 50,000 to 200,000 molecular weight.

[0094] Olefin copolymers are commercially available from Chevron Oronite Company LLC under the trade designation "PARATONE®" (such as "PARATONE® 8921" and "PARATONE®

- 26 -

8941”); from Afton Chemical Corporation under the trade designation “HiTEC®” (such as “HiTEC® 5850B”); and from The Lubrizol Corporation under the trade designation “Lubrizol® 7067C”. Hydrogenated polyisoprene star polymers are commercially available from Infineum International Limited, e.g., under the trade designation “SV200” and “SV600”. Hydrogenated diene-styrene block copolymers are commercially available from Infineum International Limited, e.g., under the trade designation “SV 50”.

[0095] The polymethacrylate or polyacrylate polymers can be linear polymers which are available from Evnoik Industries under the trade designation “Viscoplex®” (e.g., Viscoplex 6-954) or star polymers which are available from Lubrizol Corporation under the trade designation Asteric™ (e.g., Lubrizol 87708 and Lubrizol 87725).

[0096] Illustrative vinyl aromatic-containing polymers useful in this disclosure may be derived predominantly from vinyl aromatic hydrocarbon monomer. Illustrative vinyl aromatic-containing copolymers useful in this disclosure may be represented by the following general formula:

A-B

wherein A is a polymeric block derived predominantly from vinyl aromatic hydrocarbon monomer, and B is a polymeric block derived predominantly from conjugated diene monomer.

[0097] The vinyl aromatic-containing polymers or copolymers useful in this disclosure have a weight average molecular weight greater than about 80,000, and a number average molecular weight greater than about 40,000; preferably a weight average molecular weight greater than about 90,000, and a number average molecular weight greater than about 75,000; and more preferably a weight average molecular weight greater than about 100,000 and less than 1,000,000, and a number average molecular weight greater than about 100,000 and less than 1,000,000. The vinyl aromatic-containing polymers or copolymers have an amount of vinyl aromatic content greater than about 10% by weight, or greater than about 20% by weight, or greater than about 30% by weight, of the vinyl aromatic-containing polymer or copolymer. The vinyl aromatic-containing polymers or copolymers have an amount of vinyl aromatic content preferably between about 10% and about 50% by weight, more preferably between about 15% and about 40% by weight, and even more preferably between about 20% and about 35% by weight, of the vinyl aromatic-containing polymer or copolymer.

[0098] In an embodiment of this disclosure, the viscosity modifiers may be used in an amount of less than about 2.0 weight percent, preferably less than about 1.0 weight percent, and more preferably less than about 0.5 weight percent, based on the total weight of the formulated oil or lubricating engine oil. Viscosity modifiers are typically added as concentrates, in large amounts of diluent oil.

- 27 -

[0099] In another embodiment of this disclosure, the viscosity modifiers may be used in an amount of from 0.05 to about 2.0 weight percent, preferably 0.15 to about 1.0 weight percent, and more preferably 0.25 to about 0.5 weight percent, based on the total weight of the formulated oil or lubricating engine oil. Or the viscosity modifiers may be used in an amount (total solid polymer content) of from 0.5 to about 2.0 weight percent, preferably 0.8 to about 1.5 weight percent, and more preferably 1.0 to about 1.3 weight percent, based on the total weight of the formulated oil or lubricating engine oil.

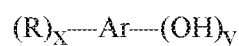
[00100] As used herein, the viscosity modifier concentrations are given on an "as delivered" basis. Typically, the active polymer is delivered with a diluent oil. The "as delivered" viscosity modifier typically contains from 20 weight percent to 75 weight percent of an active polymer for polymethacrylate or polyacrylate polymers, or from 8 weight percent to 20 weight percent of an active polymer for olefin copolymers, hydrogenated polyisoprene star polymers, or hydrogenated diene-styrene block copolymers, in the "as delivered" polymer concentrate.

Antioxidants

[00101] Typical anti-oxidant include phenolic anti-oxidants, aminic anti-oxidants and oil-soluble copper complexes.

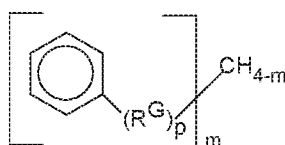
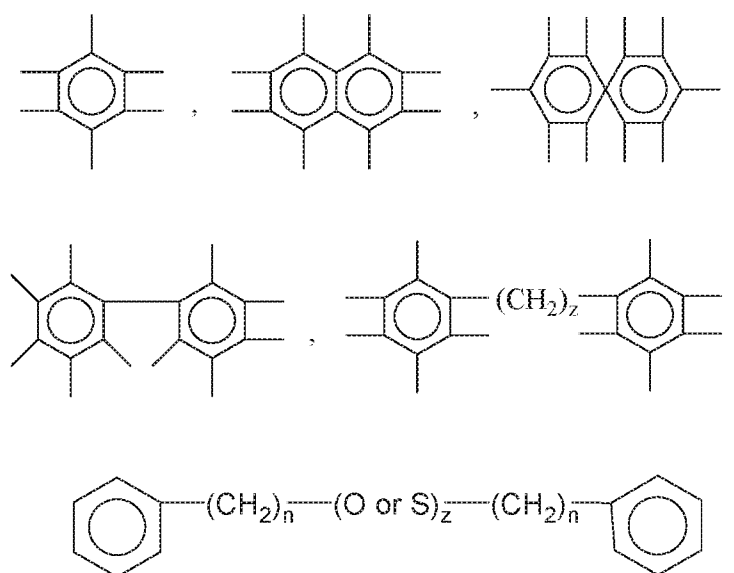
[00102] The phenolic antioxidants include sulfurized and non-sulfurized phenolic antioxidants. The terms "phenolic type" or "phenolic antioxidant" used herein includes compounds having one or more than one hydroxyl group bound to an aromatic ring which may itself be mononuclear, e.g., benzyl, or poly-nuclear, e.g., naphthyl and spiro aromatic compounds. Thus "phenol type" includes phenol per se, catechol, resorcinol, hydroquinone, naphthol, etc., as well as alkyl or alkenyl and sulfurized alkyl or alkenyl derivatives thereof, and bisphenol type compounds including such bi-phenol compounds linked by alkylene bridges sulfuric bridges or oxygen bridges. Alkyl phenols include mono- and poly-alkyl or alkenyl phenols, the alkyl or alkenyl group containing from about 3-100 carbons, preferably 4 to 50 carbons and sulfurized derivatives thereof, the number of alkyl or alkenyl groups present in the aromatic ring ranging from 1 to up to the available unsatisfied valences of the aromatic ring remaining after counting the number of hydroxyl groups bound to the aromatic ring.

[00103] Generally, therefore, the phenolic anti-oxidant may be represented by the general formula:



where Ar is selected from the group consisting of:

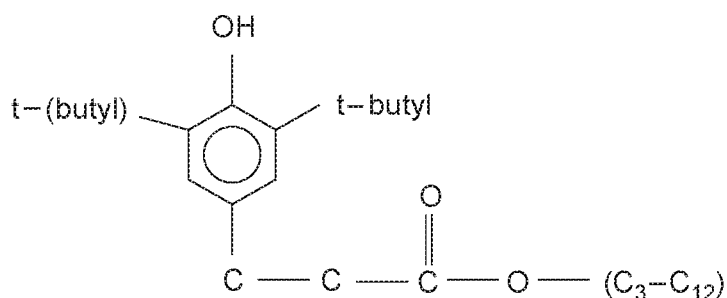
- 28 -



wherein R is a C₃-C₁₀₀ alkyl or alkenyl group, a sulfur substituted alkyl or alkenyl group, preferably a C₄-C₅₀ alkyl or alkenyl group or sulfur substituted alkyl or alkenyl group, more preferably C₃-C₁₀₀ alkyl or sulfur substituted alkyl group, most preferably a C₄-C₅₀ alkyl group, R^G is a C₁-C₁₀₀ alkylene or sulfur substituted alkylene group, preferably a C₂-C₅₀ alkylene or sulfur substituted alkylene group, more preferably a C₂-C₂ alkylene or sulfur substituted alkylene group, y is at least 1 to up to the available valences of Ar, x ranges from 0 to up to the available valences of Ar-y, z ranges from 1 to 10, n ranges from 0 to 20, and m is 0 to 4 and p is 0 or 1, preferably y ranges from 1 to 3, x ranges from 0 to 3, z ranges from 1 to 4 and n ranges from 0 to 5, and p is 0.

[00104] Preferred phenolic anti-oxidant compounds are the hindered phenolics and phenolic esters which contain a sterically hindered hydroxyl group, and these include those derivatives of dihydroxy aryl compounds in which the hydroxyl groups are in the o- or p-position to each other. Typical phenolic anti-oxidants include the hindered phenols substituted with C₁₊ alkyl groups and the alkylene coupled derivatives of these hindered phenols. Examples of phenolic materials of this type 2-t-butyl-4-heptyl phenol; 2-t-butyl-4-octyl phenol; 2-t-butyl-4-dodecyl phenol; 2,6-di-t-butyl-4-heptyl phenol; 2,6-di-t-butyl-4-dodecyl phenol; 2-methyl-6-t-butyl-4-heptyl phenol; 2-methyl-6-t-butyl-4-dodecyl phenol; 2,6-di-t-butyl-4 methyl phenol; 2,6-di-t-butyl-4-ethyl phenol; and 2,6-di-t-butyl 4 alkoxy phenol; and

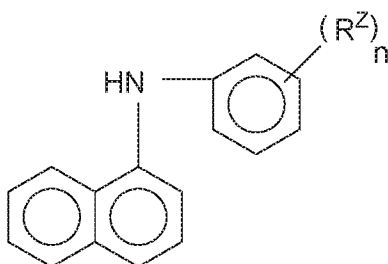
- 29 -



[00105] Phenolic type anti-oxidants are well known in the lubricating industry and commercial examples such as Ethanox® 4710, Irganox® 1076, Irganox® L1035, Irganox® 1010, Irganox® L109, Irganox® L118, Irganox® L135 and the like are familiar to those skilled in the art. The above is presented only by way of exemplification, not limitation on the type of phenolic anti-oxidants which can be used.

[00106] The phenolic anti-oxidant can be employed in an amount in the range of about 0.1 to 5 wt%, preferably about 0.5 to 3 wt%, more preferably 1 to 3 wt% on an active ingredient basis.

[00107] Aromatic amine anti-oxidants include phenyl- α -naphthyl amine which is described by the following molecular structure:



wherein R^Z is hydrogen or a C_1 to C_{14} linear or C_3 to C_{14} branched alkyl group, preferably C_1 to C_{10} linear or C_3 to C_{10} branched alkyl group, more preferably linear or branched C_6 to C_8 and n is an integer ranging from 1 to 5 preferably 1. A particular example is Irganox L06.

[00108] Other aromatic amine anti-oxidants include other alkylated and non-alkylated aromatic amines such as aromatic monoamines of the formula $R^8R^9R^{10}N$ where R^8 is an aliphatic, aromatic or substituted aromatic group, R^9 is an aromatic or a substituted aromatic group, and R^{10} is H, alkyl, aryl or $R^{11}S(O)_xR^{12}$ where R^{11} is an alkylene, alkenylene, or aralkylene group, R^{12} is a higher alkyl group, or an alkenyl, aryl, or alkaryl group, and x is 0, 1 or 2. The aliphatic group R^8 may contain from 1 to about 20 carbon atoms, and preferably contains from about 6 to 12 carbon atoms. The aliphatic group is a saturated aliphatic group. Preferably, both R^8 and R^9 are aromatic or substituted

- 30 -

aromatic groups, and the aromatic group may be a fused ring aromatic group such as naphthyl. Aromatic groups R⁸ and R⁹ may be joined together with other groups such as S.

[00109] Typical aromatic amines anti-oxidants have alkyl substituent groups of at least about 6 carbon atoms. Examples of aliphatic groups include hexyl, heptyl, octyl, nonyl, and decyl. Generally, the aliphatic groups will not contain more than about 14 carbon atoms. The general types of such other additional amine anti-oxidants which may be present include diphenylamines, phenothiazines, imidodibenzyls and diphenyl phenylene diamines. Mixtures of two or more of such other additional aromatic amines may also be present. Polymeric amine antioxidants can also be used.

[00110] Aromatic amines anti-oxidants can be employed in an amount in the range of about 0.1 to 5 wt%, preferably about 0.5 to 3 wt%, more preferably 1 to 3 wt% on an active ingredient basis.

[00111] Another class of anti-oxidant used in lubricating oil compositions and which may also be present are oil-soluble copper compounds. Any oil-soluble suitable copper compound may be blended into the lubricating oil. Examples of suitable copper antioxidants include copper dihydrocarbyl thio- or dithio-phosphates and copper salts of carboxylic acid (naturally occurring or synthetic). Other suitable copper salts include copper dithiacarbamates, sulphonates, phenates, and acetylacetonates. Basic, neutral, or acidic copper Cu(I) and or Cu(II) salts derived from alkenyl succinic acids or anhydrides are known to be particularly useful.

[00112] Such antioxidants may be used individually or as mixtures of one or more types of antioxidants, the total amount employed being an amount of about 0.50 to 5 wt%, preferably about 0.75 to 3 wt% (on an as-received basis).

Detergents

[00113] Illustrative detergents useful in this disclosure include, for example, alkali metal detergents, alkaline earth metal detergents, or mixtures of one or more alkali metal detergents and one or more alkaline earth metal detergents. Oils formulated with low concentrations of detergents and/or low ash detergents can be preferred as low ash, low metals, low phosphorus oils. A typical detergent is an anionic material that contains a long chain hydrophobic portion of the molecule and a smaller anionic or oleophobic hydrophilic portion of the molecule. The anionic portion of the detergent is typically derived from an organic acid such as a sulfur acid, carboxylic acid, phosphorous acid, phenol, or mixtures thereof. The counterion is typically an alkaline earth or alkali metal.

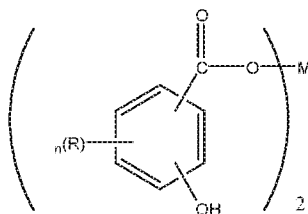
[00114] Salts that contain a substantially stoichiometric amount of the metal are described as neutral salts and have a total base number (TBN, as measured by ASTM D2896) of from 0 to 80. Many compositions are overbased, containing large amounts of a metal base that is achieved by

- 31 -

reacting an excess of a metal compound (a metal hydroxide or oxide, for example) with an acidic gas (such as carbon dioxide). Useful detergents can be neutral, mildly overbased, or highly overbased. These detergents can be used in mixtures of neutral, overbased, highly overbased calcium salicylate, sulfonates, phenates and/or magnesium salicylate, sulfonates, phenates. The TBN ranges can vary from low, medium to high TBN products, including as low as 0 to as high as 600. Mixtures of low, medium, high TBN can be used, along with mixtures of calcium and magnesium metal based detergents, and including sulfonates, phenates, salicylates, and carboxylates. A detergent mixture with a metal ratio of 1, in conjunction of a detergent with a metal ratio of 2, and as high as a detergent with a metal ratio of 5, can be used. Borated detergents can also be used.

[00115] Alkaline earth phenates are another useful class of detergent. These detergents can be made by reacting alkaline earth metal hydroxide or oxide (CaO, Ca(OH)₂, BaO, Ba(OH)₂, MgO, Mg(OH)₂, for example) with an alkyl phenol or sulfurized alkylphenol. Useful alkyl groups include straight chain or branched C1-C30 alkyl groups, preferably, C4-C20 or mixtures thereof. Examples of suitable phenols include isobutylphenol, 2-ethylhexylphenol, nonylphenol, dodecyl phenol, and the like. It should be noted that starting alkylphenols may contain more than one alkyl substituent that are each independently straight chain or branched and can be used from 0.5 to 6 weight percent. When a non-sulfurized alkylphenol is used, the sulfurized product may be obtained by methods well known in the art. These methods include heating a mixture of alkylphenol and sulfurizing agent (including elemental sulfur, sulfur halides such as sulfur dichloride, and the like) and then reacting the sulfurized phenol with an alkaline earth metal base.

[00116] Metal salts of carboxylic acids are also useful as detergents. These carboxylic acid detergents may be prepared by reacting a basic metal compound with at least one carboxylic acid and removing free water from the reaction product. These compounds may be overbased to produce the desired TBN level. Detergents made from salicylic acid are one preferred class of detergents derived from carboxylic acids. Useful salicylates include long chain alkyl salicylates. One useful family of compositions is of the formula



- 32 -

where R is an alkyl group having 1 to about 30 carbon atoms, n is an integer from 1 to 4, and M is an alkaline earth metal. Preferred R groups are alkyl chains of at least C11, preferably C13 or greater. R may be optionally substituted with substituents that do not interfere with the detergent's function. M is preferably, calcium, magnesium, or barium. More preferably, M is calcium or magnesium.

[00117] Hydrocarbyl-substituted salicylic acids may be prepared from phenols by the Kolbe reaction (see U.S. Patent No. 3,595,791). The metal salts of the hydrocarbyl-substituted salicylic acids may be prepared by double decomposition of a metal salt in a polar solvent such as water or alcohol.

[00118] Alkaline earth metal phosphates are also used as detergents and are known in the art.

[00119] Detergents may be simple detergents or what is known as hybrid or complex detergents. The latter detergents can provide the properties of two detergents without the need to blend separate materials. See U.S. Patent No. 6,034,039.

[00120] Preferred detergents include calcium phenates, calcium sulfonates, calcium salicylates, magnesium phenates, magnesium sulfonates, magnesium salicylates and other related components (including borated detergents), and mixtures thereof. Preferred mixtures of detergents include magnesium sulfonate and calcium salicylate, magnesium sulfonate and calcium sulfonate, magnesium sulfonate and calcium phenate, calcium phenate and calcium salicylate, calcium phenate and calcium sulfonate, calcium phenate and magnesium salicylate, calcium phenate and magnesium phenate.

[00121] The lubricating oils of this disclosure exhibit desired properties, e.g., wear control, deposit control and fuel efficiency, in the presence or absence of a detergent, in particular, the presence or absence of a salicylate detergent or a sulfonate detergent.

[00122] The detergent concentration in the lubricating oils of this disclosure can range from about 0.5 to about 20 weight percent or more, preferably about 0.6 to 5.0 weight percent, and more preferably from about 0.8 weight percent to about 4.0 weight percent, based on the total weight of the lubricating oil.

[00123] As used herein, the detergent concentrations are given on an "as delivered" basis. Typically, the active detergent is delivered with a process oil. The "as delivered" detergent typically contains from about 20 weight percent to about 100 weight percent, or from about 40 weight percent to about 60 weight percent, of active detergent in the "as delivered" detergent product.

Dispersants

[00124] During engine operation, oil-insoluble oxidation byproducts are produced. Dispersants help keep these byproducts in solution, thus diminishing their deposition on metal surfaces. Dispersants may be ashless or ash-forming in nature. Preferably, the dispersant is ashless. So called ashless dispersants are organic materials that form substantially no ash upon combustion. For example, non-metal-containing or borated metal-free dispersants are considered ashless. In contrast, metal-containing detergents discussed above form ash upon combustion.

[00125] Suitable dispersants typically contain a polar group attached to a relatively high molecular weight hydrocarbon chain. The polar group typically contains at least one element of nitrogen, oxygen, or phosphorus. Typical hydrocarbon chains contain 50 to 400 carbon atoms.

[00126] A particularly useful class of dispersants are the alkenylsuccinic derivatives, typically produced by the reaction of a long chain substituted alkenyl succinic compound, usually a substituted succinic anhydride, with a polyhydroxy or polyamino compound. The long chain group constituting the oleophilic portion of the molecule which confers solubility in the oil, is normally a polyisobutylene group. Polyisobutylene group with high terminal vinylic content can be preferred. Many examples of this type of dispersant are well known commercially and in the literature. Exemplary patents describing such dispersants are U.S. Patent Nos. 3,172,892; 3,219,666; 3,316,177 and 4,234,435. Other types of dispersants are described in U.S. Patent Nos. 3,036,003; and 5,705,458.

[00127] Hydrocarbyl-substituted succinic acid compounds are popular dispersants. In particular, succinimide, succinate esters, or succinate ester amides prepared by the reaction of a hydrocarbon-substituted succinic acid compound preferably having at least 50 carbon atoms in the hydrocarbon substituent, with at least one equivalent of an alkylene amine are particularly useful.

[00128] Succinimides are formed by the condensation reaction between alkenyl succinic anhydrides and amines. Molar ratios can vary depending on the amine or polyamine. For example, the molar ratio of alkenyl succinic anhydride to TEPA can vary from about 1:1 to about 5:1 or more.

[00129] Succinate esters are formed by the condensation reaction between alkenyl succinic anhydrides and alcohols or polyols. Molar ratios can vary depending on the alcohol or polyol used. For example, the condensation product of an alkenyl succinic anhydride and pentaerythritol is a useful dispersant.

[00130] Succinate ester amides are formed by condensation reaction between alkenyl succinic anhydrides and alkanol amines. For example, suitable alkanol amines include ethoxylated

polyalkylpolyamines, propoxylated polyalkylpolyamines and polyalkenylpolyamines such as polyethylene polyamines. One example is propoxylated hexamethylenediamine.

[00131] The molecular weight of the alkenyl succinic anhydrides will typically range between 400 and 5,000 with preferred ranges between 800 and 2,500. The above products can be post-reacted with various reagents such as sulfur, oxygen, formaldehyde, carboxylic acids such as oleic acid, and boron compounds such as borate esters or highly borated dispersants. The dispersants can be borated with from about 0.1 to about 5 moles of boron per mole of dispersant reaction product.

[00132] Mannich base dispersants are made from the reaction of alkylphenols, formaldehyde, and amines. Process aids and catalysts, such as oleic acid and sulfonic acids, can also be part of the reaction mixture. Molecular weights of the alkylphenols range from 800 to 2,500. Mannich base dispersants can also be borated and mixtures of Mannich base dispersants can be used.

[00133] Typical high molecular weight aliphatic acid modified Mannich condensation products can be prepared from high molecular weight alkyl-substituted hydroxyaromatics or $\text{HN}(\text{R})_2$ group-containing reactants.

[00134] Examples of high molecular weight alkyl-substituted hydroxyaromatic compounds are polypropylphenol, polybutylphenol, and other polyalkylphenols. These polyalkylphenols can be obtained by the alkylation, in the presence of an alkylating catalyst, such as BF_3 , of phenol with high molecular weight polypropylene, polybutylene, and other polyalkylene compounds to give alkyl substituents on the benzene ring of phenol having an average 600-100,000 molecular weight.

[00135] Examples of $\text{HN}(\text{R})_2$ group-containing reactants are alkylene polyamines, principally polyethylene polyamines. Other representative organic compounds containing at least one $\text{HN}(\text{R})_2$ group suitable for use in the preparation of Mannich condensation products are well known and include the mono- and di-amino alkanes and their substituted analogs, e.g., ethylamine and diethanol amine; aromatic diamines, e.g., phenylene diamine, diamino naphthalenes; heterocyclic amines, e.g., morpholine, pyrrole, pyrrolidine, imidazole, imidazolidine, and piperidine; melamine and their substituted analogs.

[00136] Examples of alkylene polyamine reactants include ethylenediamine, diethylene triamine, triethylene tetraamine, tetraethylene pentaamine, pentaethylene hexamine, hexaethylene heptaamine, heptaethylene octaamine, octaethylene nonaamine, nonaethylene decamine, and decaethylene undecamine and mixture of such amines having nitrogen contents corresponding to the alkylene polyamines, in the formula $\text{H}_2\text{N}-(\text{Z}-\text{NH})_n\text{H}$, mentioned before, Z is a divalent ethylene and n is 1 to 10 of the foregoing formula. Corresponding propylene polyamines such as propylene diamine and di-, tri-, tetra-, pentapropylene tri-, tetra-, penta- and hexamines are also

- 35 -

suitable reactants. The alkylene polyamines are usually obtained by the reaction of ammonia and dihalo alkanes, such as dichloro alkanes. Thus the alkylene polyamines obtained from the reaction of 2 to 11 moles of ammonia with 1 to 10 moles of dichloroalkanes having 2 to 6 carbon atoms and the chlorines on different carbons are suitable alkylene polyamine reactants.

[00137] Aldehyde reactants useful in the preparation of the high molecular products useful in this disclosure include the aliphatic aldehydes such as formaldehyde (also as paraformaldehyde and formalin), acetaldehyde and aldol (β -hydroxybutyraldehyde). Formaldehyde or a formaldehyde-yielding reactant is preferred.

[00138] Preferred dispersants include borated and non-borated succinimides, including those derivatives from mono-succinimides, bis-succinimides, and/or mixtures of mono- and bis-succinimides, wherein the hydrocarbyl succinimide is derived from a hydrocarbylene group such as polyisobutylene having a Mn of from about 500 to about 5000 or a mixture of such hydrocarbylene groups. Other preferred dispersants include succinic acid-esters and amides, alkylphenol-polyamine-coupled Mannich adducts, their borates and capped derivatives, such as, polycyclic carbonates, and other related components. Such additives may be used in an amount of about 0.1 to 20 wt%, preferably about 0.1 to 8 wt%, more preferably about 1 to 6 wt% (on an as-received basis or 0-10 wt% on an active ingredient basis) based on the weight of the total lubricant.

Pour Point Depressants

[00139] Conventional pour point depressants (also known as lube oil flow improvers) may also be present. Pour point depressant may be added to lower the minimum temperature at which the fluid will flow or can be poured. Examples of suitable pour point depressants include alkylated naphthalenes polymethacrylates, polyacrylates, polyarylamides, condensation products of haloparaffin waxes and aromatic compounds, vinyl carboxylate polymers, and terpolymers of dialkylfumarates, vinyl esters of fatty acids and allyl vinyl ethers. Such additives may be used in amount of about 0.0 to 0.5 wt%, preferably about 0 to 0.3 wt%, more preferably about 0.001 to 0.1 wt% on an as-received basis.

Corrosion Inhibitors/Metal Deactivators

[00140] Corrosion inhibitors are used to reduce the degradation of metallic parts that are in contact with the lubricating oil composition. Suitable corrosion inhibitors include aryl thiazines, alkyl substituted dimercapto thiodiazoles thiadiazoles and mixtures thereof. Such additives may be used in an amount of about 0.01 to 5 wt%, preferably about 0.01 to 1.5 wt%, more preferably about 0.01 to 0.2 wt%, still more preferably about 0.01 to 0.1 wt% (on an as-received basis) based on the total weight of the lubricating oil composition.

Seal Compatibility Additives

[00141] Seal compatibility agents help to swell elastomeric seals by causing a chemical reaction in the fluid or physical change in the elastomer. Suitable seal compatibility agents for lubricating oils include organic phosphates, aromatic esters, aromatic hydrocarbons, esters (butylbenzyl phthalate, for example), and polybutenyl succinic anhydride and sulfolane-type seal swell agents such as Lubrizol 730-type seal swell additives. Such additives may be used in an amount of about 0.01 to 3 wt%, preferably about 0.01 to 2 wt% on an as-received basis.

Anti-Foam Agents

[00142] Anti-foam agents may advantageously be added to lubricant compositions. These agents retard the formation of stable foams. Silicones and organic polymers are typical anti-foam agents. For example, polysiloxanes, such as silicon oil or polydimethyl siloxane, provide antifoam properties. Anti-foam agents are commercially available and may be used in conventional minor amounts along with other additives such as demulsifiers; usually the amount of these additives combined is less than 1 percent, preferably 0.001 to about 0.5 wt%, more preferably about 0.001 to about 0.2 wt%, still more preferably about 0.0001 to 0.15 wt% (on an as-received basis) based on the total weight of the lubricating oil composition.

Inhibitors and Antirust Additives

[00143] Anti-rust additives (or corrosion inhibitors) are additives that protect lubricated metal surfaces against chemical attack by water or other contaminants. One type of anti-rust additive is a polar compound that wets the metal surface preferentially, protecting it with a film of oil. Another type of anti-rust additive absorbs water by incorporating it in a water-in-oil emulsion so that only the oil touches the surface. Yet another type of anti-rust additive chemically adheres to the metal to produce a non-reactive surface. Examples of suitable additives include zinc dithiophosphates, metal phenolates, basic metal sulfonates, fatty acids and amines. Such additives may be used in an amount of about 0.01 to 5 wt%, preferably about 0.01 to 1.5 wt% on an as-received basis.

[00144] ZDDP anti-wear additives are essential components of the present disclosure. ZDDP derived from C8 to C18 primary or secondary alcohols and preferably derived from C4, C5, and/or C7 primary or secondary alcohols and mixtures thereof are often preferred. In some applications, low phosphorus ZDDP additives with <0.10% by weight phosphorus, leading to about from 0.02% to 0.08% phosphorus in finished oils can be preferred. In addition to ZDDP, other anti-wear additives can be present, including zinc dithiocarbamates, molybdenum dialkyldithiophosphates, molybdenum dithiocarbamates, other organo molybdenum-nitrogen complexes, sulfurized olefins, etc.

- 37 -

[00145] The term “organo molybdenum-nitrogen complexes” embraces the organo molybdenum-nitrogen complexes described in U.S. Patent 4,889,647. The complexes are reaction products of a fatty oil, dithanolamine and a molybdenum source. Specific chemical structures have not been assigned to the complexes. U.S. Patent 4,889,647 reports an infrared spectrum for a typical reaction product of that disclosure; the spectrum identifies an ester carbonyl band at 1740 cm^{-1} and an amide carbonyl band at 1620 cm^{-1} . The fatty oils are glyceryl esters of higher fatty acids containing at least 12 carbon atoms up to 22 carbon atoms or more. The molybdenum source is an oxygen-containing compound such as ammonium molybdates, molybdenum oxides and mixtures.

[00146] Other organo molybdenum complexes which can be used in the present disclosure are tri-nuclear molybdenum-sulfur compounds described in EP 1 040 115 and WO 99/31113 and the molybdenum complexes described in U.S. Patent 4,978,464.

Performance and Uses

[00147] The lubricant compositions of this disclosure give advantaged performance in the lubrication of internal combustion engines, power trains, drivelines, transmissions, gears, gear trains, gear sets, compressors, pumps, hydraulic systems, bearings, bushings, turbines, and the like.

[00148] Also, the lubricant compositions of this disclosure give advantaged friction, wear, and other lubricant performances in the lubrication of mechanical components, which comprise, for example, pistons, piston rings, cylinder liners, cylinders, cams, tappets, lifters, bearings (journal, roller, tapered, needle, ball, and the like), gears, valves, and the like.

[00149] Further, the lubricant compositions of this disclosure give advantaged friction, wear, and other lubricant performances under a range of lubrication contact pressures, from 1 MPas to greater than 10 GPas, preferably greater than 10 MPas, more preferably greater than 100 MPas, even more preferable greater than 300 MPas. Under certain circumstances, the instant disclosure gives advantaged wear and friction performance at greater than 0.5 GPas, often at greater than 1 GPas, sometimes greater than 2 GPas, under selected circumstances greater than 5 GPas.

[00150] Yet further, the lubricant compositions of this disclosure give advantaged friction, wear, and other lubricant performances when used in combination with lubricated surfaces comprising: metals, metal alloys, non-metals, non-metal alloys, mixed carbon-metal composites and alloys, mixed carbon-nonmetal composites and alloys, ferrous metals, ferrous composites and alloys, non-ferrous metals, non-ferrous composites and alloys, titanium, titanium composites and alloys, aluminum, aluminum composites and alloys, magnesium, magnesium composites and alloys, ion-implanted metals and alloys, plasma modified surfaces; surface modified materials; coatings; mono-layer, multi-layer, and gradient layered coatings; honed surfaces; polished surfaces; etched

- 38 -

surfaces; textured surfaces; micro and nano structures on textured surfaces; super-finished surfaces; diamond-like carbon (DLC), DLC with high-hydrogen content, DLC with moderate hydrogen content, DLC with low-hydrogen content, DLC with zero hydrogen content, DLC composites, DLC-metal compositions and composites, DLC-nonmetal compositions and composites; glasses, metallic glasses; ceramics, cermets, ceramic oxides, ceramic nitrides, FeN, CrN, ceramic carbides, mixed ceramic compositions, and the like; polymers, plastics, thermoplastic polymers, engineered polymers, polymer blends, polymer alloys, polymer composites; elastomers; materials compositions and composites containing dry lubricants, comprising for example graphite, carbon, molybdenum, molybdenum disulfide, polytetrafluoroethylene, polyperfluoropropylene, polyperfluoroalkylethers, and the like.

[00151] The viscometric properties of the lubricants of this disclosure can be measured according to standard practices. A low viscosity can be advantageous for lubricants in modern equipment. A low high temperature high shear (HTHS) viscosity, in accordance with ASTM D4683, can indicate performance of a lubricant in a modern engine. In particular, the lubricants of this disclosure can have an HTHS of less than 2.0 cP, or more preferably less than 1.9 cP, or more preferably less than 1.8 cP, or more preferably less than 1.7 cP.

[00152] The lubricants of this disclosure can have lower volatility, as determined by the Noack volatility test ASTM D5800, or as predicted by a TGA test that simulates the Noack volatility. In particular, the lubricants of this disclosure can have a Noack between 1% and 50%, or more preferably between 10% and 50%, or more preferably between 15% and 40%, or more preferably between 20% and 30%. Particularly preferred compositions have a Noack between 15% and 30%.

[00153] The lubricants of this disclosure can have lower deposition tendency, as determined by the TEOST 33C deposition test ASTM D6335. In particular, the lubricants of this disclosure can have a TEOST 33C of less than 30 mg, or more preferably less than 20 mg, or more preferably less than 15 mg.

[00154] The lubricants of this disclosure can have reduced traction as determined by the MTM (Mini Traction Machine) traction test. Traction is most easily assessed by comparison to a reference fluid, in this case a suitable reference fluid is an engine oil formulated with commercial dioctyl adipate ester such as Esterex™ A32. Accordingly, the lubricants of this disclosure can have an MTM traction reduction of 5% versus a reference, or more preferably a reduction of 10% versus a reference, or more preferably a reduction of 20% versus a reference, or more preferably a reduction of 30% versus a reference, or more preferably a reduction of 40% versus a reference.

[00155] In the above detailed description, the specific embodiments of this disclosure have been described in connection with its preferred embodiments. However, to the extent that the above

- 39 -

description is specific to a particular embodiment or a particular use of this disclosure, this is intended to be illustrative only and merely provides a concise description of the exemplary embodiments. Accordingly, the disclosure is not limited to the specific embodiments described above, but rather, the disclosure includes all alternatives, modifications, and equivalents falling within the true scope of the appended claims. Various modifications and variations of this disclosure will be obvious to a worker skilled in the art and it is to be understood that such modifications and variations are to be included within the purview of this application and the spirit and scope of the claims.

EXAMPLES

Example 1

Preparation of 2-hexyldecyl phenylacetate

[00156] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyl-1-decanol (200.0 g, 824.93 mmol, 1.0 equiv.), phenylacetic acid (146.01 g, 1072.4 mmol, 1.30 equiv.), toluene (240 ml) and p-toluenesulfonic acid monohydrate (1.5692 g, 8.2494 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 134°C under a nitrogen atmosphere for 5.5 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 3 hours to afford a light yellow liquid (279.86 g, 94%).

Example 2

Preparation of 2-hexyldecyl 3-phenylpropionate

[00157] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyl-1-decanol (180.00 g, 742.44 mmol, 1.0 equiv.), 3-phenylpropionic acid (144.95 g, 965.17 mmol, 1.30 equiv.), toluene (230 ml) and p-toluenesulfonic acid monohydrate (1.4123g, 7.4246 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 130°C under a nitrogen atmosphere for 6 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 2 hours to afford a clear, light yellow liquid (276.96 g, 99%).

Example 3

Preparation of 2-octyl-dodecyl phenylacetate

- 40 -

[00158] To a 3-neck 1000-ml round-bottomed flask was added 2-octyl-1-dodecanol (240.0 g, 803.88 mmol, 1.0 equiv.), phenylacetic acid (142.28 g, 1045.0 mmol, 1.30 equiv.), toluene (240 ml) and p-toluenesulfonic acid monohydrate (1.5291 g, 8.0386 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 133°C under a nitrogen atmosphere for 9 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 2 hours to afford a clear pale yellow liquid (330.06 g, 98%).

Example 4

Preparation of 2-butyloctyl 4-phenylbutyrate

[00159] To a 3-neck 1000-ml round-bottomed flask was added 2-butyl-1-octanol (150.00 g, 804.99 mmol, 1.0 equiv.), 4-phenylbutyric acid (165.23 g, 1006.2 mmol, 1.25 equiv.), toluene (200 ml) and p-toluenesulfonic acid monohydrate (1.5312g, 8.0496 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 132°C under a nitrogen atmosphere for 8 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 3 hours to afford a clear, light yellow liquid (246.13 g, 92%).

Example 5

Preparation of 2-hexyldecyl 4-methoxyphenylacetate

[00160] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyl-1-decanol (106.73 g, 440.22 mmol, 1.0 equiv.), 4-methoxyphenylacetic acid (95.10 g, 572.28 mmol, 1.30 equiv.), toluene (230 ml) and p-toluenesulfonic acid monohydrate (0.8374 g, 4.4023 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 134°C under a nitrogen atmosphere for 7 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 2 hours to afford a light yellow liquid (169.78 g, 98%).

Example 6

Preparation of 2-hexyldecyl m-tolylacetate

- 41 -

[00161] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyl-1-decanol (160.00 g, 659.94 mmol, 1.0 equiv.), m-tolylacetic acid (128.84 g, 857.93 mmol, 1.30 equiv.), toluene (200 ml) and p-toluenesulfonic acid monohydrate (1.2553 g, 6.5992 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 132°C under a nitrogen atmosphere for 6 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 4 hours to afford a clear, light yellow liquid (247.6 g, 100%).

Example 7

Preparation of 2-hexyldecyl m-tolylacetate

[00162] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyl-1-decanol (200.0 g, 824.93 mmol, 1.0 equiv.), p-tolylacetic acid (154.86 g, 1031.2 mmol, 1.25 equiv.), toluene (240 ml) and p-toluenesulfonic acid monohydrate (1.5692 g, 8.2494 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 134°C under a nitrogen atmosphere for 10 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 3 hours to afford a light yellow liquid (213.3 g, 69%).

Example 8

Preparation of 2-phenylethyl 2-hexyldecanoate

[00163] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyldecanoic acid (100.0 g, 389.97 mmol, 1.0 equiv.), 2-phenylethanol (64.316 g, 526.46 mmol, 1.35 equiv.), toluene (200 ml) and p-toluenesulfonic acid monohydrate (0.7418 g, 3.8997 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 132°C under a nitrogen atmosphere for 25 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 5 hours to afford a light yellow liquid (132.2 g, 94%).

Example 9

Preparation of 2-hexyldecyl benzoate

- 42 -

[00164] To a 3-neck 1000-ml round-bottomed flask was added 2-hexyl-1-decanol (160.00 g, 659.94 mmol, 1.0 equiv.), benzoic acid (104.77 g, 857.91 mmol, 1.30 equiv.), toluene (200 ml) and p-toluenesulfonic acid monohydrate (1.2553 g, 6.5992 mmol, 0.010 equiv.) at room temperature. The resulting mixture was heated at reflux with stirring in an oil bath at 134°C under a nitrogen atmosphere for 28 hours. The water produced in the reaction was collected in a Dean-Stark trap. The cooled mixture was diluted with hexanes, washed with dilute aqueous Na₂CO₃ solution, water, brine, dried (MgSO₄), filtered, and concentrated in *vacuo* to afford a crude product. Excess solvent was further removed by heating the crude product with stirring in an oil bath under high vacuum for 4 hours to afford a clear, light yellow liquid (221.98 g, 97%).

Example 10

Lube Properties

[00165] The lube properties of the products of Examples 1-9 were evaluated and the data are shown in Figs. 1 and 2. The kinematic viscosity (Kv) of the liquid product was measured using ASTM D445 or D7042, and reported at temperatures of 100°C (Kv at 100°C) or 40°C (Kv at 40°C). The viscosity index (VI) was measured according to ASTM D2270 using the measured kinematic viscosities for each product. Noack volatility was determined by ASTM D5800. These fluids were evaluated as Group V base stocks and the results are shown in Figs. 1 and 2.

[00166] Figs. 1 and 2 clearly show that the aromatic alkananoate monoester base stock examples of this disclosure (Examples 1-3 and 5-7) all have more desirable viscosity-volatility properties when compared to the commercially available low viscosity ester base stocks from different sources. In particular, the aromatic alkananoate monoester base stocks of this disclosure have lower viscosities than commercially available esters at similar volatility (e.g., compare Example 1 with entry 10 in Fig. 1, compare Example 2 with entry 12 in Fig. 1, compare Example 6 with entry 18 in Fig. 1). Also, the monoester base stocks of this disclosure have lower volatility than commercially available esters at comparable viscosities (e.g., compare Example 1 with entry 11 in Fig. 1, compare Example 3 with entry 12 in Fig. 1, compare Example 5 with entry 15 in Fig. 1).

[00167] Even more surprisingly, it has been discovered that 2-hexyl-1-decyl benzoate (counter Example 9, a benzoate ester) has both higher viscosity and higher volatility than 2-hexyl-1-decyl phenylacetate (disclosure Example 1, a phenylacetate ester). The viscosity-volatility balance of 2-hexyl-1-decyl benzoate is similar to those of the commercial ester fluids. Furthermore, 2-phenylethyl 2-hexyldecanoate (counter Example 8) derived from an aromatic alkanol and a carboxylic acid shows both higher viscosity and higher volatility than its isomer (2-hexyl-1-decyl phenylacetate, disclosure Example 1).

- 43 -

[00168] Fig. 2 is a plot of kinematic viscosity (100°C) versus volatility (Noack) for selected counter examples (counter Examples 9 and 4 as filled squares and Example 8 as filled diamond) and examples of this disclosure (Examples 1-3, 5 and 6 as filled circles) and commercially available ester base stocks (entries 10-19 as filled triangles) based on data in Fig. 1. The desirable examples of this disclosure have their volatility defined by the formula: Noack volatility (ASTM D5800) is not greater than $\text{Noack} = [-18(KV_{100})+70]$.

Example 11

Lube Properties

[00169] Selected monoester base stocks of this disclosure (i.e., Examples 1 and 7) and commercial base stocks were used to formulate ultra-low viscosity engine oils. Each formulation consisted of 82.3% by weight of the base stock and 17.7% by weight of an additive package. The additive package employed is composed of commonly used additive components (e.g., antiwear additives, friction modifiers, dispersants, detergents, antioxidants, pour point depressants, antifoaming agent, etc.). These monoester base stocks exhibit high solvency for the additive components. Potential higher viscosity engine oil grade can be formulated by addition of viscosity modifiers.

[00170] High temperature high shear (HTHS) viscosity, Noack volatility and TEOST (thermo-oxidation engine oil determination of high temperature piston deposits) results for low-viscosity engine oils formulated with base stocks of this disclosure are shown in Fig. 3. The HTHS test was conducted in accordance with ASTM D4683. Noack volatility was determined by ASTM D5800. The TEOST test was conducted in accordance with ASTM D6335.

[00171] By comparing formulations prepared from the base stocks of Examples 1, 2 and 7 with those prepared from commercially available low-viscosity base stocks (i.e., entries 4-7), it is clear that the aromatic alkanate monoester base stocks of this disclosure show low levels of deposit formation, directionally better performance than commercial polyol esters (i.e., entries 5 and 6), and substantially improved performance versus entry 4 (i.e., a commercial widely used diester), and therefore can provide excellent thermal and oxidative stability at high temperature.

[00172] Frictional characteristics of selected ester fluids of this disclosure were assessed using the MTM (Mini Traction Machine) traction test. In this test, the fluids were subjected to high pressure and high temperature when a stainless steel highly polished ball under high load was moved against a plate, both submerged into the fluids at the test temperature. The test started with the ball rolling at 100% then gradually sliding to a pure, 100% sliding mode at the end of test. The traction coefficient is an indication of the energy lost due to the fluids shearing. More energy efficient fluids have lower traction coefficients. Fig. 4 shows MTM traction curves from the ester

- 44 -

fluids of Examples 1 and 7 and two commercial esters in MTM (mini-traction machine) traction test at 100°C, 1.00 GPa, 0%-100% SRR (Slide to Roll Ratio), and 2 m/s rolling speed.

[00173] As shown in Fig. 4, the aromatic alkanoate monoester fluids of this disclosure exhibited similar to better energy efficiency than the commercially available esters.

[00174] All patents and patent applications, test procedures (such as ASTM methods, UL methods, and the like), and other documents cited herein are fully incorporated by reference to the extent such disclosure is not inconsistent with this disclosure and for all jurisdictions in which such incorporation is permitted.

[00175] When numerical lower limits and numerical upper limits are listed herein, ranges from any lower limit to any upper limit are contemplated. While the illustrative embodiments of the disclosure have been described with particularity, it will be understood that various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the spirit and scope of the disclosure. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the examples and descriptions set forth herein but rather that the claims be construed as encompassing all the features of patentable novelty which reside in the present disclosure, including all features which would be treated as equivalents thereof by those skilled in the art to which the disclosure pertains.

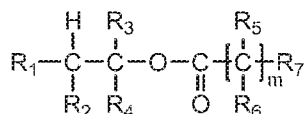
[00176] The present disclosure has been described above with reference to numerous embodiments and specific examples. Many variations will suggest themselves to those skilled in this art in light of the above detailed description. All such obvious variations are within the full intended scope of the appended claims.

arylalkyl group (C₅-C₁₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from 1 to 8, and n is a value greater than or equal to 1.

5. The composition of claims 1-4 which is selected from the group consisting of 2-hexyl-1-decyl phenylacetate, 2-hexyl-1-decyl 3-phenylpropionate, 2-hexyl-1-decyl 4-phenylbutyrate, 2-octyl-1-dodecyl phenylacetate, 2-octyl-1-dodecyl 3-phenylpropionate, 2-octyl-1-dodecyl 4-phenylbutyrate, 2-heptyl-1-undecyl phenylacetate, 2-heptyl-1-undecyl 3-phenylpropionate, 2-heptyl-1-undecyl 4-phenylbutyrate, 2-decyl-1-tetradecyl phenylacetate, 2-decyl-1-tetradecyl 3-phenylpropionate, 2-butyl-1-octyl 4-phenylbutyrate, 2-hexyl-1-decyl 4-methoxyphenylacetate, 2-octyl-1-dodecyl 4-methoxyphenylacetate, 2-decyl-1-tetradecyl 4-methoxyphenylacetate, 2-hexyl-1-decyl m-tolylacetate, 2-octyl-1-dodecyl m-tolylacetate, 2-decyl-1-tetradecyl m-tolylacetate, 2-hexyl-1-decyl p-tolylacetate, 2-octyl-1-dodecyl p-tolylacetate, 2-decyl-1-tetradecyl p-tolylacetate, 2-phenylethyl 2-hexyldecanoate, 3-phenylpropyl 2-hexyldecanoate, 4-phenylbutyl 2-hexyldecanoate, 2-phenylethyl 2-heptylundecanoate, 3-phenylpropyl 2-heptylundecanoate, and 4-phenylbutyl 2-heptylundecanoate.

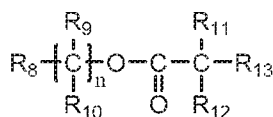
6. The composition of claims 1-5 which has a high temperature high shear (HTHS) viscosity of less than 1.7 cP as determined by ASTM D4683, and a Noack volatility from 6 to 30 percent as determined by ASTM D5800.

7. A composition comprising one or more compounds represented by the formula selected from the group consisting of



(I)

and



(II)

wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆,

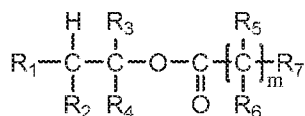
10. The lubricating oil base stock of claims 8 and 9 wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₂₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₂₀), alkenyl group (C₁-C₂₀), or alkoxy group (C₁-C₂₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₂₀), heteroaryl group (C₄-C₂₀), or arylalkyl group (C₅-C₂₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from 1 to 9, and n is a value greater than or equal to 2.

11. The lubricating oil base stock of claims 8-10 wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₁₀); R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₁₀), alkenyl group (C₁-C₁₀), or alkoxy group (C₁-C₁₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₁₀), heteroaryl group (C₄-C₁₀), or arylalkyl group (C₅-C₁₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from 1 to 8, and n is a value greater than or equal to 2.

12. The lubricating oil base stock of claims 8-11 which is selected from the group consisting of 2-hexyl-1-decyl phenylacetate, 2-hexyl-1-decyl 3-phenylpropionate, 2-hexyl-1-decyl 4-phenylbutyrate, 2-octyl-1-dodecyl phenylacetate, 2-octyl-1-dodecyl 3-phenylpropionate, 2-octyl-1-dodecyl 4-phenylbutyrate, 2-heptyl-1-undecyl phenylacetate, 2-heptyl-1-undecyl 3-phenylpropionate, 2-heptyl-1-undecyl 4-phenylbutyrate, 2-decyl-1-tetradecyl phenylacetate, 2-decyl-1-tetradecyl 3-phenylpropionate, 2-butyl-1-octyl 4-phenylbutyrate, 2-hexyl-1-decyl 4-methoxyphenylacetate, 2-octyl-1-dodecyl 4-methoxyphenylacetate, 2-decyl-1-tetradecyl 4-methoxyphenylacetate, 2-hexyl-1-decyl m-tolylacetate, 2-octyl-1-dodecyl m-tolylacetate, 2-decyl-1-tetradecyl m-tolylacetate, 2-hexyl-1-decyl p-tolylacetate, 2-octyl-1-dodecyl p-tolylacetate, 2-decyl-1-tetradecyl p-tolylacetate, 2-phenylethyl 2-hexyldecanoate, 3-phenylpropyl 2-hexyldecanoate, 4-phenylbutyl 2-hexyldecanoate, 2-phenylethyl 2-heptylundecanoate, 3-phenylpropyl 2-heptylundecanoate, and 4-phenylbutyl 2-heptylundecanoate.

13. The lubricating oil base stock of claims 8-12 which has a high temperature high shear (HTHS) viscosity of less than 1.7 cP as determined by ASTM D4683, and a Noack volatility from 6 to 30 percent as determined by ASTM D5800.

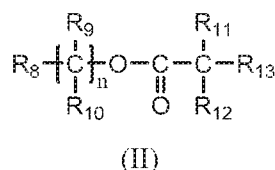
14. A lubricating oil comprising a lubricating oil base stock component, and a monoester cobase stock component; wherein said monoester cobase stock comprises one or more compounds represented by the formula selected from the group consisting of



(I)

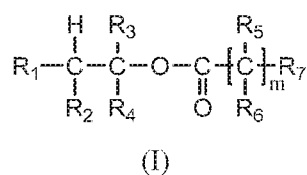
- 49 -

and

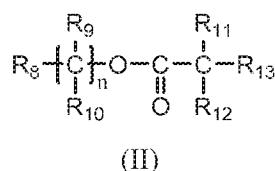


wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from 1 to 10, and n is a value greater than or equal to 1; wherein said lubricating oil has a viscosity (KV₁₀₀) from 1cSt to 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from -100 to 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800.

15. A method for improving one or more of thermal and oxidative stability, solubility and dispersancy of polar additives, deposit control and traction control in a lubricating oil by using as the lubricating oil a formulated oil comprising a lubricating oil base stock component, and a monoester cobase stock component; wherein said monoester cobase stock comprises one or more compounds represented by the formula selected from the group consisting of



and



wherein R₁ and R₂ are independently a substituted or unsubstituted alkyl group (C₁-C₃₀), R₃, R₄ and R₁₃ are independently hydrogen or a substituted or unsubstituted alkyl group (C₁-C₃₀), alkenyl group (C₁-C₃₀), or alkoxy group (C₁-C₃₀), R₇ and R₈ are independently a substituted or unsubstituted aryl group (C₄-C₃₀), heteroaryl group (C₄-C₃₀), or arylalkyl group (C₅-C₃₀), R₅, R₆, R₉, R₁₀, R₁₁ and R₁₂ are hydrogen, m is a value from 1 to 10, and n is a value greater than or equal

- 50 -

to 1; wherein said lubricating oil has a viscosity (K_{v100}) from 1cSt to 10 cSt at 100°C as determined by ASTM D445, a viscosity index (VI) from -100 to 300 as determined by ASTM D2270, and a Noack volatility of no greater than 50 percent as determined by ASTM D5800.

Fig. 1

Entry	Source	Basestock	ASTM D445 or D7042 Kinematic Viscosity (@100 °C)	ASTM D445 or D7042 Kinematic Viscosity (@40 °C)	ASTM D2270 Viscosity Index (VI)	ASTM D5600 Noack (%)
1	Example 1	2-Hexyl-1-decyl phenylacetate	2.33	7.7	120	23
2	Example 2	2-Hexyl-1-decyl 3-phenylpropionate	2.65	9.6	112	18
3	Example 3	2-Octyl-1-dodecyl phenylacetate	3.03	10.9	140	8
4	Example 4	2-Butyl-1-octyl 4-phenylbutyrate	2.25	7.9	89	37
5	Example 5	2-Hexyl-1-decyl 4-methoxyphenylacetate	2.99	12.3	94	12
6	Example 6	2-Hexyl-1-decyl m-tolylacetate	2.50	8.9	109	20
7	Example 7	2-Hexyl-1-decyl p-tolylacetate	2.49	8.7	111	n.d.
8	Example 8	2-Phenylethyl 2-hexyldecanoate	2.54	9.5	97	26
9	Example 9	2-Hexyl-1-decyl benzoate	2.66	11.0	62	28
10	Commercial	2-Ethylhexyl oleate	2.80	8.0	238	22

Fig. 1
(Cont.)

Entry	Source	Basestock	ASTM D445 or D7042 Kinematic Viscosity (@100 °C)	ASTM D445 or D7042 Kinematic Viscosity (@40 °C)	ASTM D2270 Viscosity Index (VI)	ASTM D5800 Noack (%)
11	Commercial	Bis(2-ethylhexyl) adipate	2.32	7.7	116	41
12	Commercial	Diisononyl adipate	3.06	10.8	150	17
13	Commercial	Diisodecyl adipate	3.62	14.1	146	14
14	Commercial	Bis(2-ethylhexyl) sebacate	3.22	11.6	152	16
15	Commercial	Di-2-ethylhexyl azelate	3.00	10.7	137	29
16	Commercial	Bis(2-ethylhexyl) dodecanedicarboxylate	3.75	14.1	165	11
17	Commercial	Esterex™ A32	2.80	9.5	149	30
18	Commercial	Esterex™ A34	3.20	12.0	137	20
19	Commercial	Esterex™ A41	3.60	14.0	144	16

Fig. 2

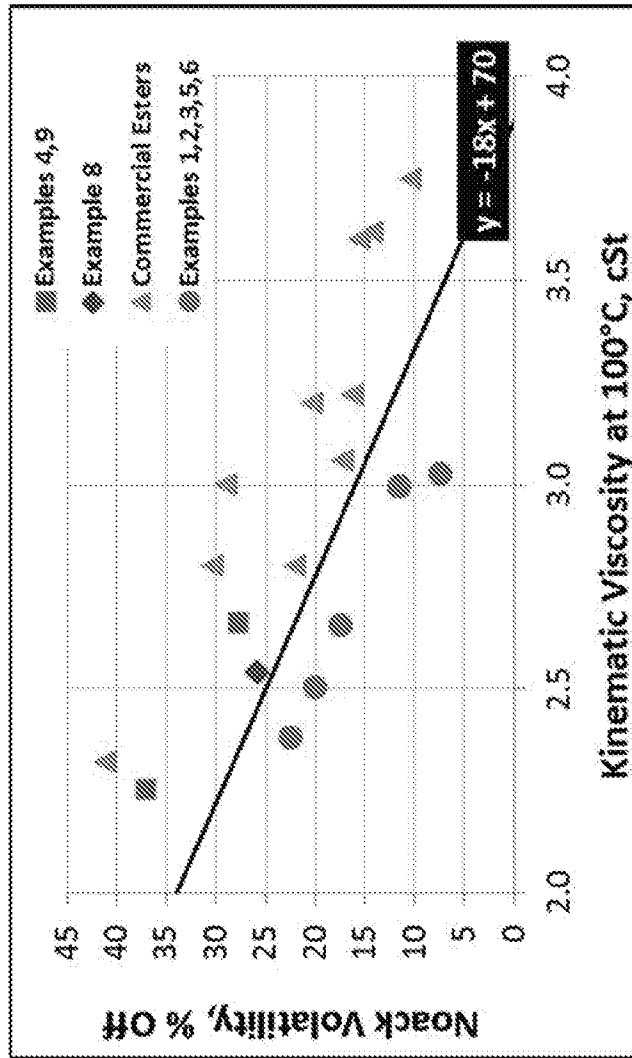


Fig. 3

Entry	Source	Formulation based on basestock	ASTM D4683 HTHS (cP, 150 °C)	ASTM D5800 Noack (%)	D6335 TEOST 33C (mg, total deposit)
1	Example 1	2-Hexyl-1-decyl phenylacetate	1.46	21	12.3
2	Example 7	2-Hexyl-1-decyl p-tolylacetate	1.55	16	16.9
3	Example 2	2-Hexyl-1-decyl 3-phenylpropionate	1.64	14	9.9
4	Commercial	Diisooctyl adipate	1.72	22	163.9
5	Commercial	nC7 Trimethylolpropane ester	n.a.* Low additive compatibility	n.a.	n.a.
6	Commercial	nC8/nC10 Trimethylolpropane ester	n.d.	4	28.2
7	Commercial	Spectrasyn 4	1.97	9	13.7

*Not applicable

Fig. 4

Engine Oils Mini Traction Machine (MTM) Traction Test Results
Test Conditions: 100°C, 1.00 GPa, 2 m/s

