US 20060264339A1

(19) **United States**

(12) **Patent Application Publication**

**Devlin et al.**

(10) **Pub. No.: US 2006/0264339 A1**

(43) **Pub. Date: Nov. 23, 2006**

# (54) POWER TRANSMISSION FLUIDS WITH ENHANCED LIFETIME CHARACTERISTICS

(76) Inventors: **Mark T. Devlin**, Richmond, VA (US); **Randall E. Baren**, Glen Allen, VA (US); **Samuel H. Tersigni**, Glen Allen, VA (US); **Tze-Chi Jao**, Glen Allen, VA (US)

Correspondence Address:
**NEW MARKET SERVICES CORPORATION**
**(FORMERLY ETHYL CORPORATION)**
**330 SOUTH 4TH STREET**
**RICHMOND, VA 23219 (US)**

(21) Appl. No.: **11/132,845**

(22) Filed: **May 19, 2005**

**Publication Classification**

(51) **Int. Cl.**
*C10M 141/12* (2006.01)

(52) **U.S. Cl.** ........................ **508/188**; 508/208; 508/206; 508/212; 508/469; 508/562; 508/322; 508/563; 508/574; 508/273

## (57) ABSTRACT

A power transmission fluid having improved characteristics, a method of lubricating a transmission, and a vehicle containing the transmission fluid is disclosed. The transmission fluid includes an amount of silicon-containing antifoam agent having a kinematic viscosity of greater than about 20,000 centistokes at 25° C. that is effective to provide gear shifting times of no more than about 0.75 seconds over a useful lifetime of the transmission fluid.

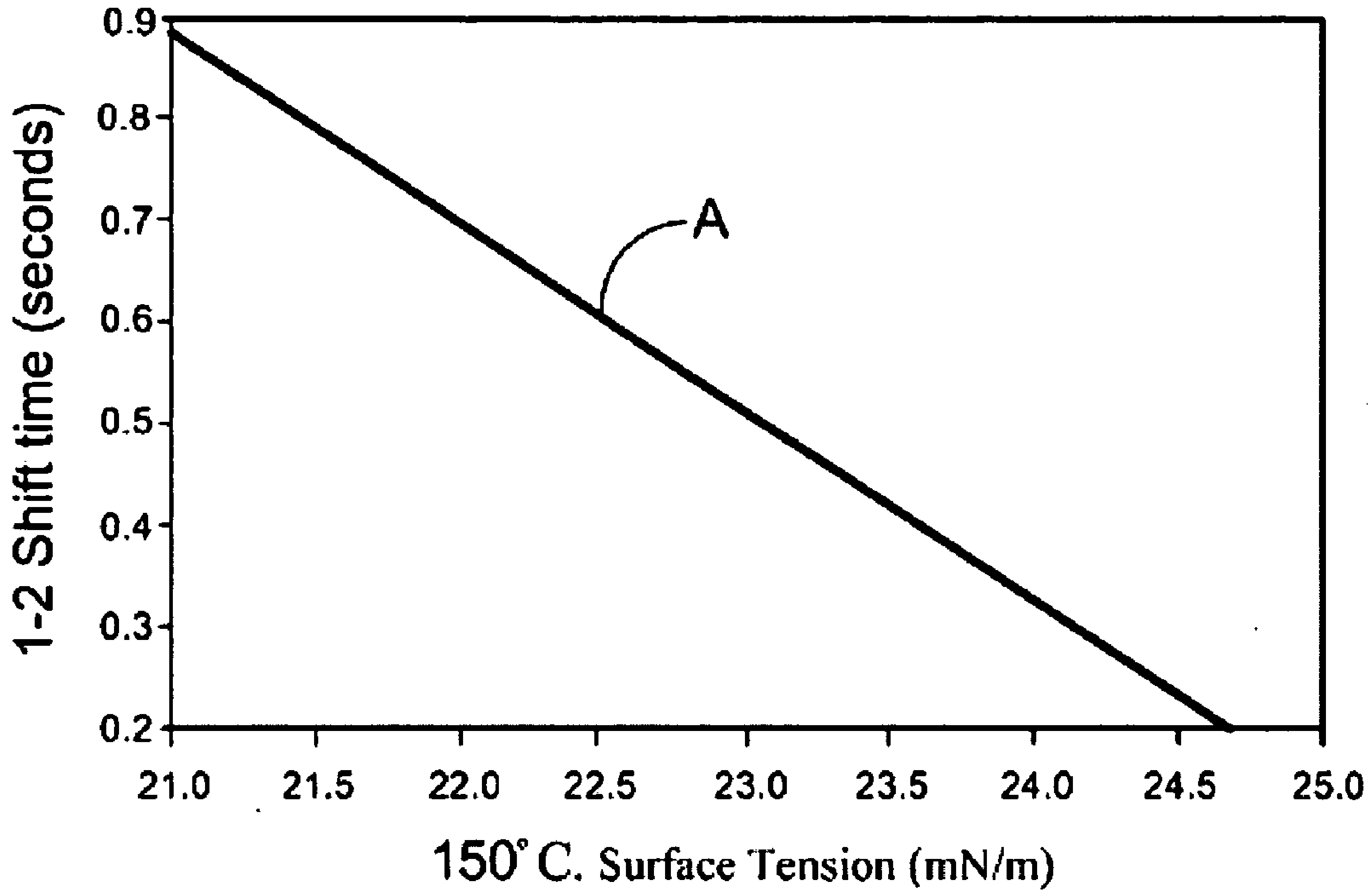
1-2 Shift time (seconds)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
A
21.0
21.5
22.0
22.5
23.0
23.5
24.0
24.5
25.0
150° C. Surface Tension (mN/m)

FIG. 1

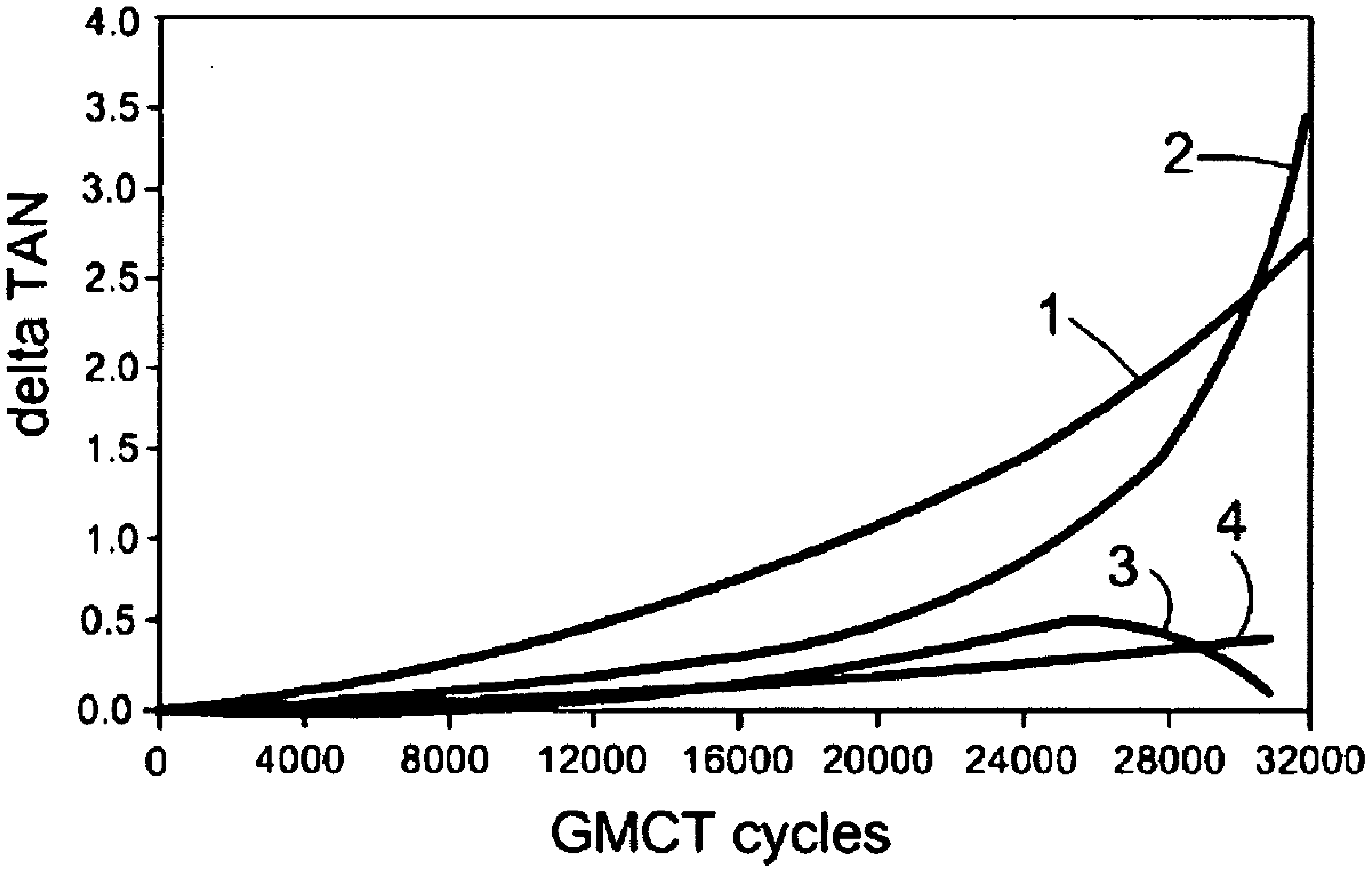
delta TAN
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
2
3
4
0
4000
8000
12000
16000
20000
24000
28000
32000
GMCT cycles

FIG. 2

# POWER TRANSMISSION FLUIDS WITH ENHANCED LIFETIME CHARACTERISTICS

## FIELD

**[0001]** The present disclosure relates to power transmission fluids having improved characteristics particularly for aged fluids. The power transmission fluids disclosed herein may include fluids suitable for use in an automatic transmission (ATF) and/or a manual transmission. By "automatic transmissions" herein is meant both continuously variable transmissions, known as CVT, and conventional automatic transmissions.

## BACKGROUND AND SUMMARY

**[0002]** Automatic transmission fluids (ATF) are designed to meet certain industry standards. A current standard for ATF is known as DEXRON® III-G specifications. However, a new specification was announced in June 2003. The new specification is known under the trade name DEXRON® III-H, which is an upgrade from the DEXRON® III-G specification. The two significant changes from III-G to III-H are: 1) an increase in the GM oxidation test (GMOT) length from 300 hours to 450 hours and 2) an increase the duration of the GM cycling test (GMCT) from 20,000 cycles to 32,000 cycles. In both cases, the test condition and performance requirements are kept constant while the test lengths are increased. For example, the total acid number (TAN) of the oil must not increase by more than 3.25 (delta TAN) during the GMOT. For the GMCT, the delta TAN must not increase by more than 2.0 and an engagement time for shifting between first and second gears (1-2 shift time) must be controlled within 0.30 to 0.75 seconds throughout the GMCT. The overall required performance changes impose a severe challenge to automatic transmission fluid (ATF) formulators. Since the delta TAN for the GMCT is lower than for the GMOT, a fluid that can pass the GMCT criteria may also meet the GMOT criteria.

**[0003]** In order for an automatic transmission to operate properly, an automatic transmission fluid must be able to effectively control engagement times during shifting from one gear to the next. However, as the fluids age there is a tendency for the shifting times to increase. There are two failure modes which may be responsible for the GMCT 1-2 shift time increase. One is an increase in air dispersed in the oils as they age and the other is thermal degradation of the band friction material.

**[0004]** A factor that may contribute to an increase in air dispersed in the oils as they age may be a decrease in surface tension of the oils. The reduction in surface tension is most likely caused by oil oxidation creating soluble and insoluble hydrophilic compounds, since such oxidized products are known to reduce surface tension. A reduction in surface tension also increases the amount of foaming of the oil. As foaming increases, greater amounts of air bubbles are present in the oil, increasing the compressibility of the oil. When a pressure is applied to the band and drum to activate the 1-2 shift, a longer shift time is required because of a greater fluid compressibility due to the presence of the air bubbles or foam. Accordingly, there continues to be a need for improved power transmission fluids that are less susceptible to foam formation as oils are aged during use.

**[0005]** With regard to the foregoing, there is provided in one exemplary embodiment a power transmission fluid including an amount of silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes that is effective to provide gear shifting times of no more than about 0.75 seconds over a useful lifetime of the transmission fluid.

**[0006]** In another exemplary embodiment, there is provided an automatic transmission fluid including: a) an oil of lubricating viscosity having a kinematic viscosity at 100° C. of 2-10 centistokes; b) sufficient weight percent of 2,5-dimercapto-1,3,4-thiadiazole (DMTD) and/or derivatives or precursors thereof to provide the fluid with antiwear properties; c) a silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes; and d) an acrylate, methacrylate, polyacrylate, polymethacrylate, or copolymer or terpolymer thereof.

**[0007]** In yet another exemplary embodiment there is provided a method of decreasing gear shifting time in an automatic transmission containing an aged transmission fluid. The method includes lubricating the transmission with a fluid comprising an oil having kinematic viscosity at 100° C. of 2-10 centistokes and an effective amount of a silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes, wherein the gear shifting time for the aged fluid is reduced relative to the gear shifting time for an aged fluid in a transmission containing an antifoam agent having a kinematic viscosity at 25° C. of less than about 20,000 centistokes.

**[0008]** Conventionally, antifoam agents are used to decrease the surface tension of a fluid so that air is released thereby reducing the foaming tendency of the fluid. Adding more conventional antifoam agent may increase the ability of a fluid to release air therefrom. However, as the fluid ages, as in the GMCT described above, the effectiveness of conventional antifoam agents decreases. As the effectiveness decreases, the 1-2 shift time increases.

**[0009]** An advantage of embodiments of the disclosure is that certain high viscosity silicon-containing antifoam agents may be used in power transmission fluid applications to maintain a lower increase in the 1-2 shift times in the GMCT for aged fluids. Without desiring to be bound by theory, it is believed that higher viscosity silicon-containing antifoam agents may increase the surface tension of the fluid and maintain such increased surface tension even as the fluid ages. Accordingly, the high viscosity silicon-containing antifoam agents may reduce foaming by preventing air from dissolving or dispersing in the fluid initially and as the fluid ages.

**[0010]** In addition to the high viscosity antifoam agent, compositions as described herein may also contain boron as contributed by borated dispersants or other borated materials such as borated epoxides or mixtures thereof. The compositions may further contain phosphorus which may be contributed by phosphorus acid esters, such as dibutyl hydrogen phosphite, diphenyl hydrogen phosphite, triphenyl phosphite, and/or triphenyl thiophosphate.

**[0011]** Another feature of the disclosed embodiments is to provide a method of treating an automatic transmission, comprising directly injecting into said transmission a composition comprising at least one silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes, with or without carrier oil.

[0012] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide further explanation of the disclosed embodiments, as claimed.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Further features and advantages of exemplary embodiments disclosed herein may become apparent by reference to the detailed description when considered in conjunction with the figures, which are not to scale, wherein like reference numbers indicate like elements through the several views, and wherein:

[0014] **FIG. 1** is a plot of 1-2 shift time versus fluid surface tension; and

[0015] **FIG. 2** is a plot of delta TAN versus GMCT cycles.

## DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0016] The disclosed embodiments use an antifoam agent having unconventionally high kinematic viscosity for ATF applications. The antifoam agent may be used in a fully formulated ATF or may be directly injected as a top treat into the ATF in the transmission to reduce clutch engagement times. In an exemplary embodiment, the ATF also contains an optional air release agent. The disclosed embodiments also include an additive system containing the aforementioned unconventionally high viscosity antifoam agent, which may be mixed with other compositions by ATF formulators for providing an ATF.

### Antifoam Agent

[0017] Suitable silicon-containing antifoam agents according to the disclosure include, but are not limited to, fluorosilicones, polydimethylsiloxane, phenyl-methyl polysiloxane, linear siloxanes, cyclic siloxanes, branched siloxanes, silicone polymers and copolymers, organo-silicone copolymers, and mixtures thereof. Such antifoam agents have a kinematic viscosity at 25° C. of greater than about 20,000 centistokes, typically from about 40,000 to about 80,000 centistokes at 25° C. and are referred to herein as "high viscosity antifoam agents." Such high viscosity antifoam agents are available from Dow Corning of Midland, Mich. under the trade name DOW CORNING 200®.

[0018] The high viscosity antifoam agent may be formulated with a conventional ATF or may be directly injected (e.g., via syringe) or otherwise added into an automatic transmission. Because of the high shear rate of many automatic transmission pumps (e.g., especially CVT pumps), the antifoam agent may be quickly and effectively mixed into the ATF.

[0019] The treat rate for the high viscosity antifoam agent (i.e., the amount of high viscosity antifoam agent needed to effectively reduce gear shift times) is that necessary to deliver from about 1 to about 100 ppm of silicon, and more preferably from 10 to about 80 ppm of silicon, to the finished lubricating transmission oil/ATF, provided the antifoam agent is substantially uniformly dispersed in the fluid. A typical antifoam agent contains about 20% by weight elemental Si, so the treat rate of the antifoam agent may range from about 5 to 500 ppm and preferably about 50 to 400 ppm in the finished oil. A diluent or carrier may be added with the antifoam agent at from about 750 to about 1500 ppm, and more preferably about 1030 ppm. The preferred diluent is a Group IV polyalphaolefin oil.

[0020] One method of treating an automatic transmission having ATF therein according to an embodiment of the disclosure includes the step of adding into the transmission a composition comprising a silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes, with or without a diluent/carrier oil. This step of adding the antifoam agent composition may be performed by direct injection thereof into the transmission, such as by syringe, a metering apparatus, or otherwise. Also, this step may be performed: at the initial building of the transmission; at its initial installation into a vehicle; at prescribed service intervals; at any servicing, maintenance or rebuilding of the transmission; at any topping off, filling or refilling of the transmission with fluid; and/or the like.

[0021] For example, one method according to the disclosure comprises the steps of: (a) building a new automatic transmission, (b) filling the transmission with ATF, (c) performing functional tests on the transmission, (d) removing some portion (e.g., one-half) of the ATF from the transmission, (e) adding a top treat composition containing the high viscosity silicon-containing antifoam agent into the partially-filled transmission, (f) shipping the transmission (e.g., to a dealer, service site, vehicle etc.), and (g) filling up the transmission with ATF. This process may optionally include the step of installing the transmission into a vehicle after step (a).

[0022] Alternatively, rather than adding the high viscosity silicon-containing antifoam agent into the transmission (i.e., top treating the transmission), a method according to the disclosure also includes the step of mixing a high viscosity silicon-containing antifoam agent with an ATF prior to filling or topping off an automatic transmission with initial or additional ATF. This prior mixing of the antifoam agent and ATF may be done by mixing the agent alone (with or without a diluent/carrier) directly with the ATF, or by mixing a top treat additive system containing the high viscosity antifoam agent with the ATF. Either way, a Fully-Formulated ATF is thus prepared which has the desired high viscosity antifoam agent therein. The resulting ATF may then be used to fill, refill, or top off an automatic transmission, so as to increase the surface tension of the fluid thereby preventing a substantial increase in the 1-2 shift time of the fluid as the fluid ages.

[0023] It should be noted that the step of adding the high viscosity antifoam agent to a transmission according to the disclosure may include adding such agent into the transmission case, the sump, the pump itself, a fill tube, a dipstick tube, a service port, the torque converter, the valve body, an accumulator, the hydraulic lines, or elsewhere in direct or indirect fluid communication with the pump. The location where the high viscosity antifoam agent is added may be proximate the transmission, or it may be at some relatively distal point from the transmission, such as at a suitable port in the pump/transmission hydraulic lines adjacent the radiator/condenser/oil cooler.

[0024] Testing has shown that adding an effective amount of high viscosity silicon-containing antifoam agent into a transmission may be very effective at maintaining and/or reducing gear shift times for aged fluids compared to aged fluids in transmissions not lubricated with a fluid containing the high viscosity silicon-containing antifoam agent. Without desiring to be bound by theory, it is believed that there is a linear relationship (Line A) between the 1-2 shift time of a transmission and the surface tension of the transmission fluid as shown in **FIG. 1**. Additives for transmission fluids that are effective to maintain relatively high fluid surface tensions may reduce the 1-2 shift time of a transmission during the GMCT.

**[0025]** In order to determine the surface tension retaining properties of various silicon-containing antifoam agents, several transmission oils containing different types and amounts of silicon-containing antifoam agents were thermally degraded for 24 hours at 160° C. The surface tensions of fresh and aged fluids were measured and the differences in surface tensions were determined. Table 1 contains a comparison of two different silicon-containing antifoam agents providing 2 and 8 ppm silicon to transmission fluids before and after aging.

TABLE 1

| | | Kinematic | Surface Tension of transmission fluid (dyne/cm) | | |
|---|---|---|---|---|---|
| Fluid # | Si (ppm) | Viscosity (cSt) of Antifoam agent | Fresh Fluid | Aged Fluid | Difference |
| 1 | 2 | 100 | 22.48 | 22.21 | −0.27 |
| 2 | 8 | 100 | 22.21 | 21.91 | −0.30 |
| 3 | 2 | 60,000 | 22.63 | 22.53 | −0.10 |
| 4 | 8 | 60,000 | 22.59 | 22.50 | −0.09 |

**[0026]** Fluids 3 and 4 having a lower change in surface tension as they are aged are expected to provide fluids that maintain a high surface tension thereby providing lower 1-2 shift times as shown by **FIG. 1**. By comparison, fluids 1 and 2 are expected to provide an increase in 1-2 shift times as the fluids are aged due to the decrease in the surface tension of the fluids. As also indicated by the foregoing example, relatively low viscosity silicon-containing antifoam agents provide a lower initial surface tension for transmission fluids (fluids 1 and 2) than the high viscosity silicon-containing antifoam agents used in fluids 3 and 4.

**[0027]** The foregoing example also indicates that within the tested range, the amount of silicon-containing antifoam agent used in the transmission fluids has less impact on the change in surface tension than does the viscosity of the silicon-containing antifoam agent. Accordingly, a relatively wide ranging amount of high viscosity silicon-containing antifoam agent may be used.

**[0028]** While a conventional relatively low viscosity antifoam agent is used to lower the surface tension of a transmission fluid in order to decrease foaming, the relatively high viscosity silicon-containing antifoam agent maintains a relatively high surface tension that prevents or reduces air entrainment in the fluid thereby preventing or significantly reducing foaming from occurring initially in the fluid. Nevertheless, a transmission fluid may contain both the high viscosity and relatively low viscosity antifoam agents.

**[0029]** Additionally, testing has indicated that an effective amount of high viscosity silicon-containing antifoam agent in a transmission fluid may maintain a lower increase in a total acid number (TAN) of the fluid during testing according to GMCT as compared to a transmission containing a conventional antifoam agent. A graphical comparison of the increase in TAN for transmission fluid during GMCT cycles is graphically presented in **FIG. 2**. Curves 1 and 2 represent the rise in TAN for conventional transmission oils, whereas curves 3 and 4 represent the rise in TAN for transmission fluids containing a high viscosity silicon-containing antifoam agent according to the disclosure.

## Additive System

**[0030]** In one embodiment, an additive system as described herein may contain N-aliphatic alkyl-substituted diethanolamine, phosphorylated and boronated ashless dispersant, a sulfurized fatty oil friction modifier, a copper corrosion inhibitor, a high viscosity silicon-containing antifoam agent, nonylated diphenyl amine, a calcium hydroxide salt of sulfurized alkyl phenate (TBN 150), octanoic acid, 3-decyloxypropylamine, an ethylene oxide-propylene oxide (EO-PO) block copolymer, an alkyl polyoxyalkylene ether, an acrylate polymer surfactant, and a diluent oil. The following additive system example further illustrates aspects of the disclosed embodiment, but does not limit the embodiments disclosed.

Additive System

| Components | Weight Percent range |
|---|---|
| N-aliphatic alkyl-substituted diethanolamine | 0.08 to 0.30 |
| Phosphorylated and boronated ashless dispersant | 2.5 to 5.0 |
| Sulfurized fatty oil friction modifier | 0.60 to 1.20 |
| Copper corrosion inhibitor | 0.02 to 0.10 |
| High viscosity silicon-containing antifoam agent | 0.02 to 0.10 |
| Nonylated diphenyl amine | 0.15 to 0.45 |
| $Ca(OH)_2$ salt of sulfurized alkyl phenate (TBN 150) | 0.02 to 0.10 |
| Octanoic acid | 0.02 to 0.10 |
| 3-decyloxypropylamine | 0.02 to 0.10 |
| Ethylene oxide-propylene oxide block copolymer | 0.005 to 0.10 |
| Alkyl polyoxyalkylene ether | 0.02 to 0.10 |
| Acrylate polymer | 0.015 to 0.060 |
| Diluent oil | greater than 0.10 |

## Fully-Formulated ATF

**[0031]** A fully-formulated composition for use as contemplated by embodiments of this disclosure may contain, in addition to the components listed above:

**[0032]** 1. borated and/or non-borated dispersants;

**[0033]** 2. anti-oxidation compounds;

**[0034]** 3. seal swell compositions (also called agents);

**[0035]** 4. friction modifiers;

**[0036]** 5. extreme pressure/anti-wear agents;

**[0037]** 6. viscosity modifiers;

**[0038]** 7. pour point depressants;

**[0039]** 8. detergents.

**[0040]** Examples of the foregoing components are well known to those skilled in the art and the amounts of each are conventional amounts used in transmission applications.

Air Release Agent/Air Entrainment Control Additive

**[0041]** One or more of several known air entrainment control additives may also useful, but are not required, for fluids according to this disclosure. When used, air entrainment control additives are those materials, chemicals or additives which by chemical and/or physical means cause or enable trapped or entrained air or other gases to more readily be released from the fluid or mixture.

**[0042]** Preferred air entrainment control additives when used herein can include, for example, fluorinated components, silicone based components, acrylate, polyacrylate or PMA based components, and the more preferred class of air entrainment control additives useful in the disclosed embodiments is fluorinated components. The air release agent can be added to or with the top treat composition, the Additive System described above or directly to the ATF.

VI Improver

**[0043]** A viscosity index improver is useful in the formulations and methods of the embodiments and can include, but is/are not limited to, one or more materials selected from polyacrylate, polymethacrylate, styrene/olefin copolymer, styrene diene copolymer, EP copolymer or terpolymers, and combinations thereof. A preferred VI Improver is a highly shear stable polymethacrylate polymer or copolymer used at, for example, 15 wt % in the fluid formulation.

Detergent/Dispersant

**[0044]** Preferably the compositions of described herein may contain a N-aliphatic alkyl-substituted diethanolamine, herein referred to as component (i), and at least one oil-soluble phosphorus-containing ashless dispersant present in amount such that the ratio of phosphorus in said ashless dispersant to component (i) is in the range of about 0.1 to about 0.4 part by weight of phosphorus per part by weight of component (i); and/or at least one oil-soluble boron-containing ashless dispersant present in amount such that the ratio of boron in said ashless dispersant to said component (i) is in the range of about 0.05 to about 0.2 part by weight of boron per part by weight of component (i). Most preferably, such compositions may contain at least one oil-soluble phosphorus- and boron-containing ashless dispersant present in amount such that the ratio of phosphorus in said ashless dispersant to said component (i) is in the range of about 0.15 to about 0.3 part by weight of phosphorus per part by weight of component (i), and such that the ratio of boron in said ashless dispersant to said component (i) is in the range of about 0.05 to about 0.15 part by weight of boron per part by weight of component (i).

**[0045]** The foregoing phosphorus- and/or boron-containing ashless dispersants may be formed by phosphorylating and/or boronating an ashless dispersant having basic nitrogen and/or at least one hydroxyl group in the molecule, such as a succinimide dispersant, succinic ester dispersant, succinic ester-amide dispersant, Mannich base dispersant, hydrocarbyl polyamine dispersant, or polymeric polyamine dispersant.

**[0046]** The polyamine succinimides in which the succinic group contains a hydrocarbyl substituent containing at least 30 carbon atoms are described for example in U.S. Pat. Nos. 3,172,892; 3,202,678; 3,216,936; 3,219,666; 3,254,025; 3,272,746; and 4,234,435. 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 a polyamine containing at least one primary amino group. The alkenyl succinic anhydride may be made readily by heating a mixture of olefin and maleic anhydride to about 180° C. to 220° C. The olefin is preferably a polymer or copolymer of a lower monoolefin such as ethylene, propylene, 1-butene, isobutene and the like. The more preferred source of alkenyl group is from polyisobutene having a GPC number average molecular weight of up to 10,000 or higher, preferably in the range of about 500 to about 2,500, and most preferably in the range of about 800 to about 1,200.

**[0047]** As used herein, the term "succinimide" is meant to encompass the completed reaction product from reaction between one or more polyamine reactants and a hydrocarbon-substituted succinic acid or anhydride (or like succinic acylating agent), and is intended to encompass compounds wherein the product may have amide, amidine, and/or salt linkages in addition to the imide linkage of the type that results from the reaction of a primary amino group and an anhydride moiety.

**[0048]** Alkenyl succinic acid esters and diesters of polyhydric alcohols containing 2-20 carbon atoms and 2-6 hydroxyl groups can be used in forming the phosphorus- and/or boron-containing ashless dispersants. Representative examples are described in U.S. Pat. Nos. 3,331,776; 3,381,022; and 3,522,179. The alkenyl succinic portion of these esters corresponds to the alkenyl succinic portion of the succinimides described above.

**[0049]** Suitable alkenyl succinic ester-amides for forming the phosphorylated and/or boronated ashless dispersant are described for example in U.S. Pat. Nos. 3,184,474; 3,576,743; 3,632,511; 3,804,763; 3,836,471; 3,862,981; 3,936,480; 3,948,800; 3,950,341; 3,957,854; 3,957,855; 3,991,098; 4,071,548; and 4,173,540.

**[0050]** Hydrocarbyl polyamine dispersants that can be phosphorylated and/or boronated are generally produced by reacting an aliphatic or alicyclic halide (or mixture thereof) containing an average of at least about 40 carbon atoms with one or more amines, preferably polyalkylene polyamines. Examples of such hydrocarbyl polyamine dispersants are described in U.S. Pat. Nos. 3,275,554; 3,394,576; 3,438,757; 3,454,555; 3,565,804; 3,671,511; and 3,821,302.

**[0051]** In general, the hydrocarbyl-substituted polyamines are high molecular weight hydrocarbyl-N-substituted polyamines containing basic nitrogen in the molecule. The hydrocarbyl group typically has a number average molecular weight in the range of about 750-10,000, more usually in the range of about 1,000-5,000, and is derived from a suitable polyolefin. Preferred hydrocarbyl-substituted amines or polyamines are prepared from polyisobutenyl chlorides and polyamines having from 2 to about 12 amine nitrogen atoms and from 2 to about 40 carbon atoms.

**[0052]** Mannich polyamine dispersants which may be used in forming the phosphorylated and/or boronated ashless dispersant is 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 one to about seven carbon atoms (especially formaldehyde and derivatives thereof), and polyamines (especially polyalkylene polyamines). Examples of Mannich condensation products, and methods for their production are described in U.S. Pat. Nos. 2,459,112; 2,962,442; 2,984,550; 3,036,003; 3,166,516; 3,236,770; 3,368,972; 3,413,347; 3,442,808; 3,448,047; 3,454,497; 3,459,661; 3,493,520; 3,539,633; 3,558,743; 3,586,629; 3,591,598; 3,600,372; 3,634,515; 3,649,229; 3,697,574; 3,703,536; 3,704,308; 3,725,277; 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; 3,872,019; 3,904,595; 3,957,746; 3,980,569; 3,985,802; 4,006,089; 4,011,380; 4,025,451; 4,058,468; 4,083,699; 4,090,854; 4,354,950; and 4,485,023.

**[0053]** The preferred hydrocarbon sources for preparation of the Mannich polyamine dispersants are those derived from substantially saturated petroleum fractions and olefin polymers, preferably polymers of mono-olefins having from 2 to about 6 carbon atoms. The hydrocarbon source generally contains at least about 40 and preferably 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 5,000 are preferred 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.

**[0054]** The preferred Mannich base dispersants for this use are Mannich base ashless dispersants formed by condensing about one molar proportion of long chain hydrocarbon-substituted phenol with from about 1 to 2.5 moles of formaldehyde and from about 0.5 to 2 moles of polyalkylene polyamine.

**[0055]** Polymeric polyamine dispersants suitable for preparing phosphorylated and/or boronated 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. Pat. Nos. 3,329,658; 3,449,250; 3,493,520; 3,519,565; 3,666,730; 3,687,849; and 3,702,300.

Base Oils

**[0056]** The base oils used in forming the automatic transmission fluids according to the disclosure may be any suitable natural or synthetic oil having the necessary viscosity properties for this usage. Thus, the base oil may be composed entirely of a natural oil such as mineral oil of suitable viscosity or it may be composed entirely of a synthetic oil such as a poly-alpha-olefin oligomer of suitable viscosity. Likewise, the base oil may be a blend of natural and synthetic base oils provided that the blend has the requisite properties for use in the formation of an automatic transmission fluid. Ordinarily, the base oil should have a kinematic viscosity in the range of 3 to 8 centistokes (cSt) at 100° C. Preferred base oils are Group III stocks. A preferred base oil viscosity is, for example, 3.8 cSt. In one embodiment, the individual viscosities of those base stocks are 2.8 cSt and 4.3 cSt, respectively. Such base stocks useful in the embodiments provided herein may include without limitation those manufactured by PetroCanada.

**[0057]** Included in the oil of lubricating viscosity is 0.025-5 weight percent on an oil-free basis based on the weight of the lubricating composition of 2,5-dimercapto-1,3,4-thiadiazole (DMTD) or derivatives thereof. Derivatives of DMTD are:

**[0058]** a) 2-hydrocarbyldithio-5-mercapto-1,3,4-thiadiazole or 2,5-bis-(hydrocarbyldithio)-1,3,4-thiadiazole and mixtures thereof;

**[0059]** b) carboxylic esters of DMTD;

**[0060]** c) condensation products of halogenated aliphatic monocarboxylic acids with DMTD;

**[0061]** d) reaction products of unsaturated cyclic hydrocarbons and unsaturated ketones with DMTD;

**[0062]** e) reaction products of an aldehyde and diaryl amine with DMTD;

**[0063]** f) amine salts of DMTD;

**[0064]** g) dithiocarbamate derivatives of DMTD;

**[0065]** h) reaction products of an aldehyde, and an alcohol or aromatic hydroxy compound, and DMTD;

**[0066]** i) reaction products of an aldehyde, a mercaptan and DMTD;

**[0067]** j) 2-hydrocarbylthio-5-mercapto-1,3,4-thiadiazole;

**[0068]** k) products from combining an oil soluble dispersant with DMTD; and mixtures thereof.

**[0069]** Components a)-k) are described in U.S. Pat. No. 4,612,129 and patent references cited therein. These references are included herein by reference. The preferred thiadiazoles for use in compositions described herein are those listed in a), h) and k) above. 2,5-bis-(hydrocarbyldithio)-1,3,4-thiadiazole and its monosubstituted equivalent 2-hydrocarbylthio-5-mercapto-1,3,4-thiadiazole are commercially available as a mixture of the two compounds in a ratio of about 85 percent bis-hydrocarbyl to 15 percent monohydrocarbyl.

Dye

**[0070]** A dye may be added to the compositions described herein. If a dye is added, the preferred level is from about 0.005 weight percent to about 0.05 weight percent of the ATF.

Seal Swell Agent

**[0071]** Depending on the base stocks that are chosen, an amount of seal swell agent could be required to meet the OEM seal compatibility requirements. Use of Group II, Group III and Group IV base oils many times require the addition of a material to swell seals. These materials are chosen from the general categories of oil soluble diesters, aromatic base oils, and sulfones. Alkyl adipates are examples of soluble diesters that can be used. Most preferred for use herein is alkyl adipate used at a treat rate of 3 to 20%, more preferably 3 to 10%, and most preferably 5%.

**[0072]** The compositions described herein are useful in the lubrication and treatment of power transmissions. Transmissions treated with the compositions or methods of the disclosed embodiments are also included herein, as well as vehicles having transmissions treated with the compositions or methods.

**[0073]** In other embodiments, there are provided methods of lubricating transmissions, methods of reducing foaming of transmissions fluids, methods of decreasing aeration in a transmission fluid by aiding the release of entrained bubbles in said fluid, methods of treating an automatic transmission by directly injecting into the transmission an antifoam composition, and methods of reducing 1-2 shift time increases in an automatic transmissions by adding to a transmission fluid a composition as described herein.

**[0074]** Thus, the disclosure is also directed to an automatic transmission containing the ATF lubricating composition described herein, a transmission lubricated by the methods described herein, and further directed to a vehicle containing such an automatic transmission.

**[0075]** Other embodiments of the disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the disclosed embodiments. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the embodiments being indicated by the following claims, including the equivalents thereof available as a matter of law. The disclosed embodiments are susceptible to considerable variation in their practice. Accordingly, the disclosure is not limited to the specific exemplifications set forth hereinabove.

**[0076]** The patentees do not intend to dedicate any disclosed embodiments to the public, and to the extent any disclosed modifications or alterations may not literally fall within the scope of the claims, they are considered to be part of the disclosed embodiments under the doctrine of equivalents.

**[0077]** At numerous places throughout this specification, reference has been made to a number of U.S. Patents. All such cited documents are expressly incorporated in full into this disclosure as if fully set forth herein.

**[0078]** 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 disclosed embodiments. 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 disclosed embodiments 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.

**1**. A power transmission fluid comprising an amount of silicon-containing antifoam agent having a kinematic viscosity of greater than about 20,000 centistokes at 25° C. that is effective to provide gear shifting times of no more than about 0.75 seconds over a useful lifetime of the transmission fluid.

**2**. The fluid of claim 1, wherein the silicon-containing antifoam agent is selected from the group consisting of fluorosilicones, polydimethylsiloxane, phenyl-methyl polysiloxane, linear siloxanes, cyclic siloxanes, branched siloxanes, silicone polymers and copolymers, organo-silicone copolymers, and mixtures thereof.

**3**. The fluid of claim 2, wherein the silicon-containing antifoam agent comprises a mixture of polydimethylsiloxane and fluorosilicone compounds.

**4**. The fluid of claim 1, further comprising an acrylate polymer antifoam agent.

**5**. The fluid of claim 4, wherein the acrylate polymer antifoamant is selected from the group consisting of a polymethacrylate, a polyacrylate, a dispersant polymethacrylate, a dispersant polyacrylate, and a mixture thereof.

**6**. The fluid of claim 1, wherein the silicon-containing antifoam agent has a kinematic viscosity ranging from about 40,000 to about 80,000 centistokes at 25° C.

**7**. An automotive transmission fluid comprising from about 0.08 to about 0.30 weight percent N-aliphatic alkyl-substituted diethanolamine; from about 2.5 to about 5.0 weight percent phosphorylated and boronated ashless dispersant; from about 0.6 to about 1.2 weight percent sulfurized fatty oil friction modifier; from about 0.02 to about 0.10 weight percent copper corrosion inhibitor; from about 0.02 to about 0.10 percent silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes; from about 0.15 to about 0.45 weight percent nonylated diphenyl amine; from about 0.02 to about 0.10 weight percent $Ca(OH)_2$ salt of sulfurized alkyl phenate (TBN 150); from about 0.02 to about 0.10 weight percent octanoic acid; from about 0.02 to about 0.10 weight percent 3-decyloxypropylamine; from about 0.005 to about 0.10 weight percent ethylene oxide-propylene oxide block copolymer; from about 0.02 to about 0.10 weight percent alkyl polyoxyalkylene ether; from about 0.015 to about 0.060 acrylate polymer; and greater than about 0.10 weight percent diluent oil.

**8**. An automatic transmission fluid, comprising:

a) an oil of lubricating viscosity having a kinematic viscosity at 100° C. of 2-10 centistokes;

b) sufficient weight percent of 2,5-dimercapto-1,3,4-thiadiazole (DMTD) and/or derivatives or precursors thereof to provide the fluid with antiwear properties;

c) a silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes; and

d) an acrylate, methacrylate, polyacrylate, polymethacrylate, or copolymer or terpolymer thereof.

**9**. The fluid of claim 8, wherein the silicon-containing antifoam agent is selected from the group consisting of fluorosilicones, polydimethylsiloxane, phenyl-methyl polysiloxane, linear siloxanes, cyclic siloxanes, branched siloxanes, silicone polymers and copolymers, organo-silicone copolymers, and mixtures thereof.

**10**. The fluid of claim 9, wherein the silicon-containing antifoam agent comprises a mixture of polydimethylsiloxane and fluorosilicone compounds.

**11**. An automatic transmission lubricated with a lubricating oil comprising the fluid of claim 1.

**12**. The automatic transmission of claim 11, wherein the transmission is a continuously variable transmission.

**13**. An automatic transmission lubricated with a lubricating oil comprising the automatic transmission fluid of claim 7.

**14**. A method of treating an automatic transmission having space between moving parts, comprising directly injecting into said space in said transmission a fluid composition comprising at least one silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes.

**15**. The method of claim 14, wherein the composition further comprises a carrier oil.

**16**. A method of maintaining a lower increase in gear shifting time in an automatic transmission containing an aged transmission fluid, comprising lubricating the transmission with a fluid comprising an oil having kinematic viscosity at 100° C. of 2-10 centistokes and an effective amount of a silicon-containing antifoam agent having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes, wherein the gear shifting time for the aged fluid is reduced relative to the gear shifting time for an aged fluid in a transmission containing an antifoam agent having a kinematic viscosity at 25° C. of less than about 20,000 centistokes.

**17**. The method of claim 16, wherein the silicon-containing antifoam agent has a kinematic viscosity at 25° C. ranging from about 40,000 to about 80,000 centistokes.

**18**. A method for maintaining an increased surface tension in an automotive transmission fluid over a life of the fluid in an automotive transmission so as to reduce an amount of air solubilized and/or dispersed in the automatic transmission fluid, said method comprising lubricating the transmission with a transmission fluid comprising at least one silicon-containing antifoam agents having a kinematic viscosity at 25° C. of greater than about 20,000 centistokes.

**19**. A method for reducing foaming of a hydrocarbon oil used as a transmission lubricating and power transmitting fluid in a vehicle, said method comprising injecting directly into said oil in a transmission a composition comprising a silicon-containing antifoam agent and an inert carrier oil, wherein the antifoam agent has a kinematic viscosity at 25° C. of greater than about 20,000 centistokes.

**20**. The method of claim 19, wherein the silicon-containing antifoam agent is selected from the group consisting of fluorosilicones, polydimethylsiloxane, phenyl-methyl polysiloxane, linear siloxanes, cyclic siloxanes, branched siloxanes, silicone polymers and copolymers, and organo-silicone copolymers.

**21**. The method of claim 20, wherein the injecting occurs into the transmission case, a sump, a fluid pump, a fill tube, a dipstick, a service port, a torque converter, a valve body, an accumulator, or a hydraulic line.

**22**. A vehicle comprising a transmission lubricated with a lubricant comprising the fluid of claim 1.

**23**. A vehicle lubricated by the method of claim 14.

**24**. A vehicle lubricated by the method of claim 16.

**25**. A vehicle lubricated by the method of claim 18.

**26**. A vehicle lubricated by the method of claim 19.

* * * * *