The invention relates to an engine oil composition disclosed that meets FZG CEC II-84/FVA 2434(A10/06.6R/90) of transportation gear oils, wherein FLS=10, which composition comprises a) an engine oil, b) a β-dithiophosphorylated Propionic Acids, and c) Other customary oil additives. Wherein component b) is about 2.0 to about 8.0% by weight, based on the weight of component a) plus component c).
ANTIWEAR PERFORMANCE OF ENGINE OILS WITH SG(B)-DITHIOPHOSPHORYLATED PROPIONIC ACIDS

[0001] The present invention relates to engine oil (engine fluid) compositions that meet specific performance requirements comprising specific levels of β-dithiophosphorylated propionic acids.

[0002] β-Dithiophosphorylated propionic acid lubricant additives are described in U.S. Pat. No. 5,922,657, the disclosure of which is hereby incorporated by reference.

[0003] It has surprisingly been found that engine oils that comprise specific levels of β-dithiophosphorylated propionic acid additives meet certain transportation gear oil specifications.

[0004] The compositions according to this invention are effective in meeting the antiwear performance specification requirements of transportation OEMs for high load gear oil classes API GL4 and API GL5.

[0005] Specifically, the present invention relates to an engine oil that meets FZG CEC IT-84/FVA 2434 (A10/16.6R/90) of transportation gear oils, wherein FLS=10, comprising:

[0006] a) An engine oil;
[0007] b) At least one compound of the formula

\[
\begin{align*}
\text{RO} & \quad \text{O} \\
\text{S} & \quad \text{R}_1 \quad \text{R}_2 \\
\text{O} & \quad \text{OH}
\end{align*}
\]

[0008] in which:

[0009] R, and R, independently of one another are C₃-C₁₀ alkyl, C₃-C₁₀ cycloalkyl, C₃-C₁₀ cycloalkylmethyl, C₃-C₁₀ bicycloalkylmethyl, C₃-C₁₀ tricycloalkylmethyl, phenyl, or C₃-C₁₀ alklyphenyl or together are (CH₂)₃C(CH₃)₂;

[0010] R₃ is hydrogen or methyl; and, optionally,

[0011] c) Other customary oil additives, for example from the groups consisting of antioxidants, anti-foam additives, metal passivators, rust inhibitors, dispersants, detergents, viscosity index improvers, pour point depressants and other antiwear additives; and

[0012] Wherein component b) is about 2.0 to about 8.0% by weight, based on the weight of component a) plus component c).

[0013] For example, component b) is present from about 3.0 to about 7.0%, or about 4.0 to about 6.0%, or about 4.5 to about 5.5%, for example about 4.75 to about 5.25%, or about 4.8 to about 5.2%, or about 4.9 to about 5.1%, or about 5.0%, by weight, based on the weight of the engine oil of component a) plus the customary oil additives of component c).

[0014] Component b) is for example, Irgalube® 353 (Trademark of Ciba Specialty Chemicals Inc.), a dialkyl dithiophosphate ester, CAS # 268567-32-4.

[0015] Component c) may particularly be an antiwear additive, which additives are known to those skilled in the art.

[0016] U.S. Pat. Nos. 4,584,021; 5,798,321; 5,750,478; 5,801,130; 4,191,666; 4,720,288; 4,025,288; 4,025,583 and WO 95120592 describe antiwear amine additives which may be used in the instant invention. These references are incorporated herein by reference. Other examples of amines are polyalkylene amines such as ethylene diamine, diethylene triamine, triethylene tetramine, tetraethylene pentamine, pentaethylene hexamine, nonaethylene decamine and aryl amines as described in U.S. Pat. No. 4,267,063, herein incorporated by reference. Salts of amine phosphates comprising specialty amines and mixed mono- and di-acid phosphates have been found to be advantageous. The mono- and di-acid phosphate amines have the structural formulae:

[0017] Wherein R₂₈ is hydrogen, C₁₋C₂₅ linear or branched chain alkyl, which is unsubstituted or substituted by one or more C₁₋C₆ alkoxy groups, a saturated acyclic or alicyclic group, or aryl;

[0018] R₃₈ is C₁₋C₂₅ linear or branched chain alkyl, which is unsubstituted or substituted by one or more C₁₋C₆ alkoxy groups, a saturated acyclic or alicyclic group, or aryl;

[0019] R₃₅₀ is hydrogen, C₁₋C₂₅ linear or branched chain alkyl, a saturated or unsaturated acyclic or alicyclic group, or aryl; and are hydrogen or C₁₋C₁₂ linear or branched chain alkyl; and

[0020] R₂₀ and R₂₁ are, each independently of the other, C₃₋C₂₅ linear or branched chain alkyl, a saturated or unsaturated acyclic or alicyclic group, or aryl. Preferably, R₂₇ and R₂₈ are linear or branched C₁₋C₆ alkyl; and R₂₉, R₃₀ and R₃₁ are linear or branched C₁₋C₁₅ alkyl.

[0021] Component c) is for example IRGALUBE 349, a mixture of amine phosphates, CAS #80939-62-4.

[0022] IRGALUBE 349 has been found to be very useful, particularly by enhancing the wear performance of the base oil such that it meets stringent military performance specifications. IRGALUBE 349 corresponds to the formula

\[
(\text{R}_1\text{O})_x \quad \text{P} \\
(\text{OH})_y \quad (\text{BD})_z \quad (\text{R}_2\text{O})_y
\]

[0023] Wherein R₁₃₃ is n-hexyl, R₅₄ is C₁₋C₁₄ branched alkyl, and when x=1 then y=2; when x=2 then y=1.
[0024] R₁ and R₂ independently of one another are for example C₃₋₅ alkyl, C₃₋₅ cycloalkyl or C₅₋₁₀ alkylphenyl.

[0025] R₁ and R₂ are for instance i-propyl, i-butyl or 2-ethylhexyl and R₃ is, for instance hydrogen. Where R₁ and R₂ in the above formula (I) are C₃-C₅ alkyl they are branched or unbranched radicals. Examples of these are propyl, isopropyl, n-butyl, isobutyl, t-butyl, pentyl, isopentyl, hexyl, heptyl, octyl, 2-ethylhexyl, nonyl, decyl, undecyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, 2-ethylbutyl, 1-methylpentyl, 1,3-dimethylbutyl, 1,1,3,3-tetramethylbutyl, 1-methylhexyl, isohexyl, 1-methylethylhexyl, 1,1,3-trimethylhexyl and 1-methylnonyl.

[0026] R₁, R₂ and R₃ as C₃-C₅ cycloalkyl are, for example, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl or cyclododecyl.

[0027] R₁ and R₂ as C₅-C₁₀ cycloalkylmethyl are, for example, decalinylmethyl. As C₅-C₁₀ tricycloalkylmethyl R₁ and R₂ are, for example, groups of the partial formula

![partial formula]

[0028] Examples of alkylphenyl are methylphenyl, dimethylphenyl, trimethylphenyl, ethylphenyl, isopropylphenyl, t-butylphenyl, di-t-butylphenyl and 2,6-di-t-butyl-4-methylphenyl.

[0029] The invention also relates to the use of component b) as additives in engine oils at the levels according to this invention. The use according to the invention includes the protection of metal parts to be lubricated against mechanical wear (high-pressure and wear protection) and also an anticorrosion effect. Consequently, the present invention likewise relates to a method of improving the service properties of engine oils which method comprises adding compounds of the formula (I) thereto.

[0030] Specifically disclosed is a method of improving the service properties of engine oils which method comprises adding thereto about 2.0 to about 8.0% by weight, based on the weight of the engine oil plus other customary oil additives, of at least one compound of formula (I), wherein the other customary oil additives are selected from the group consisting of antioxidants, anti-foam additives, metal passivators, rust inhibitors, dispersants, detergents, viscosity index improvers, pour point depressants and antiwear additives.

[0031] The engine oils in accordance with the invention utilize mineral oils, poly-alpha-olefins (PAOs), esters and mixtures thereof. The finished fluids are used, for example, in internal combustion engines, for example in motor vehicles fitted, for example, with engines of the Otto, Diesel, two-stroke, Wankel or orbital type.

[0032] The engine oils in accordance with the invention are used, for example, in internal combustion engines, for example in motor vehicles fitted, for example, with engines of the Otto, Diesel, two-stroke, Wankel or orbital type.

[0033] The compounds of the formula (I) can be introduced into the engine oil in a manner known per se. The compounds are readily soluble in oils. It is also possible to prepare a so-called master batch, which can be diluted with the corresponding oil to use concentrations at the rate at which they are consumed. The compounds of formula (I) may be introduced as part of a so-called additive package.

[0034] The engine oils stabilized in accordance with the invention may additionally include other additives, which are added in order to improve still further the basic properties of these formulations. Such additives include antioxidants, metal passivators, other rust inhibitors, viscosity index improvers, pour point depressants, solid lubricants, dispersants, detergents, anti-foam, further high-pressure additives, antiwear additives and additives which reduce the coefficient of friction. Such additives are added in the customary amounts in each case in the range from in each case 0.01 to 10.0% by weight, based on the engine oil. Some additional additives are described below:

[0035] 1. Phenolic Antioxidants

[0037] 1.1. Alkylated monophenols, for example 2,6-di-tert-butyl-4-methylphenol, 2-butyl-4,6-di-tert-butylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,6-di-tert-butylisononylphenol, 2,6-di-cyclopentyl-4-methylphenol, 2-(3-ethyl-cyclohexyl)-4,6-dimethylphenol, 2,6-di-octadecyl-4-methylphenol, 2,6-di-tert-butyl-4-methoxyethylphenol, linear or side chain-branched nonylphenols, for example 2,6-di-nonyl-4-methylphenol, 2,4-dimethyl-6-(1'-methylundec-1'-yl)phenol, 2,4-dimethyl-6-(1'-methyltridec-1'-yl)phenol and mixtures thereof.

[0038] 1.2. Alkylthiophenol-methanols, for example 2,4-di-octylthiomethyl-6-tert-butylphenol. 2,4-di-octylthiomethyl-6-methylphenol, 2,4-di-octylthiomethyl-6-ethylphenol, 2,6-di-dodecylthiomethyl-4-nonylphenol.

[0039] 1.3. Hydroquinones and alkylated hydroquinones, for example 2,6-di-tert-butyl-4-methoxyphenol, 2,5-di-tert-butylhydroquinone, 2,5-di-tert-butyl-4-methoxyisole, 3,5-di-tert-butyl-4-hydroxyisole, 3,5-di-tert-butylhydroxyphenyl stearate, bis(3,5-di-tert-butyl-4-hydroxyphenyl) adipate.

[0040] 1.4. Tocophenols, for example α-, β-, γ- or δ-tocopherol and mixtures thereof (vitamin E).

[0041] 1.5. Hydroxylated thiodiphenyl ethers, for example 2,2'-thiobis(6-tert-butyl-4-methylphenol), 2,2'-thiobis(4-octylophenol), 4,4'-thiobis(4-tert-butyl-3-methylphenol), 4,4'-thiobis(6-tert-butyl-2-methylphenol), 4,4'-thiobis(3,6-di-sec-amylphenol), 4,4'-bis(2,6-dimethyl-4-hydroxyphenyl) disulfide.

[0042] 1.6. Alkylidene bisphenols, for example 2,2'-methylenekis(6-tert-butyl-4-methylphenol), 2,2'-methylenekis(6-tert-butyl-4-ethylphenol), 2,2'-methylenekis(4-methyl-6-(α-methylcyclohexyl)phenol, 2,2'-methylenekis(4-methyl-6-cyclohexylphenol), 2,2'-methylenekis(6-nonyl-4-methylphenol), 2,2'-methylenekis(4,6-di-tert-butylphenol), 2,2'-ethylenekis(4,6-di-tert-butylphenol), 2,2'-eth-
yildenebis(6-tert-butylisobutylphenol), 2,2'-methylenebis-6-(α-methylbenzyl)4-sonylphenol, 2,2'-methylene-bis-6-(α, α-dimethylbenzyl)4-sonylphenol, 4,4'-methylenebis(2,6-di-tet-butylphenol), 4,4'-methylenebis(6-tert-butyl-2-methylphenol), 1,1-bis(5-tert-butyl-4-hydroxy-2-methylphenyl)butane, 2,6-bis(3-tert-butyl-5-methyl-2-hydroxybenzyl)4-methylphenol, 1,1,3-tris(5-tert-butyl-4-hydroxy-2-methylphenyl)butane, 1,1-bis(5-tert-butylhydroxy-2-methylphenyl)-3-n-dodecylmercaptobutane, ethylene glycol bis-3,3'-bis(3'-tert-butyl-4-hydroxyphenyl)butyrate, bis(3'-tert-butyl-4-hydroxy-5-methylbenzyl)dicyclo-pentadiene, bis(3'-tert-butyl-2-hydroxy-5-methylbenzyl)-6-tert-butylmethylphenylerthephthalate, 1,1-bis(3-methyl-4-hydroxyphenyl)butane, 2,2-bis(3,5-di-tet-butyl-4-hydroxyphenyl)propane, 2,2-bis(5-tert-butyl-4-hydroxy-2-methylphenyl)-4-n-dodecylmercaptobutane, 1,1,5,5-tetra(5-tert-butylhydroxy-2-methylphenyl)-pentane.

[0043] 1.7. O-, N- and S-benzyl compounds, for example 3,5,3',5'-tetra-tert-butyl-4,4'-dihydroxybenzyl ether, octadecyl 4-hydroxy-3,5-dimethylbenzylmercaptoacetate, tridecyl 4-hydroxy-3,5-di-tet-butylmercaptoacetate, tris(3,5-di-tet-butyl)amine, bis(4-tert-butyl-3-hydroxy-2,6-dimethoxybenzyldihiteterepthalate, bis(3,5-di-tet-butyl-4-hydroxybenzyl) sulfide, isooctyl 3,5-di-tet-butylhydroxybenzylmercaptoacetate.

[0044] 1.8. Hydroxybenzylated malonates, for example diocytadecyl 2,2-bis(3,5-di-tet-butyl-2-hydroxybenzyl)malonate, diocytadecyl 2-(3-tert-butyl-4-hydroxy-5-methylbenzyl)-malonate, di-2-mercaptobenzyl 2,2-bis(3,5-di-tet-butyl-4-hydroxybenzyl)malonate, di-4-(1,1,3,3-tetramethylylphenyl)-2-bis(3,5-di-tet-butyl-4-hydroxybenzyl)malonate.

[0045] 1.9. Aromatic hydroxybenzyl compounds, for example 1,3,5-tris(3,5-di-tet-butyl-4-hydroxybenzyl)-2,4,6-trimethylbenzene, 1,4-bis(3,5-di-tet-butyl-4-hydroxybenzyl)-2,3,5,6-tetramethylbenzene, 2,4,6-tris(3,5-di-tet-butyl-4-hydroxybenzyl)phenol.

[0046] 1.10. Triazine compounds, for example 2,4-bis(octadecylmercapto)-6-(3,5-diet-butyl-4-hydroxyanilino)-1,3,5-triazine, 2-oc-tadecylmercapto-4,6-bis(3,5-di-tet-butyl-4-hydroxyanilino)-1,3,5-triazine, 2-octadecylmercapto-4,6-bis(3,5-di-tet-butyl-4-hydroxyphenyl)-1,3,5-triazine, 2,4,6-tris(3,5-di-tet-butyl-4-hydroxyanilino)-1,3,5-triazine, 2,4,6-tris(3,5-di-tet-butyl-4-hydroxybenzyl)-1,3,5-triazine, 1,3,5-tris(3,5-di-tet-butyl-4-hydroxybenzyl)-isoanuranate, 1,3,5-tris(3,5-di-tet-butyl-3-hydroxy-2,5,8,11-tetramethylbenzyl)-isoanuranate, 2,4,6-tris(3,5-di-tet-butyl-4-hydroxyanilinoethyl)-1,3,5-triazine, 1,3,5-tris(3,5-di-tet-butyl-4-hydroxyphenylpropionyl)hexahydro-1,3,5-triazine, 1,3,5-tris(3,5-di-cyclohexyl-4-hydroxybenzyl)-isoanuranate.

[0047] 1.11. Benzyl phosphonates, for example dimethyl 2,5-di-tet-butyl-4-hydroxybenzylphosphonate, diethyl 3,5-di-tet-butyl-4-hydroxybenzylphosphonate, dioctadecyl 3,5-di-tet-butyl-4-hydroxybenzylphosphonate, dioctadecyl 5-tet-butyl-4-hydroxy-3-methylphosphonate, the calcium salt of the monochloro cester of 3,5-di-tet-butyl-4-hydroxybenzylphosphonic acid.

[0048] 1.12. Acylaminophenols, for example 4-hydroxy-lauramidile, 4-hydroxystearanilide, octyl N-(3,5-di-tet-butylhydroxyphenyl)carbamate.

[0049] 1.13. Esters of β-(3,5-di-tet-butyl-4-hydroxyphenyl)propionic acid, β-(5-tet-butyl-4-hydroxy-3-methylphenyl)propionic acid, β-(3,5-dicyclohexyl-4-hydroxyphenyl)propionic acid, 3,5-di-tet-butyl-4-hydroxyphenylacetic acid or β-(3-tet-butyl-4-hydroxyphenyl)-3-thiabutyric acid with mono- or polyhydric alcohols, e.g. with methanol, ethanol, n-octanol, i-octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaoxyritol, tri(hydroxyethyl)isocyanurate, N,N,N'-bis(hydroxyethyl)oxalamide, 3-thianodecanol, 3-thia-pentadecanol, trimethylhexanediol, trimethylpropanol, 4-hydroxyethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane, glycerol and transterification products based on natural triglycerides of, for example, coconut oil, rape seed oil, sunflower oil or colza oil.

[0050] 1.14. Amides of β-(3,5-di-tet-butyl-4-hydroxyphenyl)propionic acid, e.g. N,N'-bis(3,5-di-tet-butyl-4-hydroxyphenyl)propionylhexamethylene diamine, N,N'-bis(3,5-di-tet-butyl-4-hydroxyphenyl)propionyltrimethylene diamine, N,N'-bis(3,5-di-tet-butyl-4-hydroxyphenyl)propionylhexamethylene diamine, N,N'-bis(3,5-di-tet-butyl-4-hydroxyphenyl)propionylhydrazine.

[0051] 1.15. Ascorbic acid (vitamin C).

[0052] 1.16. Aminie-type antioxidants, for example N,N'-disopropyl-p-phenylenediamine, N,N'-di-sec-butyl-p-phenylenediamine, N,N'-bis(1,4-dimethylphenyl)-p-phenylenediamine, N,N'-bis(1-ethyl-3-methyl-pentyl)-p-phenylenediamine, N,N'-bis(1-methyl-heptyl)-p-phenylenediamine, N,N'-dicyclohexyl-p-phenylenediamine, N,N'-diphenyl-p-phenylenediamine, N,N'-di-(naphth-2-yl)-p-phenylenediamine, N-isopropyl-N'-phenyl-p-phenylenediamine, N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine, N-(1-methylheptyl)-N'-phenyl-p-phenylenediamine, N-cyclohexyl-N'-phenyl-p-phenylenediamine, 4-(p-toluene-sulfonamido) diphenylamine, N,N'-dimethyl-N,N'-di-sec-butyl-p-phenylenediamine, diphenylamine, N-allyl diphenylamine, 4-isoproxy-diphenylamine, N-phenyl-1-naphthylamine, N-(4-tet-oc-tylphenyl)-1-naphthylamine, N-phenyl-2-naphthylamine, octylated diphenylamine, e.g. p,p'-di-tet-oc-tyl diphenylamine, N-4-nbutylaminophenol, 4-butoxyaminophenol, 4-nonylaminophenol, 4-dodecylaminophenol, 4-octadecylaminophenol, di-(4-methoxyphenyl)amine, 2,6-di-tet-butyl-4-dimethylamino-phenol, 2,4-diaminobenzaldehyde, 3,4'-diamino-biphenylmethane, N,N,N'-tetramethyl-4,4'-diaminobiphenylmethane, 1,2-dii-(2-methyl-phenyl)aminocine, 2,4,6-tris(3,5-di-tet-butyl-4-hydroxyphenylpropionyl)hexahydro-1,3,5-triazine, 1,3,5-tris(3,5-di-tet-butyl-4-hydroxyphenylpropionyl)hexahydro-1,3,5-triazine, 1,3,5-tris(3,5-di-cyclohexyl-4-hydroxybenzyldi-isoanuranate.

[0053] 1.17. Examples of further antioxidants, for example aliphatic or aromatic phosphites, esters of thio-
dipropionic acid or of thiodiacectic acid, or salts of dithiobarbituric acid, 2,2,12,12-tetramethyl-5,9-dihydropyrido-3,7,1-trithiatriadecane and 2,2,15,15-tetramethyl-5,12-dihydropyrido-3,7,10,14-tetraathiahexadecane.

[0054] 2. Examples of metal passivators, for example for copper, are:

[0055] 2.1. Benzotriazole and their derivatives, for example 4- or 5-alkylbenzotriazoles (e.g. tolutriazole) and derivatives thereof, 4,5,6,7-tetrahydrobenzotriazole, 5,5'-methylenebischloroacetelylene; Mannich bases of benzotriazole or tolutriazole, such as 1-di(2-ethylhexyl)aminomethyltolutriazole and 1-di(2-ethylhexyl)aminomethyl-benzotriazole; alkoxyalkylbenzotriazoles, such as 1-(nonyl oxy)methyl)-benzotriazole, 1-(1-butoxyethyl)-benzotriazole and 1-(1-cyclohexoxybutyl)-tolutriazole.

[0056] 2.2. 1,2,4-Triazoles and derivatives thereof, for example 3-alkyl- (or aryl)-1,2,4-triazoles, Mannich bases of 1,2,4-triazoles such as 1-di(2-ethylhexyl)aminomethyl-1,2,4-triazole; alkoxyalkyl-1,2,4-triazoles such as 1-(1-butoxyethyl)-1,2,4-triazole; acylated-3-amino-1,2,4-triazoles.

[0057] 2.3. Imidazole derivatives, for example 4,4'-methylenebis(2-undecyl-5-methyl-imidazole), bis-(N-methyl)imidazole-2-ylcarbonyl octyl ether.

[0058] 2.4. Sulfur-containing heterocyclic compounds, for example 2-mercaptobenzothiazole, 2,5-dimercapto-1,3,4-thiadiazole, 2,5-dimercaptothiazolidine and derivatives thereof, 3,5-bis-di(2-ethylhexyl)aminomethyl-1,3,4-thiadiazolin-2-one.

[0059] 2.5. Amino compounds, for example salicylidene propylenediamine, salicylaminoguanidine and salts thereof.

[0060] 3. Examples of rust inhibitors are:

[0061] 3.1. Organic acids, their esters, metal salts, amine salts and anhydrides, for example alkyl- and alkenylicamines and the partial esters thereof with alcohols, diols or hydroxyarboxylic acids, partial amides of alkyl- and alkenylicacids, 4-nonyl-phenoxycetic acid, alkoxy- and alkoxystearicarboxylic acids, such as dodecylstearyl acid, dodecylstearyl ether, and the amine salts thereof, and also N-oleylsarcosine, sorbitol monoanolate, lead naphthenate, alkenylicanhydrides, for example dodecanedioic anhydride, 2-(carboxyethyl)-1-dodecyl-3-methylgllycerine and its salts, especially sodium and triethanolamine salts.

[0062] 3.2. Nitrogen-containing compounds, for example:

[0063] 3.2.1. Primary, secondary or tertiary aliphatic or cycloaliphatic amines and amine salts of organic and inorganic acids, for example oil-soluble alkylylammonium carbohydrates, and also 1-N,N-bis(2-hydroxyethyl)aminomethyl-3-(4-nonylphenoxy)-propan-2-ol.

[0064] 3.2.2. Heterocyclic compounds, for example substituted imidazolines and oxazolines, 2-heptadecenyl-1-(2-hydroxyethyl)-imidazoline.

[0065] 3.3. Phosphorus-containing compounds, for example amine salts of phosphonic acid partial esters or phosphonic acid partial esters, zinc dialkyldihosphites.

[0066] 3.4. Sulfur-containing compounds, for example barium dimonylnaphthalene-sulfonates, calcium petroleum

sulfonates, alkylthio-substituted aliphatic carboxylic acids, esters of aliphatic 2-sulfocarboxylic acids and salts thereof.

[0067] 3.5. Glycerol derivatives, for example glycerol monooctylate, 1-(allylphenoxy)-3-(2-hydroxyethyl)glycerol, 1-(allylphenoxy)-3-(2,3-dihydroxypropyl)glycerol, 2-carboxyalkyl-1,3-dialkylglycerols.

[0068] 4. Examples of viscosity index improvers are: polyacrylates, polylmethacrylates, vinylpyrrolidone/methacrylate copolymers, polyvinylpyrrolidones, polybutenes, olefin copolymers, styrene/ acrylicate copolymers, polyesters.

[0069] 5. Examples of pour point depressants are polyurethane, alkylated naphthenic derivatives.

[0070] 6. Examples of dispersants/surfactants are: Polybutynlysuccinamides and -imides, polybutenylphosphonic acid derivatives, and basic magnesium, calcium and barium sulfonates, phenolates and salicylates.

[0071] 7. Examples of antifoams are silicone oils and polymethacrylens.

[0072] 8. Examples of solid lubricants are TEFALON or molybdenum sulfide.

[0073] 9. Examples of wear control additives are sulfur-containing sulfur-rich- or/and halogen-containing compounds, such as sulfureified olefins and vegetable oils, zinc dialkyldithiophosphates, tritolyl phosphate, tricresyl phosphate, chlorinated paraffins, alkyl and aryl di- and tri-sulfides, amine salts of mono- and dialkyl phosphates, amine salts of methylyphosphonic acid, diethylaminomethylthioltriazole, di(2-ethylhexyl)-aminomethylthioltriazole, derivatives of 2,5-dimercapto-1,3,4-thiadiazole, ethyl ((bisopropoxy)oxyphosphinoyl)propioniate, triphenyl (triphenyl phosphorothioate), tris-(alkyllyphosphoryl) phosphorothioates and mixtures thereof, for example tris(isonylonphenoxy) phosphorothioate, diphenylmonononylphosphorothioate, isobutylphenyl diphenyl phosphorothioate, the dodecylamine salt of 3-hydroxy-1,3-thiaphtophan 3-oxide, triphosphoric acid 5,5,5-tris(octyl) 2-acetate, derivatives of 2-mercaptobenzothenzole, such as 1-N,N-bis(2-ethylhexyl)aminomethyl-2-mercapto-1H-1,3-benzothiazole, and ethoxy carbonyl 5-octylthioisocarbamate.

[0074] The compounds of the formula (I) and their preparation are known per se. They serve primarily as intermediates for various products and applications, such as the ones described for example in V. Oveltnikov et al., Org. React. (Tarua) 15(2) (1978)), 194-203 (eng.) CA 90: 120801s and in L.A. Belova et al., Zh. Obsch. Khim 51 (9) (1981) 1982-88 ( Russ.) CA 96: 103597m.

[0075] The synthesis of β-dithiophosphorylated propionic acid by addition of dithiophosphoric acid onto acrylic or methacrylic acid is known and is described, for example, in U.S. Pat. No. 5,362,419 (Ex. 1-11). U.S. Pat. No. 5,922,657 also describes the synthesis of some β-dithiophosphorylated propionic acids.

[0076] The following Example illustrates the invention in more detail. They are not to be construed as limiting the instant invention in any manner whatsoever.

EXAMPLE

[0077] 5.0 wt. % of IRGALUBE 353 is added to an engine oils formulation containing antioxidants, defoamers and
viscosity index improvers in a mixture of ester and poly-o-olefin (PAO). The resulting blend is evaluated via the reversed FZG transmission test (as described in CEC IT 84/FVA 243, A10/16.6R/90). This test assesses the load bearing capacity of lubricants for use in high load transportation gear oils. Test severity is increased compared to the standard test (DIN 51354 Part 2) as a result of the following conditions: The pinion face is halved to b=20 mm, the rotational speed is doubled to 16.6 m/s, and the wheel drives the pinion hence the description of the method as “reversed FZG”). The load exerted on the gears is raised level by level. From power stage 4 onwards, after each power level the change in the flanks is recorded. The test is stopped at the “Failure Load Stage”, that is the level at which the flanks of at least two gear wheels show clear damage (cracks or the like). The results show that this formulation meets OEM specification requirements for this property of a Failure Load Stage (FLS)=10. When the Example is repeated with the further inclusion of IRGALUBE 349, the specifications are met.

1. An engine oil composition that meets FZG CEC IT-84/FVA 243(A10/16.6R/90) of transportation gear oils, wherein FLS=10, comprising
   a) An engine oil;
   b) At least one compound of the formula

   ![Chemical Structure](image)

   in which

   \[ R_1 \text{ and } R_2 \text{ independently of one another are } C_2-C_{18} \text{ alkyl, } C_{5}-C_{12} \text{ cycloalkyl, } C_{7}-C_{10} \text{ cycloalkylmethyl, } C_{5}-C_{18} \text{ bicycloalkylmethyl, } C_{12}-C_{20} \text{ tricycloalkylmethyl, phenyl or } C_{7}-C_{2} \text{ alkylphenyl or together are } (CH_2)_m(CH_2)_n, \]

   R_3 \text{ is hydrogen or methyl, and, if desired,}

c) other customary oil additives selected from the group consisting of antioxidants, antifoam additives, metal passivators, rust inhibitors, dispersants, detergents, viscosity index improvers, and antiwear additives; and

   wherein component b) is about 2.0 to about 8.0% by weight, based on the weight of component a) plus component c):

2. A composition according to claim 1, wherein component b) is about 4.0 to about 6.0% by weight, based on the weight of component a) plus component c).

3. A composition according to claim 1, wherein component b) is about 4.5 to about 5.5% by weight, based on the weight of component a) plus component c).

4. A composition according to claim 1, wherein component b) is about 5.0% by weight, based on the weight of component a) plus component c).

5. A composition according to claim 1, in which \( R_1 \) and \( R_2 \) independently of one another are \( C_3-C_{18} \) alkyl, \( C_7-C_{12} \) cycloalkyl or \( C_7-C_{12} \) alkylphenyl.

6. A composition according to claim 1, in which the antwear additives of component c) are selected from the group consisting of amine phosphate additives of the formula

   \[ (R_3O)_2PO(OH)_x(HN(R_3))_y \]

   wherein \( R_3 \) is n-hexyl, \( R_3 \) is \( C_7-C_{14} \) branched alkyl, and \( x \) and \( y \) are 1 or 2 where \( x+y=3 \).

7. A method of improving the service properties of engine oils which method comprises adding thereto about 2.0 to about 8.0% by weight, based on the weight of the engine oil plus other customary oil additives, of at least one compound of formula (I) according to claim 1, wherein the other customary oil additives are selected from the group consisting of antioxidants, antifoam additives, metal passivators, rust inhibitors, dispersants, detergents, viscosity index improvers, pour point depressants and antiwear additives.

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