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(54) **Power transmission fluids with enhanced antishudder durability**

(57) A finished power transmitting fluid having enhanced friction durability and improved μ/v characteristics on paper, steel and advanced friction materials such as carbon fiber, and which may provide a lubricant composition that carries minimal concern for skin sensitization and related health, safety, and environmental issues, can contain lubricating base oil, a friction modifier produced by reacting a polyamine with an aliphatic mono acid such as oleic or isostearic acid under conditions to form a mixture of 1,2-disubstituted imidazoline containing components, wherein further acylation of residual active nitrogens with mono or diacids or anhydrides affords friction modifier compositions having enhanced frictional and handling characteristics.

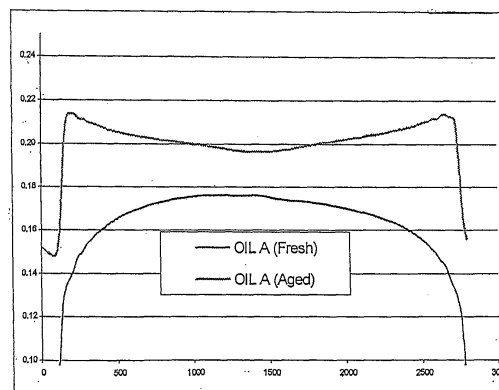
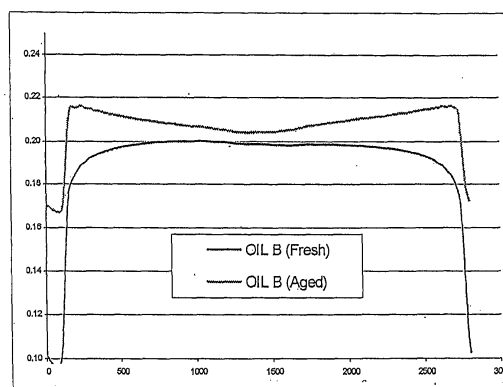


FIG. 1

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Description**FIELD OF THE INVENTION**

5 **[0001]** The present disclosure relates to fluids having improved friction durability and μ/v characteristics on paper, metal and advanced friction materials. The fluids disclosed herein can exhibit improved handling characteristics, and improved anti-shudder durability. The invention includes devices, such as a power transmission apparatus, lubricated with such fluids.

BACKGROUND OF THE INVENTION

10 **[0002]** New and advanced transmission systems are being developed by the automotive industry. These new systems often involve high energy requirements. Therefore, component protection technology must be developed to meet the increasing energy requirements of these advanced systems, to promote fuel economy, and to extend satisfactory friction requirements at low and high speeds.

15 **[0003]** These new and advance transmissions used in passenger cars and heavy duty vehicles continue to become more sophisticated in design as vehicle technology advances. These design changes result from the need to improve vehicle operability, reliability, and fuel economy. Vehicle manufacturers worldwide are increasing vehicle warranty periods and service intervals on their vehicles. This means that the transmission and the transmission fluid must be designed to operate reliably without maintenance for longer periods of time. In the case of the fluid, this means longer drain intervals. To improve vehicle operability, especially at low temperature, manufacturers have imposed strict requirements for fluid viscosity at -40°C. To cope with longer drain intervals and more severe operating conditions, manufacturers have increased the requirements for fluid oxidation resistance, required less change in viscosity with vehicle mileage (improved shear stability), and increased the amount of wear protection that the fluid must provide for the transmission. To improve
20 the fuel economy of the vehicle and reduce energy loss, manufacturers nowadays employ continuously slipping clutches either as wet starting clutches or as a torque converter clutch. These devices require very precise control of fluid frictional properties.

25 **[0004]** The continuing search for methods to improve overall vehicle fuel economy has identified the torque converter, or fluid coupling, used between the engine and automatic transmission, as a relatively large source of energy loss. Since the torque converter is a fluid coupling it is not as efficient as a solid disk type clutch. At any set of operating conditions (engine speed, throttle position, ground speed, transmission gear ratio), there is a relative speed difference between the driving and driven members of the torque converter. This relative speed differential represents lost energy which is dissipated from the torque converter as heat.

30 **[0005]** One method of improving overall vehicle fuel economy used by transmission builders is to build into the torque converter a clutch mechanism capable of "locking" the torque converter. "Locking" refers to eliminating relative motion between the driving and driven members of the torque converter so that no energy is lost in the fluid coupling. These "locking" or "lock-up" clutches are very effective at capturing lost energy at high road speeds. However, when they are used at low speeds, vehicle operation is rough and engine vibration is transmitted through the drive train. Rough operation and engine vibration are not acceptable to drivers.

35 **[0006]** The higher the percentage of time that the vehicle can be operated with the torque converter clutch engaged, the more fuel efficient the vehicle becomes. A further generation of torque converter clutches have been developed which operate in a "slipping" or "continuously sliding mode." These devices have a number of names, but are commonly referred to as continuously slipping torque converter clutches. The difference between these devices and lock-up clutches is that they allow some relative motion between the driving and driven members of the torque converter, normally a relative speed of 50 to 500 rpm. This slow rate of slipping allows for improved vehicle performance as the slipping clutch acts as a vibration damper. Whereas the "lock-up" type clutch could only be used at road speeds above approximately 50 mph, the "slipping" type clutches can be used at speeds as low as 25 mph, thereby capturing significantly more lost energy. It is this feature that makes these devices very attractive to vehicle manufacturers.

40 **[0007]** Another approach to reducing energy loss in the coupling between the engine and transmission is to use a wet starting clutch. Wet starting clutches resemble shifting clutches but are made to handle the entire energy of the vehicle. Therefore they tend to be physically larger than shifting clutches. However, just as with the torque converter clutch, they are continuously slipped to improve overall vehicle driveability and ride feel.

45 **[0008]** Continuously slipping clutches have been fitted to all types of transmissions. Continuously slipping torque converter clutches and/or wet starting clutches are routinely used with transmission types such as conventional automatic transmissions, continuously variable transmissions (CVTs), manual transmissions, and dual clutch transmissions.

50 **[0009]** Continuously slipping clutches, such as continuously slipping torque converter clutches, impose very exacting friction requirements on automatic transmission fluids (ATFs) used with them. The fluid must have a very good friction versus velocity relationship, i.e., friction must always increase with increasing speed. If friction decreases with increasing

speed then a selfexciting vibrational state can be set up in the driveline. This phenomenon is commonly called "stick-slip" or "dynamic frictional vibration" and manifests itself as "shudder" or low speed vibration in the vehicle. Clutch shudder is very objectionable to the driver. A fluid which allows the vehicle to operate without vibration or shudder is said to have good "anti-shudder" characteristics. Not only must the fluid have an excellent friction versus velocity relationship when it is new, it must retain those frictional characteristics over the lifetime of the fluid, which can be the lifetime of the transmission. The longevity of the anti-shudder performance in the vehicle is commonly referred to as "anti-shudder durability."

[0010] Lubricating a continuously variable transmission equipped with a steel push belt or chain drive variator and a slipping clutch system is not a simple matter. It presents a unique challenge of providing high steel-on-steel friction for the variator and excellent paper-on-steel friction for the slipping clutch. Compounding the challenge to satisfy these requirements is the further need for the fluid to provide durability of desired friction performance over a wide range of operating temperatures. Therefore, the friction modifier system must provide very precise control of the steel-on-steel friction and the paper-on-steel friction over a wide range of operating conditions, such as a wide range in temperatures.

[0011] Past efforts include those described in U.S. Patent No. 5,395,539, which are said to be imidazole-free, as well as those described in U.S. Patent Nos. 5,750,476; 5,811,377; 5,840,662; 5,840,663; EP 0393769 B2; EP 0877784 B1; among others.

[0012] Despite these past efforts there remains a need for compositions and methods that can address the needs in the industry.

[0013] We have discovered certain compounds as described hereinbelow that are readily formulated into power transmission fluids, such as for an automatic transmission, provide a unique solution for providing desired characteristics, such as extending the anti-shudder durability of the fluid.

SUMMARY OF THE INVENTION

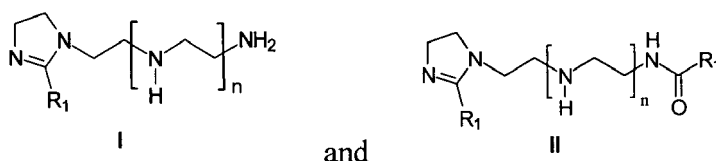
[0014] An aspect of the present invention relates to an improved power transmitting fluid having enhanced friction durability and μ/v characteristics, particularly one that can exhibit a positive μ/v curve and can maintain high static capacity during expected use, on paper, steel, and advanced friction materials such as carbon fiber.

[0015] Another aspect of the present invention is to provide a lubricant composition that carries minimal concern for skin sensitization and related health, safety, and environmental issues.

[0016] In an aspect of the present invention, a composition and a method of improving the anti-shudder durability of power transmitting fluids, particularly automatic transmission fluids, are provided.

[0017] An embodiment of the present invention is a fluid composition comprising a lubricating base oil, a friction modifier produced by reacting a polyamine with an aliphatic mono acid such as oleic or isostearic acid under conditions to form a mixture of 1,2-disubstituted imidazoline containing components, and, optionally, other performance enhancing additives. Further acylation of residual active nitrogens with mono or diacids or anhydrides affords a friction modifier ("FM") compound(s) having enhanced frictional and handling characteristics.

[0018] In one aspect of the invention, a fluid comprises a reaction product of aliphatic carboxylic acids with polyamines, and particularly a reaction product obtained under conditions to produce compounds that include 1,2- disubstituted imidazolines, including such as compounds as represented by formulas I and II hereinbelow:



wherein the formulae R_1 can be selected from the group consisting C_3 to C_{30} straight chain or branched alkyl, alkenyl, aryl, or a heteroatom derivative thereof, or hydrocarbyl groups as oligomers/polymers derived from propylene isobutylene and higher olefins having terminal, internal and vinylidene double bonds, and their heteroatom derivatives; and "n" ranges from 0 to 5; and/or such a reaction product post-treated with a second carboxylic acid or carboxylic acid derivative.

[0019] A fluid formulated as a power transmission fluid can contain an effective amount of at least one oil soluble ashless dispersant, such as a succinimide dispersant, succinic ester dispersant, succinic ester-amide dispersant, Mannich base dispersant, phosphorylated and/or boronated forms thereof.

[0020] A fluid formulation according to an aspect of the invention may optionally include commercially available supplemental additives such as, for example, air expulsion additives, antioxidants, corrosion inhibitors, foam inhibitors, metallic detergents, organic phosphorus compounds, seal-swell agents, viscosity index improvers, EP additives used

in their conventional amounts.

[0021] A fluid according to an aspect of the invention can be formulated for use in an industrial gear or an automotive gear. In an automotive aspect, a fluid can be formulated for use in a power transmitting apparatus, such as a transmission employing one or more of an electronically controlled converter clutch, a slipping torque converter, a lock-up torque converter, a starting clutch, and one or more shifting clutches; or a differential. For example, a fluid containing a friction modifier comprised of compounds represented by formula I and/or II, or their post-treated reaction products, at least one ashless dispersant, and, optionally, one or more other performance additives such as antioxidants, anti foam agents, antiwear agents, corrosion inhibitors, EP additives, metallic detergents, organic phosphorus compound(s), rust inhibitors, seal-swell agents viscosity index improvers, can be used in automatic transmissions, including those that incorporate lock-up and dual clutches, semi-automatic transmissions, automated manual transmissions, and continuously variable transmissions ("CVTs").

[0022] The present invention includes such further embodiments as a method for improving the stability against oxidation degradation, e.g. promoting the duration of a relatively constant dynamic coefficient of friction, in a power transmission fluid by incorporating into the fluid an effective amount of a friction modifier compound(s) represented by a formula I to VI described herein.

Brief Description of the Figures

[0023]

FIG. 1 represents side-by-side graphs to illustrate comparison between a conventional automatic transmission fluid A and an automatic transmission fluid B according to this invention.

FIG. 2 is a diagram depicting apparatus for conducting a LFW- 1 test.

Detailed Description of the Invention

[0024] Vehicles meeting stringent consumer demands require durability and performance in all of the vehicular systems. One of the most important systems is the power transmission system ("transmission") which transmits the power generated by the automobile engine to the wheels. It is one of the most complex systems in the vehicle, it is also one of the most costly to diagnose, repair, or replace. The transmission usually includes, *inter alia*, a clutch with plates, a torque converter, and a plurality of gears to alter the power delivered to the wheels by changing the gear ratio.

[0025] Discriminating consumers primarily desire high performance, low maintenance (high mileage between servicing), and extended life expectancy. However, with the advent of new transmission technologies, old standards of performance which were previously met with approval are now becoming problematic.

[0026] The advent of electronically controlled converter clutch (ECCC) designs, as well as vehicles equipped with a continuously variable transmission (CVT) and advances in aerodynamic body design generally result in passenger cars with smaller transmissions which tend to operate with higher energy densities and higher operating temperatures. Such changes challenge lubricant suppliers to formulate automatic transmission fluids with new and unique performance characteristics including higher torque and friction durability. Original equipment manufacturers (OEMs) desire automatic transmission fluids with frictional characteristics capable of meeting the requirements of ECCC, CVT, and other designs while retaining sufficient performance in the antiwear arena.

[0027] A long felt need exists for an effective way of overcoming the problems associated with automatic transmissions, such as to meet the needs of OEM automobile designers and suppliers, for extended transmission fluid life and durability of high static capacity and improved durability of the dynamic coefficient of friction.

[0028] This invention responds to the long felt need for improved durability in a lubricating fluid by providing an automatic transmission fluid that exhibits good performance during its lifetime and that can exhibit a sufficient dynamic coefficient of friction for longer periods of time without significant degradation, e.g. improved stability against oxidation, with extended anti-shudder durability.

[0029] Friction modifiers can be used in automatic transmission fluids to decrease friction between surfaces (e.g., the members of a torque converter clutch or a shifting clutch) at low sliding speeds. The result is a friction-vs.-velocity (μ -v) curve that has a positive slope, which in turn leads to smooth clutch engagements and minimizes "stick-slip" behavior (e.g., shudder, noise, and harsh shifts).

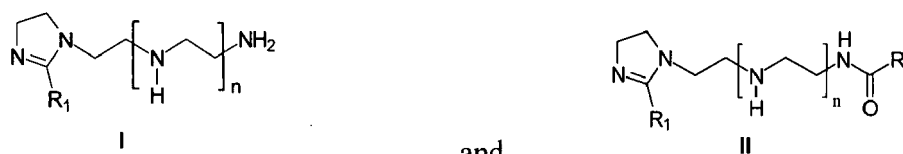
[0030] Increasing desired properties, such as anti-shudder durability and stability against oxidation with reduced variation in the dynamic coefficient of friction, is a complex, challenging problem. Contrary to the apparently facile solution of increasing the amount of a conventional friction modifier in a power transmission fluid, an increased concentration can actually reduce the overall level of friction exhibited by the fluid. Reducing the friction coefficients below certain minimum values is not desired since the holding capacity of a clutch in a transmission can be adversely reduced, thereby making clutch slippage more likely when the transmission is being operated. Clutch wear increases and a clutch can be

ruined by unwanted slippage.

[0031] To address these and other challenges in the art, a fluid according to the present invention contains, as an essential component, a reaction product of an aliphatic carboxylic acid (RCOOH) and a polyamine (PA), for example a reaction product obtained under conditions sufficient to generate a mixture of 1,2 disubstituted imidazolines represented by formulas I and/or II, and/or such a reaction product which is post-treated, such as with a second carboxylic acid or a carboxylic acid derivative to obtain compound represented by any of formulas III-VI. The composition of the final reaction product can be determined by the molar ratio between carboxylic acid and the polyamine.

[0032] Generalized structures I through VI exemplify typical friction modifiers for use in the various fluid embodiments according to the invention. These friction modifiers can form under conditions as described below.

[0033] A reaction product of a polyamine(s) with a first acid (R_1COOH) can yield a mixture containing a compound represented by formula I and a compound represented by formula II. A molar excess of the first organic acid is used relative to the polyamine.



[0034] A molar ratio of the first carboxylic acid to the polyamine can vary according to the desired composition of the reaction product. In general, the molar ratio can be suitably chosen with a range of about 1.0 to about 2.0, and as a further example, about 1.2 to about 1.6. For instance, at lower molar ratios the composition may in principle predominately be comprised of compound(s) represented by formula I, whereas at a higher molar ratio the composition may in principle be predominately comprised of compound(s) represented by formula II. The molar ratio may correspond to an excess of the first carboxylic acid to polyamine.

[0035] Representative first acids are those providing the R₁ moieties. The R₁ moieties may be independent of one another, and can be C₃ to C₃₀ straight or branched alkyl, alkenyl or aryl groups or a heteroatom derivative thereof, such as an alkyl having heteroatoms, as one example. The present invention therefore contemplates, in one of its embodiments, using a combination of first acids. Representative moieties include fatty acids such as lauric, myristic, palmitic, stearic, isostearic, dodecenoic, hexadecenoic, oleic, iso-oleic, linoleic, arachidic, or a combination of any thereof. The R₁ group may incorporate hydrocarbyl aromatic acids like 4-dodecylbenzoic acid, 2-hexadecylnicotinic acid, and 4-polyisobutyl acid. Suitable friction modifiers include those that are obtained from the reaction of fatty acids exemplified by oleic acid or isostearic acid with a polyamine, such as triethylene tetramine.

[0036] Heteroatom derivatives of R₁ can include O, S, N, and/or P atoms as would be understood by those skilled in the art.

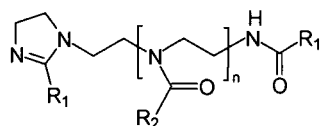
[0037] Representative polyamines can be linear, as connoted by the compounds represented by formulas I to VI (n= 0 to 5), or branched. An exemplary class of polyethylene amines contains an internal repeating unit of $-(CH_2 CH_2NH)_x-$ where x can be an integer from 1 to 10, and as a further example, x can be an integer of 1 to 6. In the case where the polyamine is represented by a formula $H_2N-(CH_2 CH_2NH)_x-CH_2 CH_2NH_2$, and x is 1 it is diethylene triamine, when x is 2 it is triethylene tetramine, and when x is 3 it is tetraethylene pentamine, which are among the suitable polyamines. Commercial mixtures of higher polyamines are also suitable. Amino groups can be attached to or be part of an aromatic or aliphatic ring structure, such as o-phenylenediamine, p-phenylenediamine, 4,4'-diaminodiphenylamine, melamine, or 1,8-diamino-p-mentane, among others.

[0038] For instance, reacting a selected first acid, such as $C_{17}H_{33}COOH$, and a suitable selected polyamine, such as where $x = 2$, in a molar ratio of about 4 to about 3 at a suitable elevated temperature in a range of about $120^{\circ}C$ to about $180^{\circ}C$, such as about $150^{\circ}C$, for a sufficient period of time, such as for about 5 to about 20 hours or, as a further example, for about 12 to about 16 hours, can produce a reaction product containing compound(s) represented by the formulas I and II wherein R_1 is a $C_{17}H_{35}$ moiety. The relative ratio of the compound represented by the just described formula I to the compound represented by the just described formula II can, in principle, be about 2:1. Other ratios may be feasible. The relative ratio of a compound(s) represented by formula I to a compound(s) represented by formula II can be determined by the ratio of carboxylic acid to polyamine.

[0039] An embodiment of the invention is a fluid, such as a power transmission fluid or a concentrate, which contains at least one compound represented by formula I and/or formula II.

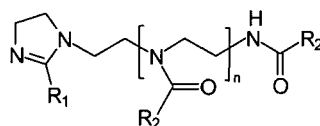
[0040] A post-treatment of a mixture (or reaction product) containing compound(s) represented by formulas I and/or II with at least one second organic acid (R_2COOH) can be conducted. The second organic acid may be in an amount sufficient to acylate all reactive nitrogen atoms to obtain a second mixture (or second reaction product) containing a

compound(s) represented by formula III and a compound(s) represented by formula IV:



III

and



IV

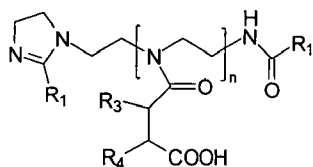
The level of acylation may, in general, be above about 0% to about 100%, and a further exemplary range can be, for instance, from about 50% to about 100%.

[0041] Representative second acids are those providing the R₂ moieties. The R₂ moieties may be independent of one another, and can be C₃ to C₃₀ straight or branched alkyl, alkenyl, or aryl, or heteroatom derivatives thereof, such as an alkyl having heteroatoms, as one example. The present invention therefore also contemplates using a combination of first acids. Representative moieties include those from fatty acids such as lauric, myristic, palmytic, stearic, iso-stearic, dodecenoic, hexadecenoic, oleic, iso-oleic, linoleic, arachidic, or a mixture of any thereof. The R₂ group may incorporate hydrocarbyl aromatic or heteroaromatic acids, such as 4-dodecylbenzoic acid, 2-hexadecylnicotinic acid, or 4-polyisobutyl benzoic acid, among others.

[0042] Heteroatom derivatives of R₂ can include O, S, N, and/or P atoms as would be understood by those skilled in the art.

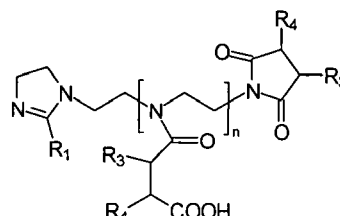
[0043] An embodiment of the invention is a fluid, such as a power transmission fluid or a concentrate, which contains one or more compounds represented by structures III and IV.

[0044] A post-treatment of a mixture containing compounds represented by formulas I and II with an excess of substituted anhydride, such as a substituted succinic anhydride, can be conducted. The amount of the substituted organic acid or anhydride may be in an amount sufficient to acylate all or a portion of the reactive nitrogens to yield a mixture of compounds that includes a compound(s) represented by formula V and a compound(s) represented by formula VI:



V

and



VI

The level of acylation may, in general, be above about 0% to about 100%, and a further exemplary range can be, for instance, from about 50% to about 100%.

[0045] Representative of the substituted organic acids and anhydrides are those corresponding to the R₃ and R₄ moieties. The R₃ and R₄ moieties may be independent of each other, and may reflect the use of combinations of suitable reagents. The R₃ and R₄ groups can be selected from a group consisting of H, -OH, -OR, -COOH, -SH, -SR, straight chain, branched alkyl, alkenyl radicals or hydrocarbyl groups in oligomeric or polymeric forms of propylene, isobutylene and higher olefins having terminal, internal, and vinylidene double bonds. The molecular weight of R₃ and R₄ can vary and may be as high as 1000 amu. The R represents an alkyl or alkenyl group having up to 30 carbon atoms in linear, branched or cyclic form, for example from 16 to 22 carbon atoms.

[0046] Accordingly, representative substituted organic acids and anhydrides include low molecular weight, oil-insoluble acids or anhydrides. Examples include succinic anhydride, phthalic anhydride, tartaric acid, citric acid, maleic acid, and mercaptosuccinic acid.

[0047] A suitable post-treatment reagent is a succinic anhydride produced from isomerization of linear α -olefins with an acid catalyst followed by reaction with maleic anhydride. Such preparation is described, for example, in U.S. Pat Nos. US 6,548,458; 5,620,486; 5,393,309; 5,021,169; US 4,958,034; 4,234,435; 3,676,089; 3,361,673; and 3,172,892 and European Patent 0623631 B1, herein incorporated by reference.

[0048] An embodiment of the invention is a fluid, such as a power transmission fluid or a concentrate, which contains

one or more compound(s) represented by formula V and/or VI.

[0049] The friction modifier(s) described above are idealized compositions in the sense that they don't incorporate cross-linking products and by-products due to variation in the level of acylation.

[0050] A fluid according to the invention can contain one or more compounds from among those represented by formulas I to VI, including any combination of such compounds. Suitable mixtures of compounds include, for instance, a mixture of compounds represented by formula I, a mixture of compounds represented by formula II, a mixture of compounds represented by formula III, a mixture of compounds represented by formula IV, a mixture of compounds represented by formula V, a mixture of compounds represented by formula VI, a mixture of a compound(s) represented by formula I and a compound(s) represented by formula II, a mixture of a compound(s) represented by formula III and a compound(s) represented by formula IV, a mixture of a compound(s) represented by formula V and a compound(s) represented by formula VI, a mixture of compounds from among those represented by formulas I, II, III, and IV, a mixture of compounds from among those represented by formula I, II, V and VI.

[0051] A combination of the suitable reactants and reagents can be selected to produce a friction modifier composition that contains a compound(s) where R₁ is oleyl or isostearyl, and R₃ and/or R₄ is an isomerized α -olefin derived hydrocarbyl group. Further, R₃ and/or R₄ may comprise a moiety from polyisobutylene having a molecular weight of about 200 to about 950 amu or a C₁₆ to C₂₂ isomerized α -olefin.

[0052] Compounds represented by formulas I to VI can each be borated, maleated, treated with an inorganic acid, such as phosphoric, phosphorous and sulfuric acids, as described in U.S. Patent Nos. 3,254,025; 3,502,677; 4,686,054; and 4,857,214.

[0053] The level of this component in a finished oil-containing power transmission fluid may range from about 0.01 to about 10 % (weight percent). A suitable range is from about 0.1 to about 5.0 % weight percent. For example, the component can comprise a mixture of compounds represented by formula V and by formula VI.

Dispersants (Oil-Soluble)

[0054] In an aspect of the invention, the fluid can contain at least one oil soluble type dispersant, such as a succinimide dispersant, succinic ester dispersant, succininic ester-amide dispersant, Mannich base dispersant, phosphorylated and/or boronated forms thereof. The total dispersant content of a fluid, such as a power transmission fluid, according to the invention can vary from 0.1 to 20 weight percent. As a further example, the suitable range can be from about 2.0 to about 7.0 weight percent.

[0055] Oil-soluble dispersants may include ashless dispersants such as succinimide dispersants, Mannich base dispersants, and polymeric polyamine dispersants. Hydrocarbyl-substituted succinic acylating agents are used to make hydrocarbyl-substituted succinimides. The hydrocarbyl-substituted succinic acylating agents include, but are not limited to, hydrocarbyl-substituted succinic acids, hydrocarbyl-substituted succinic anhydrides, the hydrocarbyl-substituted succinic acid halides (especially the acid fluorides and acid chlorides), and the esters of the hydrocarbyl-substituted succinic acids and lower alcohols (e.g., those containing up to 7 carbon atoms), that is, hydrocarbyl-substituted compounds which can function as carboxylic acylating agents.

[0056] Hydrocarbyl substituted acylating agents are made by reacting a polyolefin or chlorinated polyolefin of appropriate molecular weight with maleic anhydride. Similar carboxylic reactants can be used to make the acylating agents. Such reactants may include, but are not limited to, maleic acid, fumaric acid, malic acid, tartaric acid, itaconic acid, itaconic anhydride, citraconic acid, citraconic anhydride, mesaconic acid, ethylmaleic anhydride, dimethylmaleic anhydride, ethylmaleic acid, dimethylmaleic acid, hexylmaleic acid, and the like, including the corresponding acid halides and lower aliphatic esters.

[0057] The molecular weight of the olefin can vary depending upon the intended use of the substituted succinic anhydrides. Typically, the substituted succinic anhydrides will have a hydrocarbyl group of from about 8 to about 500 carbon atoms. However, substituted succinic anhydrides used to make lubricating oil dispersants will typically have a hydrocarbyl group of about 40 to about 500 carbon atoms. With high molecular weight substituted succinic anhydrides, it is more accurate to refer to number average molecular weight (Mn) since the olefins used to make these substituted succinic anhydrides may include a mixture of different molecular weight components resulting from the polymerization of low molecular weight olefin monomers such as ethylene, propylene, and isobutylene.

[0058] The mole ratio of maleic anhydride to olefin can vary widely. It may vary, for example, from about 5:1 to about 1:5, or for example, from about 1:1 to about 3:1. With olefins such as polyisobutylene having a number average molecular weight of about 500 to about 7000, or as a further example, about 800 to about 3000 or higher and the ethylene- α -olefin copolymers, the maleic anhydride may be used in stoichiometric excess, e.g. about 1.1 to about 3 moles maleic anhydride per mole of olefin. The unreacted maleic anhydride can be vaporized from the resultant reaction mixture.

[0059] Polyalkenyl succinic anhydrides may be converted to polyalkyl succinic anhydrides by using conventional reducing conditions such as catalytic hydrogenation. For catalytic hydrogenation, a suitable catalyst is palladium on carbon: Likewise, polyalkenyl succinimides may be converted to polyalkyl succinimides using similar reducing conditions.

[0060] The polyalkyl or polyalkenyl substituent on the succinic anhydrides employed herein is generally derived from polyolefins, which are polymers or copolymers of mono-olefins, particularly 1-mono-olefins, such as ethylene, propylene, and butylene. The mono-olefin employed may have about 2 to about 24 carbon atoms, or as a further example, about 3 to about 12 carbon atoms. Other suitable mono-olefins include propylene, butylene, particularly isobutylene, 1-octene, and 1-decene. Polyolefins prepared from such mono-olefins include polypropylene, polybutene, polyisobutene, and the polyalphaolefins produced from 1-octene and 1-decene.

[0061] In some embodiments, the ashless dispersant may include one or more alkenyl succinimides of an amine having at least one primary amino group capable of forming an imide group. The alkenyl succinimides may be formed by conventional methods such as by heating an alkenyl succinic anhydride, acid, acid ester, acid halide, or lower alkyl ester with an amine containing at least one primary amino group. The alkenyl succinic anhydride may be made readily by heating a mixture of polyolefin and maleic anhydride to about 180°C-220°C. The polyolefin may be a polymer or copolymer of a lower mono-olefin such as ethylene, propylene, isobutene, and the like, having a number average molecular weight in the range of about 300 to about 3000 as determined by gel permeation chromatography (GPC).

[0062] Amines which may be employed in forming the ashless dispersant include any that have at least one primary amino group which can react to form an imide group and at least one additional primary or secondary amino group and/or at least one hydroxyl group. Representative examples include: N-methyl-propanediamine, N-dodecylpropanediamine, N-aminopropyl-piperazine, ethanolamine, N-ethanol-ethylenediamine, and the like.

[0063] Suitable amines may include alkylene polyamines, such as propylene diamine, dipropylene triamine, di-(1,2-butylene)triamine, and tetra-(1,2-propylene)pentamine. A further example includes the ethylene polyamines which can be depicted by the formula $H_2N(CH_2CH_2NH)_nH$, wherein n may be an integer from about 1 to about 10. These include: ethylene diamine, diethylene triamine (DETA), triethylene tetramine (TETA), tetraethylene pentamine (TEPA), pentaethylene hexamine (PEHA), and the like, including mixtures thereof in which case n is the average value of the mixture. Such ethylene polyamines have a primary amine group at each end so they may form mono-alkenylsuccinimides and bis-alkenylsuccinimides. Commercially available ethylene polyamine mixtures may contain minor amounts of branched species and cyclic species such as N-aminoethyl piperazine, N,N'-bis(aminoethyl)piperazine, N,N'-bis(piperazinyl)ethane, and like compounds. The commercial mixtures may have approximate overall compositions falling in the range corresponding to diethylene triamine to tetraethylene pentamine. The molar ratio of polyalkenyl succinic anhydride to polyalkylene polyamines may be from about 1:1 to about 3.0:1.

[0064] In some embodiments, the ashless dispersant may include the products of the reaction of a polyethylene polyamine, e.g., triethylene tetramine or tetraethylene pentamine, with a hydrocarbon substituted carboxylic acid or anhydride made by reaction of a polyolefin, such as polyisobutene, of suitable molecular weight, with an unsaturated polycarboxylic acid or anhydride, e.g., maleic anhydride, maleic acid, fumaric acid, or the like, including mixtures of two or more such substances.

[0065] Polyamines that are also suitable in preparing the dispersants described herein include N-arylphenylenediamines, such as N-phenylphenylenediamines, for example, N-phenyl-1,4-phenylenediamine, N-phenyl-1,3-phenylenediamine, and N-phenyl-1,2-phenylenediamine; aminothiazoles such as aminothiazole, aminobenzothiazole, aminobenzothiadiazole, and aminoalkylthiazole; aminocarbazoles; aminoindoles; aminopyrroles; amino-indazolinones; amino-mercaptotriazoles; aminoperimidines; aminoalkyl imidazoles, such as 1-(2-aminoethyl) imidazole, 1-(3-aminopropyl) imidazole; and aminoalkyl morpholines, such as 4-(3-aminopropyl) morpholine. These polyamines are described in more detail in U.S. Patent Nos. 4,863,623 and 5,075,383. Such polyamines can provide additional benefits, such as anti-wear and antioxidancy, to the final products.

[0066] Additional polyamines useful in forming the hydrocarbyl-substituted succinimides include polyamines having at least one primary or secondary amino group and at least one tertiary amino group in the molecule as taught in U.S. Patent Nos. 5,634,951 and 5,725,612. Examples of suitable polyamines include N,N,N',N''-tetraalkyldialkylenetriamines (two terminal tertiary amino groups and one central secondary amino group), N,N,N',N''-tetraalkyltrialkylenetetramines (one terminal tertiary amino group, two internal tertiary amino groups and one terminal primary amino group), N,N,N',N'',N'''-pentaalkyltrialkylenetetramines (one terminal tertiary amino group, two internal tertiary amino groups and one terminal secondary amino group), tris(dialkylaminoalkyl)-aminoalkylmethanes (three terminal tertiary amino groups and one terminal primary amino group), and like compounds, wherein the alkyl groups are the same or different and typically contain no more than about 12 carbon atoms each, and which may contain from about 1 to about 4 carbon atoms each. As a further example, these alkyl groups may be methyl and/or ethyl groups. Polyamine reactants of this type may include dimethylaminopropylamine (DMAPA) and N-methyl piperazine.

[0067] Hydroxyamines suitable for use herein include compounds, oligomers or polymers containing at least one primary or secondary amine capable of reacting with the hydrocarbyl-substituted succinic acid or anhydride. Examples of hydroxyamines suitable for use herein include aminoethylethanolamine (AEEA), aminopropyl-diethanolamine (AP-DEA), ethanolamine, diethanolamine (DEA), partially propoxylated hexamethylene diamine (for example HMDA-2PO or HMDA-3PO), 3-amino-1,2-propanediol, tris(hydroxymethyl)aminomethane, and 2-amino-1,3-propanediol.

[0068] The mole ratio of amine to hydrocarbyl-substituted succinic acid or anhydride may range from about 1:1 to

about 3.0:1. Another example of a mole ratio of amine to hydrocarbyl-substituted succinic acid or anhydride may range from about 1.5:1 to about 2.0:1.

[0069] The foregoing dispersant may also be a post-treated dispersant made, for example, by treating the dispersant with maleic anhydride and boric acid as described, for example, in U.S. Patent No. 5,789,353, or by treating the dispersant with nonylphenol, formaldehyde and glycolic acid as described, for example, in U.S. Patent No. 5,137,980.

[0070] The Mannich base dispersants may be a reaction product of an alkyl phenol, typically having a long chain alkyl substituent on the ring, with one or more aliphatic aldehydes containing from about 1 to about 7 carbon atoms (especially formaldehyde and derivatives thereof), and polyamines (especially polyalkylene polyamines). For example, a Mannich base ashless dispersants may be formed by condensing about one molar proportion of long chain hydrocarbon-substituted phenol with from about 1 to about 2.5 moles of formaldehyde and from about 0.5 to about 2 moles of polyalkylene polyamine.

[0071] Hydrocarbon sources for preparation of the Mannich polyamine dispersants may be those derived from substantially saturated petroleum fractions and olefin polymers, such as polymers of mono-olefins having from about 2 to about 6 carbon atoms. The hydrocarbon source generally contains, for example, at least about 40 carbon atoms, and as a further example, at least about 50 carbon atoms to provide substantial oil solubility to the dispersant. The olefin polymers having a GPC number average molecular weight between about 600 and about 5,000 are suitable for reasons of easy reactivity and low cost. However, polymers of higher molecular weight can also be used. Especially suitable hydrocarbon sources are isobutylene polymers and polymers made from a mixture of isobutene and a raffinate I stream.

[0072] Suitable Mannich base dispersants may be Mannich base ashless dispersants formed by condensing about one molar proportion of long chain hydrocarbon-substituted phenol with from about 1 to about 2.5 moles of formaldehyde and from about 0.5 to about 2 moles of polyalkylene polyamine.

[0073] Polymeric polyamine dispersants suitable as the ashless dispersants are polymers containing basic amine groups and oil solubilizing groups (for example, pendant alkyl groups having at least about 8 carbon atoms). Such materials are illustrated by interpolymers formed from various monomers such as decyl methacrylate, vinyl decyl ether or relatively high molecular weight olefins, with aminoalkyl acrylates and aminoalkyl acrylamides. Examples of polymeric polyamine dispersants are set forth in U.S. Patent Nos. 3,329,658; 3,449,250; 3,493,520; 3,519,565; 3,666,730; 3,687,849; and 3,702,300. Polymeric polyamines may include hydrocarbyl polyamines wherein the hydrocarbyl group is composed of the polymerization product of isobutene and a raffinate I stream as described above. PIB-amines and PIB-polyamines may also be used.

[0074] Methods for the production of ashless dispersants as described above are known to those skilled in the art and are reported in the patent literature. For example, the synthesis of various ashless dispersants of the foregoing types is described in such patents as U.S. Patent Nos. 2,459,112; 2,962,442; 2,984,550; 3,036,003; 3,163,603; 3,166,516; 3,172,892; 3,184,474; 3,202,678; 3,215,707; 3,216,936; 3,219,666; 3,236,770; 3,254,025; 3,271,310; 3,272,746; 3,275,554; 3,281,357; 3,306,908; 3,311,558; 3,316,177; 3,331,776; 3,340,281; 3,341,542; 3,346,493; 3,351,552; 3,355,270; 3,368,972; 3,381,022; 3,399,141; 3,413,347; 3,415,750; 3,433,744; 3,438,757; 3,442,808; 3,444,170; 3,448,047; 3,448,048; 3,448,049; 3,451,933; 3,454,497; 3,454,555; 3,454,607; 3,459,661; 3,461,172; 3,467,668; 3,493,520; 3,501,405; 3,522,179; 3,539,633; 3,541,012; 3,542,680; 3,543,678; 3,558,743; 3,565,804; 3,567,637; 3,574,101; 3,576,743; 3,586,629; 3,591,598; 3,600,372; 3,630,904; 3,632,510; 3,632,511; 3,634,515; 3,649,229; 3,697,428; 3,697,574; 3,703,536; 3,704,308; 3,725,277; 3,725,441; 3,725,480; 3,726,882; 3,736,357; 3,751,365; 3,756,953; 3,793,202; 3,798,165; 3,798,247; 3,803,039; 3,804,763; 3,836,471; 3,862,981; 3,872,019; 3,904,595; 3,936,480; 3,948,800; 3,950,341; 3,957,746; 3,957,854; 3,957,855; 3,980,569; 3,985,802; 3,991,098; 4,006,089; 4,011,380; 4,025,451; 4,058,468; 4,071,548; 4,083,699; 4,090,854; 4,173,540; 4,234,435; 4,354,950; 4,485,023; 5,137,980; and Re 26,433, herein incorporated by reference.

[0075] An example of a suitable ashless dispersant is a borated dispersant. Borated dispersants may be formed by boronating (borating) an ashless dispersant having basic nitrogen and/or at least one hydroxyl group in the molecule, such as a succinimide dispersant, succinamide dispersant, succinic ester dispersant, succinic ester-amide dispersant, Mannich base dispersant, or hydrocarbyl amine or polyamine dispersant. Methods that can be used for boronating the various types of ashless dispersants described above are described in U.S. Patent Nos. 3,087,936; 3,254,025; 3,281,428; 3,282,955; 2,284,409; 2,284,410; 3,338,832; 3,344,069; 3,533,945; 3,658,836; 3,703,536; 3,718,663; 4,455,243; and 4,652,387.

[0076] The borated dispersant may include a high molecular weight dispersant treated with boron such that the borated dispersant includes up to about 2 wt. % of boron. As another example the borated dispersant may include from about 0.8 wt. % or less of boron. As a further example, the borated dispersant may include from about 0.1 to about 0.7 wt. % of boron. As another example, the borated dispersant may include from about 0.25 to about 0.7 wt. % of boron. As a still further example, the borated dispersant may include from about 0.35 to about 0.7 wt. % of boron. The dispersant may be dissolved in oil of suitable viscosity for ease of handling. It should be understood that the weight percentages given here are for neat dispersant, without any diluent oil added.

[0077] A dispersant may be further reacted with an organic acid, an anhydride, and/or an aldehyde/phenol mixture.

Such a process may enhance compatibility with elastomer seals, for example. The borated dispersant may further include a mixture of borated dispersants. As a further example, the borated dispersant may include a nitrogen-containing dispersant and/or may be free of phosphorus.

5 Other Additives

[0078] The power transmission fluid may also include conventional additives of the type used in automatic transmission fluid formulations and gear lubricants. Such additives include, but are not limited to antifoamants (foam inhibitors), antioxidants, anti-rust additives, antiwear additives, colorants, corrosion inhibitors, dispersants, metal deactivators, metallic detergents, organic phosphorus compounds, pour point depressants, seal swell agents, and/ viscosity index improvers. Additives are generally described in C.V. Smalheer et al., Lubricant Additives, pages 1-11 (1967) and in U.S. Patent No. 4,105,571, among others. The supplemental additives include those that are commercially available.

15 Antifoam agents

[0079] In some embodiments, a fluid according to the present invention can include a foam inhibitor(s), which is another component suitable for use in the compositions. Foam inhibitors may be selected from silicones, polyacrylates, surfactants, and the like. The amount of antifoam agent in the transmission fluid formulations described herein may range from about 0.001 wt.% to about 0.5 wt.% based on the total weight of the formulation. As a further example, antifoam agent may be present in an amount from about 0.01 wt.% to about 0.1 wt.%.

25 Antioxidant Additives

[0080] In some embodiments, antioxidant compounds may be included in the compositions. Antioxidants include phenolic antioxidants, aromatic amine antioxidants, sulfurized phenolic antioxidants, and organic phosphites, among others. Examples of phenolic antioxidants include 2,6-di-tert-butylphenol, liquid mixtures of tertiary butylated phenols, 2,6-di-tert-butyl-4-methylphenol, 4,4'-methylenebis(2,6-di-tert-butylphenol), 2,2'-methylenebis(4-methyl-6-tert-butylphenol), mixed methylene-bridged polyalkyl phenols, and 4,4'-thiobis(2-methyl-6-tert-butylphenol), N,N'-di-sec-butyl-phenylenediamine, 4-isopropylaminodiphenylamine, phenyl- α -naphthyl amine, phenyl- α -naphthyl amine, diarylamines such as diphenylamine and ring-alkylated diarylamines such as ring-alkylated diphenylamines. Examples include the sterically hindered tertiary butylated phenols, bisphenols and cinnamic acid derivatives and combinations thereof. The amount of antioxidant in the transmission fluid compositions described herein may range from about 0.01 to about 10 wt. % based on the total weight of the fluid formulation. As a further example, antioxidant may be present in an amount from about 0.1 wt. % to about 2.0 wt. %.

35 Anti-Rust Additives

[0081] A fluid composition according to the present invention may include one or more rust or corrosion inhibitors. Such materials include monocarboxylic acids and polycarboxylic acids. Examples of suitable monocarboxylic acids are octanoic acid, decanoic acid and dodecanoic acid. Suitable polycarboxylic acids includedimer and trimer acids such as are produced from such acids as tall oil fatty acids, oleic acid, linoleic acid, or the like. Another useful type of rust inhibitor may comprise alkenyl succinic acid and alkenyl succinic anhydride corrosion inhibitors such as, for example, tetrapropenylsuccinic acid, tetrapropenylsuccinic anhydride, tetradecenylsuccinic acid, tetradecenylsuccinic anhydride, hexadecenylsuccinic acid, hexadecenylsuccinic anhydride, and the like. Also useful are the half esters of alkenyl succinic acids having about 8 to about 24 carbon atoms in the alkenyl group with alcohols such as the polyglycols. Other suitable rust or corrosion inhibitors include ether amines; acid phosphates; amines; polyethoxylated compounds such as ethoxylated amines, ethoxylated phenols, and ethoxylated alcohols; imidazolines; aminosuccinic acids or derivatives thereof, and the like. Materials of these types are commercially available. Mixtures of such rust or corrosion inhibitors can be used. The amount of rust inhibitor in the transmission fluid formulations described herein may range from about 0.01 to about 5.0 wt.% based on the total weight of the formulation.

45 Antiwear Additives

[0082] The antiwear characteristics of a finished fluid optionally may be modified by addition of one or more supplemental antiwear agents. The supplemental antiwear agents may include phosphorus-containing antiwear agents, such as those comprising an organic ester of phosphoric acid, phosphorous acid, or an amine salt thereof. For example, the phosphorus-containing antiwear agent may include one or more of a dihydrocarbyl phosphite, a trihydrocarbyl phosphite, a dihydrocarbyl phosphate, a trihydrocarbyl phosphate, any sulfur analogs thereof, and any amine salts thereof. As a

further example, the phosphorus-containing antiwear agent may include at least one of dibutyl hydrogen phosphite and an amine salt of sulfurized dibutyl hydrogen phosphite.

[0083] The phosphorus-containing antiwear agent may be present in an amount sufficient to provide about 50 to about 500 parts per million by weight of phosphorus in the power transmission fluid. As a further example, the phosphorus-containing antiwear agent may be present in an amount sufficient to provide about 150 to about 300 parts per million by weight of phosphorus in the power transmission fluid.

[0084] The power transmission fluid may include from about 0.01 wt. % to about 5.0 wt. % of the phosphorus-containing antiwear agent. As a further example, the power transmission fluid may include from about 0.2 wt. % to about 0.3 wt. % of the phosphorus-containing antiwear agent. As an example, the power transmission fluid may include from about 0.1 wt. % to about 0.2 wt. % of a dibutyl hydrogen phosphite or 0.3 wt. % to about 0.4 wt. % an amine salt of a sulfurized dibutyl hydrogen phosphate.

Colorant (dye)

[0085] In some embodiments, a fluid according to the present invention can include a colorant to give the fluid a detectable character. Generally, azo class dyes are used, such as C.I. Solvent Red 24 or C.I. Solvent Red 164, as set forth in the "Color Index" of the American Association of textile Chemists and Colorists and the Society of Dyers and Colourists (U.K.). For automatic transmission fluids, Automatic Red Dye is preferred. Dye is present in a very minimal amount, such as about 200 to about 300 ppm in the finished fluid.

Corrosion Inhibitors

[0086] In some embodiments, a fluid according to the present invention can include copper corrosion inhibitors. Suitable copper corrosion inhibitors include such compounds as thiazoles, triazoles, and thiadiazoles. Examples of such compounds include benzotriazole, tolyltriazole, octyltriazole, decyltriazole, dodecyltriazole, 2-mercapto benzothiazole, 2,5-dimercapto-1,3,4-thiadiazole, 2-mercapto-5-hydrocarbylthio-1,3,4-thiadiazoles, 2-mercapto-5-hydrocarbyldithio-1,3,4-thiadiazoles, 2,5-bis(hydrocarbylthio)-1,3,4-thiadiazoles, and 2,5-bis(hydrocarbyldithio)-1,3,4-thiadiazoles. Suitable compounds include the 1,3,4-thiadiazoles, a number of which are available as articles of commerce, and also combinations of triazoles such as tolyltriazole with a 1,3,5-thiadiazole such as a 2,5-bis(alkyldithio)-1,3,4-thiadiazole. Regarding dialkyl thiadiazoles, for imparting corrosion inhibition, that additive previously has been used in much smaller treat levels than the levels used in the present invention to enhance extreme pressure and antiwear properties (when used in combination with relatively high levels of sulfurized fatty oil as indicated herein). The 1,3,4-thiadiazoles are generally synthesized from hydrazine and carbon disulfide by known procedures. See, for example, U.S. Patent Nos. 2,765,289; 2,749,311; 2,760,933; 2,850,453; 2,910,439; 3,663,561; 3,862,798; and 3,840,549.

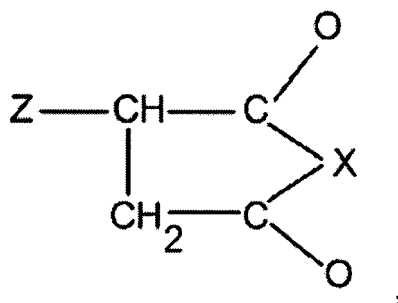
Other Friction Modifiers

[0087] A fluid according to the present invention containing a friction modifier compound represented by a formula I - VI hereinabove, or any combination of such friction modifiers, may optionally contain other friction modifiers, including those known in the art. Exemplary of such other friction modifiers are alkylated or ethoxylated fatty amines, amides, glycerol esters and different imidazolines (or their derivatives).

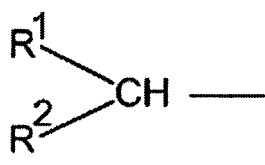
[0088] Other friction modifiers include such compounds as aliphatic amines or ethoxylated aliphatic amines, ether amines, alkoxylated ether amines, aliphatic fatty acid amides, acylated amines, aliphatic carboxylic acids, aliphatic carboxylic esters, polyol esters, aliphatic carboxylic ester-amides, imidazolines, tertiary amines, aliphatic phosphonates, aliphatic phosphates, aliphatic thiophosphonates, aliphatic thiophosphates, etc., wherein the aliphatic group usually contains one or more carbon atoms so as to render the compound suitably oil soluble. As a further example, the aliphatic group may contain about 8 or more carbon atoms. Also suitable are aliphatic substituted succinimides formed by reacting one or more aliphatic succinic acids or anhydrides with ammonia or primary amines.

[0089] The succinimide may include the reaction product of a succinic anhydride and ammonia or primary amine. The alkenyl group of the alkenyl succinic acid may be a short chain alkenyl group, for example, the alkenyl group may include from about 12 to about 36 carbon atoms. Further, the succinimide may include an about C₁₂ to about C₃₆ aliphatic hydrocarbyl succinimide. As a further example, the succinimide may include an about C₁₆ to about C₂₈ aliphatic hydrocarbyl succinimide. As an even further example, the succinimide may include an about C₁₈ to about C₂₄ aliphatic hydrocarbyl succinimide.

[0090] The succinimide may be prepared from a succinic anhydride and ammonia as described in European Patent Application No. 0 020 037, herein incorporated by reference. In some embodiments, the succinimide may include one or more of a compound(s) having the following structure:



wherein Z may have the structure:



wherein either R^1 or R^2 may be hydrogen, but not both, and wherein R^1 and R^2 may be independently straight or branched chain hydrocarbon groups containing from about 1 to about 34 carbon atoms such that the total number of carbon atoms in R^1 and R^2 is from about 11 to about 35; X is an amino group derived from ammonia or a primary amine; and wherein,

in addition to or in the alternative, the parent succinic anhydride may be formed by reacting maleic acid, anhydride, or ester with an internal olefin containing about 12 to about 36 carbon atoms, said internal olefin being formed by isomerizing the olefinic double bond of a linear α -olefin or mixture thereof to obtain a mixture of internal olefins. The reaction may involve an equimolar amount of ammonia and may be carried out at elevated temperatures with the removal of water.

[0091] One group of other friction modifiers includes the N-aliphatic hydrocarbyl-substituted diethanol amines in which the N-aliphatic hydrocarbyl-substituent is at least one straight chain aliphatic hydrocarbyl group free of acetylenic unsaturation and having in the range of about 14 to about 20 carbon atoms.

[0092] An example of a suitable other friction modifier system is composed of a combination of at least one N-aliphatic hydrocarbyl-substituted diethanol amine and at least one N-aliphatic hydrocarbyl-substituted trimethylene diamine in which the N-aliphatic hydrocarbyl-substituent is at least one straight chain aliphatic hydrocarbyl group free of acetylenic unsaturation and having in the range of about 14 to about 20 carbon atoms. Further details concerning this friction modifier system are set forth in U.S. Patent Nos. 5,372,735 and 5,441,656.

[0093] Another example of a suitable other friction modifier system is one based on the combination of (i) at least one di(hydroxyalkyl) aliphatic tertiary amine in which the hydroxyalkyl groups, being the same or different, each contain from about 2 to about 4 carbon atoms, and in which the aliphatic group is an acyclic hydrocarbyl group containing from about 10 to about 25 carbon atoms, and (ii) at least one hydroxyalkyl aliphatic imidazoline in which the hydroxyalkyl group contains from about 2 to about 4 carbon atoms, and in which the aliphatic group is an acyclic hydrocarbyl group containing from about 10 to about 25 carbon atoms. For further details concerning this friction modifier system, reference should be had to U.S. Patent No. 5,344,579.

[0094] Another suitable group of other friction modifiers includes polyolesters, for example, glycerol monooleate (GMO), glycerol monolaurate (GML), and the like.

[0095] Other friction modifiers include, for instance, those described in European Patent Publications 877784B1, 856042, and 988357; U.S. Patent Nos. 5,750,476 and 5,942,472; and PCT patent publication WO 97/14772 (April 24, 1997), among others.

[0096] In general, in a composition embodiment, the composition, such as a power transmission fluid or an additive package, may contain up to about 5 wt. %, or, as a further example, from about 0.01 to about 3 wt. % of one or more of these other, additional, friction modifiers.

Metallic Detergents

[0097] Certain metallic detergents may optionally be included in an additive package or in a power transmission fluid of the present invention. A suitable metallic detergent may include an oil-soluble neutral or overbased salt of alkali or alkaline earth metal with one or more of the following acidic substances (or mixtures thereof): (1) a sulfonic acid, (2) a carboxylic acid, (3) a salicylic acid, (4) an alkyl phenol, (5) a sulfurized alkyl phenol, and (6) an organic phosphorus acid

characterized by at least one direct carbon to-phosphorus linkage. Such an organic phosphorus acid may include those prepared by the treatment of an olefin polymer (e.g., polyisobutylene having a molecular weight of about 1,000) with a phosphorizing agent such as phosphorus trichloride, phosphorus heptasulfide, phosphorus pentasulfide, phosphorus trichloride and sulfur, white phosphorus and a sulfur halide, or phosphorothioic chloride.

[0098] Suitable salts may include neutral or overbased salts of magnesium, calcium, or zinc. As a further example, suitable salts may include magnesium sulfonate, calcium sulfonate, zinc sulfonate, magnesium phenate, calcium phenate, and/or zinc phenate. See, e.g., U.S. Patent Nos. 6,482,778. These salts can be used alone or in combination with another additive. For example, in principle, a suitable calcium salt may be included in combination with other additives, such as an organic phosphate in a power transmission fluid, an additive package, or in a concentrate.

[0099] Oil-soluble neutral metal-containing detergents are those detergents that contain stoichiometrically equivalent amounts of metal in relation to the amount of acidic moieties present in the detergent. Thus, in general the neutral detergents will have a low basicity when compared to their overbased counterparts. The acidic materials utilized in forming such detergents include carboxylic acids, salicylic acids, alkylphenols, sulfonic acids, sulfurized alkylphenols and the like.

[0100] The term "overbased" in connection with metallic detergents is used to designate metal salts wherein the metal is present in stoichiometrically larger amounts than the organic radical. The commonly employed methods for preparing the overbased salts involve heating a mineral oil solution of an acid with a stoichiometric excess of a metal neutralizing agent such as the metal oxide, hydroxide, carbonate, bicarbonate, or sulfide at a temperature of about 50°C, and filtering the resultant product. The use of a "promoter" in the neutralization step to aid the incorporation of a large excess of metal likewise is known. Examples of compounds useful as the promoter include phenolic substances such as phenol, naphthol, alkyl phenol, thiophenol, sulfurized alkylphenol, and condensation products of formaldehyde with a phenolic substance; alcohols such as methanol, 2-propanol, octanol, ethylene glycol, stearyl alcohol, and cyclohexyl alcohol; and amines such as aniline, phenylene diamine, phenothiazine, phenyl-beta-naphthylamine, and dodecylamine. A particularly effective method for preparing the basic salts comprises mixing an acid with an excess of a basic alkaline earth metal neutralizing agent and at least one alcohol promoter, and carbonating the mixture at an elevated temperature such as 60°C to 200°C.

[0101] Examples of suitable metal-containing detergents include, but are not limited to, neutral and overbased salts of such substances as neutral sodium sulfonate, an overbased sodium sulfonate, a sodium carboxylate, a sodium salicylate, a sodium phenate, a sulfurized sodium phenate, a lithium sulfonate, a lithium carboxylate, a lithium salicylate, a lithium phenate, a sulfurized lithium phenate, a magnesium sulfonate, a magnesium carboxylate, a magnesium salicylate, a magnesium phenate, a sulfurized magnesium phenate, a calcium sulfonate, a calcium carboxylate, a calcium salicylate, a calcium phenate, a sulfurized calcium phenate, a potassium sulfonate, a potassium carboxylate, a potassium salicylate, a potassium phenate, a sulfurized potassium phenate, a zinc sulfonate, a zinc carboxylate, a zinc salicylate, a zinc phenate, and a sulfurized zinc phenate. Further examples include a lithium, sodium, potassium, calcium, and magnesium salt of a hydrolyzed phosphosulfurized olefin having about 10 to about 2,000 carbon atoms or of a hydrolyzed phosphosulfurized alcohol and/or an aliphatic-substituted phenolic compound having about 10 to about 2,000 carbon atoms. Even further examples include a lithium, sodium, potassium, calcium, and magnesium salt of an aliphatic carboxylic acid and an aliphatic substituted cycloaliphatic carboxylic acid and many other similar alkali and alkaline earth metal salts of oil-soluble organic acids. A mixture of a neutral or an overbased salt of two or more different alkali and/or alkaline earth metals can be used. Likewise, a neutral and/or an overbased salt of mixtures of two or more different acids can also be used.

[0102] As is well known, overbased metal detergents are generally regarded as containing overbasing quantities of inorganic bases, generally in the form of micro dispersions or colloidal suspensions. Thus the term "oil-soluble" as applied to metallic detergents is intended to include metal detergents wherein inorganic bases are present that are not necessarily completely or truly oil-soluble in the strict sense of the term, inasmuch as such detergents when mixed into base oils behave much the same way as if they were fully and totally dissolved in the oil. Collectively, the various metallic detergents referred to herein above, are sometimes called neutral, basic, or overbased alkali metal or alkaline earth metal-containing organic acid salts.

[0103] Methods for the production of oil-soluble neutral and overbased metallic detergents and alkaline earth metal-containing detergents are well known to those skilled in the art, and extensively reported in the patent literature. See, for example, U.S. Patent Nos. 2,001,108; 2,081,075; 2,095,538; 2,144,078; 2,163,622; 2,270,183; 2,292,205; 2,335,017; 2,399,877; 2,416,281; 2,451,345; 2,451,346; 2,485,861; 2,501,731; 2,501,732; 2,585,520; 2,671,758; 2,616,904; 2,616,905; 2,616,906; 2,616,911; 2,616,924; 2,616,925; 2,617,049; 2,695,910; 3,178,368; 3,367,867; 3,496,105; 3,629,109; 3,865,737; 3,907,691; 4,100,085; 4,129,589; 4,137,184; 4,184,740; 4,212,752; 4,617,135; 4,647,387; and 4,880,550.

[0104] The metallic detergents utilized in this invention can, if desired, be oil-soluble boronated neutral and/or overbased alkali or alkaline earth metal-containing detergents. Methods for preparing boronated metallic detergents are described in, for example, U.S. Patent Nos. 3,480,548; 3,679,584; 3,829,381; 3,909,691; 4,965,003; and 4,965,004.

[0105] While any effective amount of the metallic detergents may be used to enhance the benefits of this invention, typically these effective amounts will range from about 0.01 to about 5.0 wt. % in the finished fluid, or as a further example, from about 0.05 to about 3.0 wt. % in the finished fluid.

5 Organic Phosphorus Additives

[0106] When formulated as a power transmission fluid, or as a concentrate or as an additive package, a composition of the present invention can include an organic phosphate. As an example, an organic phosphate can have the structure $R_1-X_2-(X_1)(R_2X_3)-X-R_5$ wherein R_1 , and R_2 may independently be substituted or unsubstituted alkyl, aryl, alkylaryl or cycloalkyl having 1 to 24 carbon atoms and X , X_1 , X_2 and X_3 can independently be sulfur or oxygen. R_1 , and R_2 may also contain substituent heteroatoms, in addition to carbon and hydrogen, such as chlorine, sulfur, oxygen or nitrogen; R_5 can be derived from a reactive olefin and can be either $-CH_2-CHR-C(:O)OR_6$; $-CH_2-CR_7HR_8$; or $R_9-OC(:O)CH_2-CH-C(:O)O-R_{10}$ where R is H or the same as R_1 , R_6 , R_7 , R_9 and R_{10} are the same as R_1 , and R_8 is a phenyl or alkyl or alkenyl substituted phenyl moiety, the moiety having from 6 to 30 carbon atoms.

15 Seal Swell Agents

[0107] In some embodiments, a fluid according to the present invention can include a seal swell agent, such as used in a transmission fluid composition, selected from oil-soluble diesters, oil-soluble sulfones, and mixtures thereof. Generally, the most suitable diesters include the adipates, azelates, and sebacates of C_8 - C_{13} alkanols (or mixtures thereof), and the phthalates of C_4 - C_{13} alkanols (or mixtures thereof). Mixtures of two or more different types of diesters (e.g., dialkyl adipates and dialkyl azelates, etc.) can also be used. Examples of such materials include the n-octyl, 2-ethylhexyl, isodecyl, and tridecyl diesters of adipic acid, azelaic acid, and sebacic acid, and the n-butyl, isobutyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl, and tridecyl diesters of phthalic acid.

[0108] Other esters which may give generally equivalent performance are polyol esters. Suitable sulfone seal swell agents are described in U.S. Patent Nos. 3,974,081 and 4,029,587. Typically these products are employed at levels in the range of about 0.1 wt. % to about 10.0 wt. % in the finished transmission fluid. As a further example, they may be provided in an amount of about 0.25 wt. % to about 1.0 wt. %.

[0109] Suitable seal swell agents are the oil-soluble dialkyl esters of (i) adipic acid, (ii) sebacic acid, or (iii) phthalic acid. The adipates and sebacates should be used in amounts in the range of from about 1.0 to about 15.0 wt. % in the finished fluid. In the case of the phthalates, the levels in the transmission fluid should fall in the range of from about 1.5 to about 10.0 wt. %. Generally, the higher the molecular weight of the adipate, sebacate or phthalate, the higher should be the treat rate within the foregoing ranges.

35 Viscosity Index Additives

[0110] A fluid composition embodiment of the invention may include one or more viscosity index improvers. Since the fluid composition can be used as a fluid transmission or gear lubricant composition, suitable viscosity index additives include any conventional viscosity index improvers. In general, exemplary classes of viscosity index additives are polyisoalkylene compounds and polymethacrylate compounds, among others. An example of a suitable polyisoalkylene compound for use as a viscosity index improver includes polyisobutylene having a weight average molecular weight ranging from about 700 to about 2,500. Embodiments may include a mixture of one or more viscosity index improvers of the same or different molecular weight. Suitable viscosity index improvers may include styrene-maleic esters, polyalkylmethacrylates, and olefin copolymer viscosity index improvers. Mixtures of the foregoing products can also be used as well as dispersant and dispersant-antioxidant viscosity index improvers.

Additive Package - Diluent

[0111] If a friction modifier compound represented by any of formula through VI, or a mixture of any such compounds, is provided in an additive package (sometimes called a concentrate), the concentrate includes a suitable carrier diluent is added to ease blending, solubilizing ingredients, and transporting the additive package. The diluent oil needs to be compatible with the base oil and the other ingredients that comprise an additive package. An additive package can comprise a major amount of an additive comprised of effective amounts of at least one friction modifier(s) represented by formula to VI, a minor amount of a diluent oil, and, optionally, other desired, compatible additives. The diluent can be present, for instance, in the concentrate in an amount of between about 5 to about 20%, although it can vary widely with application. Generally speaking, less diluent is preferable as it lowers transportation costs and treat rates.

[0112] Additives used in formulating the compositions described herein can be blended into base oil individually or in various sub-combinations. However, it is suitable to blend all of the components concurrently using an additive concentrate

(i.e., additives plus a diluent, such as a hydrocarbon solvent). The use of an additive concentrate takes advantage of the mutual compatibility afforded by the combination of ingredients when in the form of an additive concentrate. Also, the use of a concentrate reduces blending time and lessens the possibility of blending errors.

5 Finished Products and Base Oil

[0113] A finished power transmission fluid according to the present invention typically (but not necessarily always) is formulated with a major amount of a base oil and a minor amount of an additive package which includes at least one compound represented by formula I, II, III, IV, V and/or VI at an effective addition level.

[0114] In one embodiment, a power transmission fluid composition is formulated to contain a major amount of base oil and an effective but minor amount of a fluid containing at least one fluid modifier represented by a formula to VI. An exemplary power transmission fluid can contain about 1.0 wt. % to about 25 wt. % of an additive composition containing a fluid composition according to the present invention.

[0115] Base oils suitable for use in formulating transmission fluid compositions according to the invention may be selected from any of the synthetic or natural oils or mixtures thereof. Natural oils include animal oils and vegetable oils (e.g., castor oil, lard oil) as well as mineral lubricating oils such as liquid petroleum oils and solvent treated or acid-treated mineral lubricating oils of the paraffinic, naphthenic or mixed paraffinic, naphthenic types. Oils derived from coal or shale are also suitable. The base oil typically has a viscosity of, for example, from about 2 to about 15 cSt and, as a further example, from about 2 to about 10 cSt at 100°C. Further, oils derived from a gas-to-liquid process are also suitable.

[0116] Synthetic oils include hydrocarbon oils such as polymerized and interpolymerized olefins (e.g., polybutylenes, polypropylenes, propylene isobutylene copolymers, etc.); polyalphaolefins such as poly(1-hexenes), poly-(1-octenes), poly(1-decenes), etc. and mixtures thereof; alkylbenzenes (e.g., dodecylbenzenes, tetradecylbenzenes, di-nonylbenzenes, di-(2-ethylhexyl)benzenes, etc.); polyphenyls (e.g., biphenyls, terphenyl, alkylated polyphenyls, etc.); alkylated diphenyl ethers and alkylated diphenyl sulfides and the derivatives, analogs and homologs thereof and the like.

[0117] Alkylene oxide polymers and interpolymers and derivatives thereof where the terminal hydroxyl groups have been modified by esterification, etherification, etc., constitute another class of known synthetic oils that may be used. Such oils are exemplified by the oils prepared through polymerization of ethylene oxide or propylene oxide, the alkyl and aryl ethers of these polyoxyalkylene polymers (e.g., methylpolyisopropylene glycol ether having an average molecular weight of about 1000, diphenyl ether of polyethylene glycol having a molecular weight of about 500-1000, diethyl ether of polypropylene glycol having a molecular weight of about 1000-1500, etc.) or mono- and polycarboxylic esters thereof, for example, the acetic acid esters, mixed C₃₋₈ fatty acid esters, or the C₁₃ oxo acid diester of tetraethylene glycol.

[0118] Another class of synthetic oils that may be used includes the esters of dicarboxylic acids (e.g., phthalic acid, succinic acid, alkyl succinic acids, alkenyl succinic acids, maleic acid, azelaic acid, suberic acid, sebacic acid, fumaric acid, adipic acid, linoleic acid dimer, malonic acid, alkyl malonic acids, alkenyl malonic acids, etc.) with a variety of alcohols (e.g., butyl alcohol, hexyl alcohol, dodecyl alcohol, 2-ethylhexyl alcohol, ethylene glycol, diethylene glycol monoether, propylene glycol, etc.) Specific examples of these esters include dibutyl adipate, di(2-ethylhexyl)sebacate, di-n-hexyl fumarate, dioctyl sebacate, diisooctyl azelate, diisodecyl azelate, dioctyl phthalate, didecyl phthalate, dieicosyl sebacate, the 2-ethylhexyl diester of linoleic acid dimer, the complex ester formed by reacting one mole of sebacic acid with two moles of tetraethylene glycol and two moles of 2-ethylhexanoic acid and the like.

[0119] Esters useful as synthetic oils also include those made from C₅ to C₁₂ monocarboxylic acids and polyols and polyol ethers such as neopentyl glycol, trimethylol propane, pentaerythritol, dipentaerythritol, tripentaerythritol, etc.

[0120] Hence, the base oil used which may be used to make the transmission fluid compositions as described herein may be selected from any of the base oils in Groups I-V as specified in the American Petroleum Institute (API) Base Oil Interchangeability Guidelines.

[0121] Such base oil groups are as follows:

Base Oil Group ¹	Sulfur (wt. %)		Saturates (wt. %)	Viscosity Index
Group I	> 0.03	and/or	< 90	80 to 120
Group II	≤ 0.03	And	≥ 90	80 to 120
Group III	≤ 0.03	And	≥ 90	≥120
Group IV	All polyalphaolefins (PAOs)			
Group V	all others not included in Groups I-IV			
¹ Groups I-III are mineral oil base stocks.				

[0122] As set forth above, the base oil may be a poly-alpha-olefin (PAO). Typically, the poly-alpha-olefins are derived from monomers having from about 4 to about 30, or from about 4 to about 20, or from about 6 to about 16 carbon atoms. Examples of useful PAOs include those derived from octene, decene, mixtures thereof, and the like. PAOs may have a viscosity of from about 2 to about 15, or from about 3 to about 12, or from about 4 to about 8 cSt at 100°C. Examples of PAOs include 4 cSt at 100°C poly-alpha-olefins, 6 cSt at 100°C poly-alpha-olefins, and mixtures thereof. Mixtures of mineral oil with the foregoing poly-alpha-olefins may be used.

[0123] The base oil may be an oil derived from Fischer-Tropsch synthesized hydrocarbons. Fischer-Tropsch synthesized hydrocarbons are made from synthesis gas containing H₂ and CO using a Fischer-Tropsch catalyst. Such hydrocarbons typically require further processing in order to be useful as the base oil. For example, the hydrocarbons may be hydroisomerized using processes disclosed in U.S. Patent Nos. 6,103,099 or 6,180,575; hydrocracked and hydroisomerized using processes disclosed in U.S. Patent Nos. 4,943,672 or 6,096,940; dewaxed using processes disclosed in U.S. Patent No. 5,882,505; or hydroisomerized and dewaxed using processes disclosed in U.S. Patent Nos. 6,013,171; 6,080,301; or 6,165,949.

[0124] Unrefined, refined and rerefined oils, either natural or synthetic (as well as mixtures of two or more of any of these) of the type disclosed hereinabove can be used in the base oils. Unrefined oils are those obtained directly from a natural or synthetic source without further purification treatment. For example, a shale oil obtained directly from retorting operations, a petroleum oil obtained directly from primary distillation or ester oil obtained directly from an esterification process and used without further treatment would be an unrefined oil. Refined oils are similar to the unrefined oils except they have been further treated in one or more purification steps to improve one or more properties. Many such purification techniques are known to those skilled in the art such as solvent extraction, secondary distillation, acid or base extraction, filtration, percolation, etc. Rerefined oils are obtained by processes similar to those used to obtain refined oils applied to refined oils which have been already used in service. Such rerefined oils are also known as reclaimed or reprocessed oils and often are additionally processed by techniques directed to removal of spent additives, contaminants, and oil breakdown products.

[0125] In selecting any of the optional additives, it is important to ensure that the selected component(s) is/are soluble or stably dispersible in the additive package and finished automatic transmission fluid ("ATF") composition, are compatible with the other components of the composition, and do not interfere significantly with the performance properties of the composition, such as the extreme pressure, antiwear, friction, anti-shudder, viscosity and/or shear stability properties, needed or desired, as applicable, in the overall finished composition.

[0126] In general, the ancillary additive components are employed in the oil in minor amounts sufficient to improve the performance characteristics and properties of the base fluid. The amounts will thus vary in accordance with such factors as the viscosity characteristics of the base fluid employed, the viscosity characteristics desired in the finished fluid, the service conditions for which the finished fluid is intended, and the performance characteristics desired in the finished fluid.

[0127] However, generally speaking, the following generally concentrations (weight percent unless otherwise indicated) of the additional components in the base fluids are illustrative.

[0128] Additives are blended into a base oil in their respective amounts which amounts are sufficient to provide their expected performance. Representative effective amounts are illustrated as follows:

<u>Component</u>	<u>wt %</u>
Dispersant	1- 20
Viscosity Index Improver	0.1- 25
Antioxidant	0.01- 10
Corrosion Inhibitor	0.01-2
Detergents and Rust Inhibitors	0.01- 5
Seal-swell Agent	0.1-10
Anti-foam Agent	0.001-0.1
Anti-wear Agents	0.01-0.5
Other Friction Modifiers	0.01- 5
Lubricating Base Oil	Balance

[0129] It will be appreciated that the individual components employed can be separately blended into the base fluid or can be blended therein in various subcombinations, if desired. Ordinarily, the particular sequence of such blending steps is not crucial. Moreover, such components can be blended in the form of separate solutions in a diluent. It is preferable, however, to blend the additive components used in the form of a concentrate, as this simplifies the blending

operations, reduces the likelihood of blending errors, and takes advantage of the compatibility and solubility characteristics afforded by the overall concentrate.

[0130] Additive concentrates can thus be formulated to contain all of the additive components and if desired, some of the base oil component, in amounts proportioned to yield finished fluid blends consistent with the concentrations described above. In most cases, the additive concentrate will contain one or more diluents such as light mineral oils, to facilitate handling and blending of the concentrate. Thus concentrates containing up to about 50 wt. % of one or more diluents or solvents can be used, provided the solvents are not present in amounts that interfere with the low and high temperature and flash point characteristics and the performance of the finished power transmission fluid composition. In this regard, the additive components used pursuant to this invention may be selected and proportioned such that an additive concentrate or package formulated from such components will have a flash point of about 170°C or above, using the ASTM D-92 test procedure.

[0131] Power transmission fluids of the embodiments herein are formulated to provide enhanced extreme pressure properties for applications where metal-to-metal contact is made under high pressures, e.g., pressures in excess of 2 GPa. Such fluids are suitable for automatic and manual transmissions such as step automatic transmissions, continuously variable transmissions, automated manual transmissions, and dual clutch transmissions. High metal-to-metal contact pressures such as those found in automotive transmissions, for example, may cause damage to transmission parts if a fluid is used that does not possess sufficient properties, including extreme pressure protection characteristics. Power transmission fluid compositions as described herein have improved performance characteristics. Further, the power transmission fluids of the present disclosure also are suitable for use in transmissions with an electronically controlled converter clutch, a slipping torque converter, a lock-up torque converter, a starting clutch, and/or one or more shifting clutches. Such transmissions include four-, five-, six-, and seven-speed transmissions, and continuously variable transmissions (chain, belt, or disk type). They also may be used in gear applications, such as industrial gear applications and automotive gear applications. Gear-types may include, but are not limited to, spur, spiral bevel, helical, planetary, and hypoid gears. They may be used in axles, transfer cases, and the like. Further, they may also be useful in metalworking applications.

[0132] The so-called LFW-1 test involves measuring friction between a rotating steel ring against a stationary block having a friction material of interest at a given load and temperature. A test cycle involves acceleration and deceleration modes between zero and a maximum speed of 0.5 m/sec. The X-axis and Y-axis in the graphs in FIG. 1 represent speed and coefficient of friction (μ), respectively. End-points on the curves, being close to zero speed, are regarded as static coefficient of friction (μ_{sta}), while the friction in mid-point (maximum speed) is regarded as dynamic coefficient of friction (μ_{dyn}). Surprisingly, a fluid according to the invention exhibits a reduced change (Δ) in the dynamic coefficient of friction, μ_d , between its fresh versus an aged condition in comparison to conventional fluids. Samples having μ_s/μ_d values higher than one can be said to exhibit shudder problem when used as a power transmission fluid; for example, a fluid according to the invention that has a fresh oil μ_s/μ_d value in a secure shudder-free range (~ 0.9) can manifest a low Δ in μ_s/μ_d , while showing improved (higher) dynamic coefficient of friction on aging (FMs 8, 11, 12, 13, 14 in Table 1). The smaller the Δ μ_s/μ_d between fresh and aged, the better is the friction durability and if μ_d increases it can translate to more effective power transmitting capability in dynamic mode upon aging.

[0133] As shown in FIG. 1, there is less chance of a change overall in the dynamic coefficient of friction for a power transmission fluid B according to the invention versus a conventional formulation A when the LFW1 test was conducted on samples that are subjected to 296 hours of heating at 170°C under an air flow of 10L/minute. Frictional benefits of using the compositions described in this invention are illustrated in FIG. 1 that graphically shows a LFW- friction test comparison between fresh and aged oils. Oil A contains oleic acid/TEPA-derived bisacylamide whereas, Oil B contains oleic acid/TETA-derived imidazoline reacted with 750 molecular weight PIBSA. Both friction modifiers ("FMs") are at a level to provide 950 ppm of nitrogen to the finished fluid.

[0134] A fluid according to the present invention can be formulated for use in a power transmitting apparatus, including a power transmission fluid, such as an ATF, in a transmission. An aspect of the present invention is a transmission. Exemplary transmissions include those described in "Transmission and Driveline Design", SAE Paper Number SP-108, Society of Automotive Engineers, Warrendale PA 1995; "Design of Practices: Passenger Car Automotive Transmissions", The Third Edition, SAE Publication # AE-18, Society of Automotive Engineers, Warrendale PA 1994; and "Automotive Transmission Advancements", SAE Paper Number SP-854, Society of Automotive Engineers, Warrendale PA 1991.

[0135] An aspect of the present invention includes a transmission containing a power transmission fluid, provided the fluid contains, as a fluid modifier(s), at least one compound represented by a formula I, II, III, IV, V or VI, or a mixture of compounds of any of these formulas. For example, a suitable mixture may include a compound represented by the formula I, and a compound represented by at least one of formula II, III, IV, V or VI. The transmission embodiment includes a belt, chain, or disk-type continuously variable transmission, a 4-, 5-, 6-, or 7-speed automatic transmission, a manual transmission, a dual clutch transmission.

[0136] A further aspect of the invention is a vehicle comprising an engine and a transmission, the transmission including a power transmission fluid as described above. A vehicle can contain a differential, and therefore in another embodiment,

a vehicle contains a differential including a lubricant containing a fluid composition as described above. Vehicle includes without limitation a truck, an automobile, and a piece of mechanized farm equipment, such as a tractor or reaper.

EXAMPLES

[0137] Illustrative compositions suitable for use in the practice of this invention are presented in the following Examples, wherein all parts and percentages are by weight unless specified otherwise.

Example 1

[0138] Reaction of isostearic acid with triethylenetetramine (TETA) was performed in a 2L 3-neck round bottom flask, equipped with a pressure equilibrated addition funnel, distillation condenser, and a mechanical stirrer. To stirred isostearic acid (405.3 g), TETA (153.0 g) was added drop-wise at 75° C. Addition continued slowly below 100°C until the reaction is no longer exothermic. After addition of the remaining amine, vacuum was applied (28" Hg) with caution and temperature was increased gradually to 150°C. The mixture was stirred under vacuum for 19 hours. The reaction was expected to form 44.9 g. of water. Total of 48.2 g of volatile material was collected in a dry-ice trap.

[0139] Following analysis, these results were obtained for the product: TAN (D-664) 3.1 mg KOH/g; TBN (D-2869) 262.8 mg KOH/g; KV (100) 20.22 cSt; N : 10.97% (Calc'd: 11.41%). IR (cm⁻¹): 1660, 1613, 1459, 1248, 1004, 726.

Example 2

[0140] Reaction product of Example 1 (67.2 g), a diluent oil (76.2 g) and C20-24 alkyl succinic anhydride (87.5 g) from Dixie Chemical Company were charged into a 500 mL round bottom flask equipped with a distillation condenser and a mechanical stirrer. The mixture was stirred at 100° C under vacuum (28" Hg) for 1 hour. Analysis of the resulting product gave: TAN (D-664) 31.1 mg KOH/g; TBN (D-2869) 37.6 mg KOH/g; N: 3.18% (Calc'd: 3.38%). IR (cm⁻¹): 1771, 1705, 1649.

Example 3

[0141] Reaction product of Example 1 (55.33 g), a diluent oil (55.91 g) and 200 mol. wt. PIBSA (56.29 g) having activity of 3.34 meq/g were reacted under conditions described in Example 2. Analysis of the resulting product gave TAN (D-664) 28.8 mg KOH/g; TBN (D-2869) 43.5 mg KOH/g; N: 3.61% (Calc'd: 3.68%). IR (cm⁻¹): 1778, 1705, 1642.

Example 4

[0142] Table 1 shows LFW-1 results for fresh and aged oils. An embodiment from the broad composition described hereinabove was used to evaluate the following friction modifiers in LFW-1 Friction Test as shown in Table 1. Data are plotted in FIG. 1.

[0143] Table 1 shows a number of examples of oil-containing fluid formulations according to the present invention that provide good fresh oil friction characteristics (μ_s/μ_d < about 1.0) that undergo much less change after oxidation compared to a conventional formulation.

TABLE I

	REACTANTS	Molar Ratios	New			Aged			Delta μ_s/μ_d *100	Delta μ_d *1000
			μ_s/μ_d	μ_s	μ_d	μ_s/μ_d	μ_s	μ_d		
FM1	OA:TETA:C ₂₀₋₂₄ ASA	4:3:5	0.8387	0.1611	0.1921	1.0065	0.2010	0.1997	16.78	7.62
FM2	OA:TETA:C ₂₀₋₂₄ ASA	4:3:3.7	0.8294	0.1561	0.1882	1.0184	0.2037	0.2000	18.9	11.82
FM3	OA:TETA:C ₂₀₋₂₄ ASA	4:3:2.5	0.7916	0.1441	0.1820	1.0316	0.2073	0.2009	24	18.91
FM4	OA:TETA:200MW PIBSA	4:3:5	0.8207	0.1572	0.1915	1.0493	0.2160	0.2059	22.86	14.31
FM5	OA:TETA:350MW PIBSA	4:3:5	0.8832	0.1773	0.2007	1.0443	0.2159	0.2067	16.11	5.99
FM6	OA:TETA:750MW PIBSA	4:3:5	0.8957	0.1793	0.2002	1.0438	0.2149	0.2059	14.81	5.70
FM7	ISA:TETA:200MW PIBSA	4:3:5	0.9624	0.2183	0.2268	1.0330	0.2345	0.2270	7.06	0.18
FM8	ISA:TETA:200MW PIBSA	4:3:2.5	0.9008	0.1941	0.2125	1.0247	0.2184	0.2131	12.39	-2.34
FM9	ISA:TETA:750MW PIBSA	4:3:5	0.9768	0.2171	0.2223	1.0278	0.2299	0.2237	5.1	1.43
FM10	ISA:TETA:750MW PIBSA	4:3:2.5	0.9245	0.2022	0.2187	1.0181	0.2278	0.2238	9.36	5.04
Ref1	Ref1	Ref1	0.8241	0.1460	0.1772	1.0513	0.2102	0.1999	22.72	22.73
FM11	ISA:TETA:C ₂₀₋₂₄ ASA	4:3:2.5	0.8821	0.1806	0.2047	0.9911	0.2018	0.2036	10.9	-1.13
FM12	ISA:TETA:C ₂₀₋₂₄ ASA	4:3:5	0.9152	0.1900	0.2076	0.9807	0.1977	0.2016	6.55	-6.01
FM13	ISA:TETA:C ₁₈ ASA	4:3:2.5	0.8940	0.1818	0.2034	0.9867	0.1960	0.1986	9.27	-4.71
FM14	ISA:TETA:C ₁₈ ASA	4:3:5	0.8677	0.1759	0.2027	0.9982	0.2002	0.2006	13.05	-2.16
FM15	ISA:TETA:C ₁₂ ASA	4:3:2.5	0.9573	0.2073	0.2165	1.0201	0.2107	0.2065	6.28	-10.00
FM16	ISA:TETA:C ₁₂ ASA	4:3:5	0.9070	0.1912	0.2108	1.0184	0.2093	0.2055	11.14	-5.29
Ref2	Ref2	Ref2	0.8369	0.1484	0.1773	1.0098	0.1976	0.1957	17.28	18.44

[0144] In Table 1, OA is oleic acid; ISO is isostearic acid; TETA is triethylene tetramine; and C₂₀₋₂₄-ASA is an alkyl succinic anhydride where the alkyl group is an isomerized form of a mixture of C₂₀ to C₂₄ alpha-olefins. PIBSA refers to polyisobutylene succinic anhydride and the designations 200MW, 350MW, and 750MW relate the molecular weights (amu).

[0145] Reference 1 and Reference 2 use Ethomeen T-12, which is a commercially available ethoxylated tallow-alkylamine from Akzo Nobel at equal nitrogen content.

[0146] The friction modifiers (FM's) reported in Table 1 are prepared by a two-stage process. In a first stage, a fatty acid is reacted with a polyamine, and in a second stage, the first stage product(s) are post-treated with an alkyl succinic anhydride. More particularly, a first stage product (OL/TETA or ISA/TETA) is post-treated with an alkyl succinic anhydride. The reaction stoichiometry is presented in Table 1. The various alkyl succinic anhydrides are also presented in Table

1. Example 1 describes suitable reaction conditions for the first stage. The FM9 is prepared by applying the conditions and procedures described in Example 1 for the first stage, and in Example 2 for the second stage. The FM12 is prepared by applying the conditions and procedures described in Example 1 for the first stage, and in Example 3 for the second stage. The other FM's in Table 1 are prepared using the same protocols as in Examples 1 and 2.

[0147] FM1 through Ref 1 provide 970 ppm nitrogen to the finished fluid. The duration of stability against oxidation for these oils is tested for 198 hours at 170°C with bubbling air at a rate of 10L/h.

[0148] The duration of stability against oxidation for oils containing FM11 through Ref 2 were different in that the test was conducted for only 120 hours and the nitrogen contribution from these friction modifiers was 375 ppm.

[0149] For instance, values for μ_s/μ_d of a friction modifier composition (such as FM-1 through FM-16) generally can be up to about 1.0, and as a further example may be less than about 0.9, while still avoiding shudder problems and exhibiting sufficient durability against oxidation.

[0150] The dynamic coefficient of friction, μ_d , is known to relate to effectiveness of torque transfer, and therefore to fuel efficiency. High numerical values for this parameter (μ_d) are suitable. In terms of friction durability, change in these parameters resulting from aging of the oil should be minimal. High delta values indicate that oil loses its initial friction characteristics as a result of thermal and oxidative stress.

[0151] At numerous places throughout this specification, reference has been made to a number of U.S. Patents, European Patent Applications (published), PCT International patent publications, and literature references. All such cited documents are expressly incorporated in full into this disclosure as if fully set forth herein.

[0152] As used throughout the specification and claims, "a" and/or "an" may refer to one or more than one. Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as molecular weight, percent, ratio, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the specification and claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

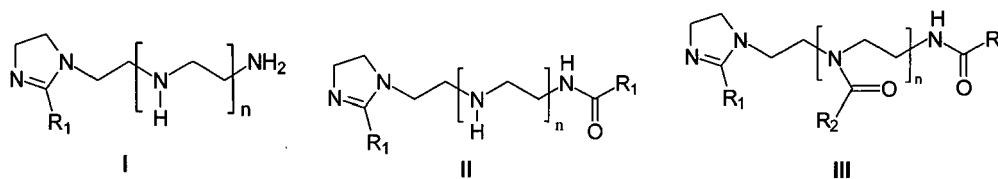
[0153] While the present invention has been principally demonstrated hereinabove as a power transmitting fluid for transmissions, it is contemplated that the benefits of the fluid embodiment are similarly applicable to other power transmitting fluids included within the scope of the present invention are gear oils, hydraulic fluids, heavy duty hydraulic fluids, industrial oils, power steering fluids, pump oils, tractor fluids, and universal tractor fluids, and apparatus embodiments include gears, hydraulic mechanisms, power steering devices, pumps and the like incorporating a fluid according to the invention.

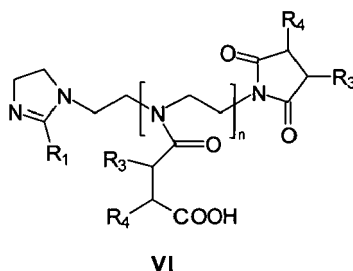
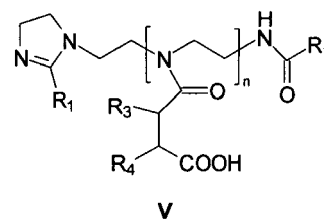
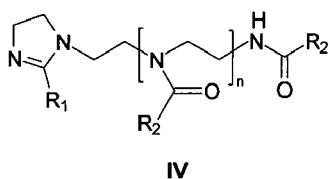
[0154] Other embodiments of the present invention will be apparent to those skilled in the art from consideration of the specification, Figure and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

Claims

1. An additive composition including:

- (i) a mixture containing at least one compound represented by formulae I-II; or
- (ii) a mixture containing at least one compound represented by formulae I-II, and at least one compound represented by formulae III-VI, wherein said formulae I-VI are:





wherein R_1 and R_2 are independently selected from C_3 to C_{30} straight or branched alkyl, alkenyl and aryl groups, or heteroatom derivatives thereof; R_3 and R_4 are independently selected from H, -OH, -OR, -COOH, -SH, -SR, straight chain, beta branched alkyl, alkenyl radicals, and hydrocarbyl groups in oligomeric or polymeric form that are derived from propylene, isobutylene and higher olefins having terminal, internal and vinylidene double bonds, wherein R represents an organic group having up to 30 carbon atoms; and n is a value from 0 to 5.

2. The additive composition of claim 1, wherein the additive includes a compound represented by the formula I, and a compound represented by the formula II.
3. The additive composition of claim 1, wherein the additive includes a compound represented by the formula I, a compound represented by the formula II, a compound represented by the formula III, and a compound represented by the formula IV.
4. The additive composition of claim 1, wherein the additive includes a compound represented by the formula I, a compound represented by the formula II, a compound represented by the formula V, and a compound represented by the formula VI.
5. The additive composition of claim 1, wherein the additive includes a compound represented by the formula III and a compound represented by the formula IV.
6. The additive composition of claim 1, wherein the additive includes a compound represented by the formula V and a compound represented by the formula VI.
7. The additive composition of claim 1, wherein said additive is a mixture containing at least one compound represented by the formulae I-II, and at least one compound represented by the formulae III-VI.
8. The additive composition of any one of claims 1-7, wherein the at least one compound of the formulae I-II is a reaction product of an aliphatic carboxylic acid and a polyamine
9. The additive composition of any one of claims 1-7, wherein the at least one compound of the formulae III-VI is a reaction product obtained by: (a) reacting an aliphatic carboxylic acid and a polyamine under conditions sufficient to produce a mixture of 1,2-disubstituted imidazolines containing one or more compounds represented by the formulae I-II, and subsequently (b) treating said mixture of 1,2-disubstituted imidazolines under conditions sufficient to produce a further mixture containing one or more compounds represented by the formulae III-VI.
10. A fluid composition including:

- (1) a major amount of a base oil, and
- (2) a minor amount of an additive composition as claimed in any one of claims 1-9.

11. The fluid composition of claim 10, wherein the base oil includes one or more of a natural oil, a mixture of natural oils, a synthetic oil, a mixture of synthetic oils, a mixture of natural and synthetic oils, and a base oil derived from a Fischer-Tropsch or gas-to-liquid process.

12. The fluid composition of any one of claims 10-11, wherein the base oil has a kinematic viscosity of from 2 centistokes to 10 centistokes at 100° C.

13. The fluid composition of any one of claims 10-12, wherein the fluid composition includes an ashless dispersant.

14. The fluid composition according to any one of claims 10-13, wherein said fluid composition includes at least one additional compound selected from a detergent, another friction modifier, an antioxidant, an antiwear agent, an antifoam agent, a viscosity index improver, a copper corrosion inhibitor, an anti-rust additive, a seal swell agent, and a metal deactivator.

15. The fluid composition of any one of claims 10-14, wherein the additive is present in an amount of 0.01 wt.% to 10 wt.%, based on the total weight of the fluid composition.

16. The fluid composition of any one of claims 10-14, wherein the additive is present in an amount of from 0.1 wt.% to 5.0 wt.%, based on the total weight of the fluid composition.

17. The fluid composition of any one of claims 10-16, wherein the fluid is suitable for use in a transmission employing one or more of an electronically controlled converter clutch, a slipping torque converter, a lock-up torque converter, a starting clutch, and one or more shifting clutches.

18. The fluid composition of any one of claims 10-16, wherein the fluid is suitable for use in a belt, chain, or disk-type continuously variable transmission, a 4-, 5-, 6-, or 7-speed automatic transmission, a manual transmission, an automated manual transmission, or a dual clutch transmission.

19. The fluid composition of any one of claims 10-16, wherein the fluid is suitable for use in an industrial gear or an automotive gear.

20. A transmission containing the fluid composition of any one of claims 10-19.

21. The transmission of claim 20, when dependent on any one of claims 10-16 and 18, wherein the transmission is a continuously variable transmission.

22. The transmission of claim 20, when dependent on any one of claims 10-16 and 18, wherein the transmission is a dual clutch transmission.

23. The transmission of claim 20, when dependent on any one of claims 10-16 and 18, wherein the transmission is an automatic transmission.

24. The transmission of claim 20, when dependent on any one of claims 10-16 and 18, wherein the transmission is a manual transmission.

25. A vehicle including an engine and a transmission as claimed in any one of claims 20-24.

26. A vehicle including a differential, the differential including a lubricant containing the fluid composition of any one of claims 10-19.

27. A method for producing friction modifier compounds including the step of:

reacting a molar excess of at least one carboxylic acid represented by the formula: $R_1\text{COOH}$, wherein R_1 is selected from a C_3 to C_{30} straight or branched alkyl, alkenyl or aryl group, or a heteroatom derivative thereof; with a linear polyamine represented by the formula: $H_2N-(CH_2CH_2NH)_x-CH_2$, wherein x represents an integer

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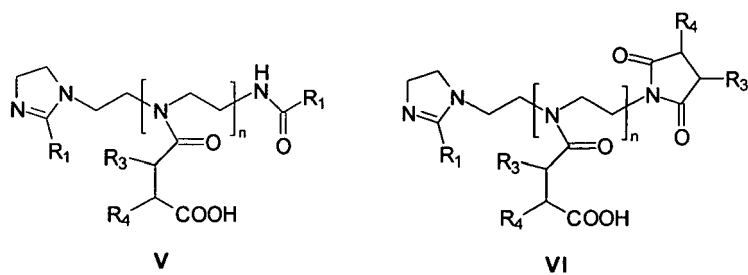


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wherein R_1 and n are as defined above; and R_3 and R_4 are independently selected from: H, -OH, -OR, -COOH, -SH, -SR, straight chain, beta branched alkyl, alkenyl radicals, and hydrocarbyl groups in oligomeric or polymeric form that are derived from propylene, isobutylene and higher olefins having terminal, internal and vinylidene double bonds, wherein R is an organic group having up to 30 carbon atoms.

37. A method for providing improved durability of friction characteristics in a lubricated power transmitting apparatus including the steps of:

- 1) providing a fluid as claimed in any one of claims 10-19 to a power transmitting apparatus, and
- 2) operating the fluid in the power transmitting apparatus, wherein the durability of friction characteristics in said power transmission apparatus improved relative to the performance of the same power transmitting apparatus without said fluid.

38. The method of claim 37, wherein the power transmitting apparatus includes a transmission.

39. The method of claim 37, wherein the power transmitting apparatus includes an industrial gear or an automotive gear.

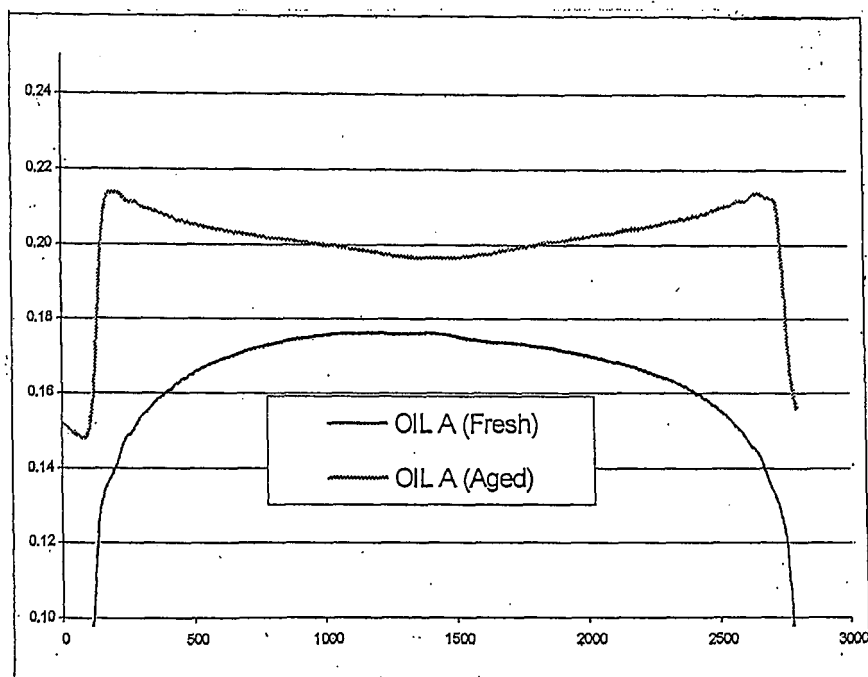
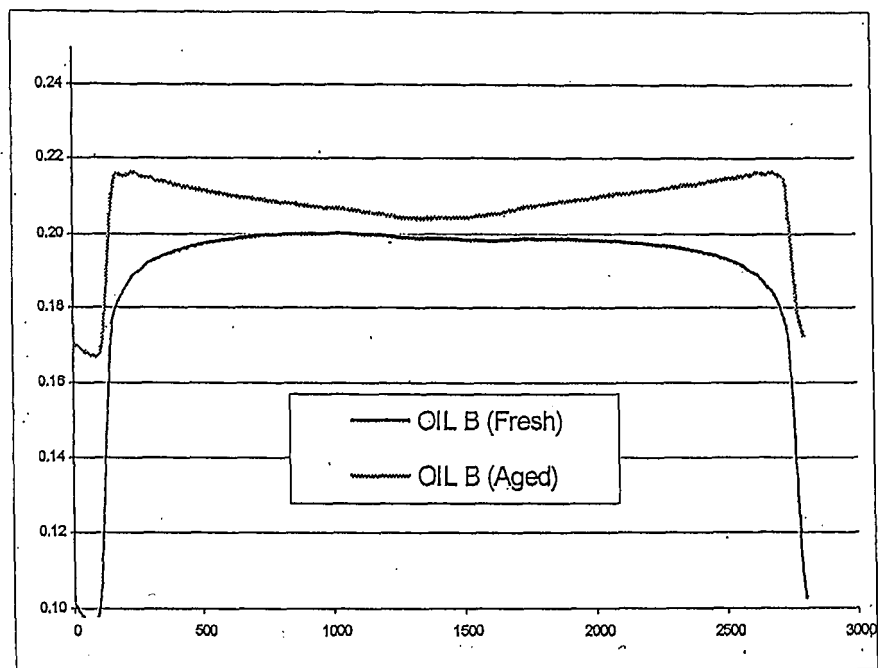
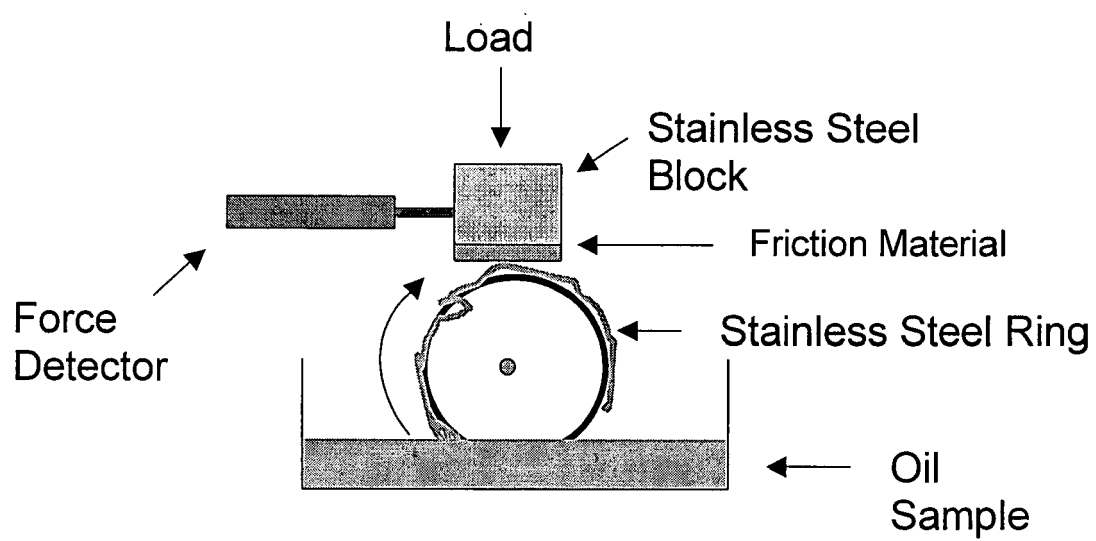


FIG. 1

FIG. 2





European Patent
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EUROPEAN SEARCH REPORT

Application Number
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Place of search Munich		Date of completion of the search 18 January 2006	Examiner Dötterl, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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