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HYDRAULIC PRESSURE TRANSMISSION FLUID

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This invention relates to new and improved hydraulic pressure transmission fluids for use in fluid pressure operating devices such as hydraulic transmissions, hydraulic brake systems, hydraulic steering mechanisms, etc. More particularly, this invention relates to central system fluids which contain as a lubricant the random or heteric addition product of ethylene oxide and propylene oxide with tripentaerythritol.

A wide variety of hydraulic fluid compositions have been suggested in the art. Commonly, the hydraulic pressure transmission fluids, such as brake fluids, are made up of three principal units. The first is a base or lubricant for the system which may include heavy-bodied fluids such as polyglycols, castor oil, mixtures of these materials, etc. Diluents, which are employed for the purpose of controlling the viscosity of the fluid as represented by glycol ethers, glycols, alcohols, etc., form the second basic unit. Finally, the third basic unit is represented by an inhibitor system comprising small quantities of inhibitors which are added to reduce oxidation, to improve wetting and flow and to maintain the pH of the hydraulic system above 7. Although the hydraulic fluids of the prior art possesses one or more of the desired characteristics of viscosity-temperature relationship, volatility, or pour-point, they all suffer from one or more disadvantages and their use is handicapped by the fact that a wide range of suitable properties cannot be obtained. Fluids known in the art suffer from lack of lubricity, some are not stable against oxidation or deterioration, with others it is found over long periods of use that insoluble materials are formed which greatly reduce their efficiency and in some instances exposure to oxidizing conditions also results in the formation of insoluble compositions. Frequently, it is found that these fluids are also corrosive and that they do not possess the required rubber swelling properties.

One of the salient features of the instant fluids is their enhanced oxidation stability. While many factors must be considered in the selection of a fluid for a centralized power system, high-temperature oxidation stability is one of the more important since the heat introduced from the compressor combined with the normal frictional heating of the fluid in brake operation must be dissipated. This is accomplished by conduction or convection from the hydraulic tubing or heat exchanger to the ambient air. To produce a practical differential temperature the central system fluid must tolerate temperatures of 100° F. to 200° F. above ambient. It is important, therefore, that the central system fluid have a high degree of oxidation stability and that it not produce varnish, gum, sludge, or other products of deterioration which will impair the proper functioning of the system components.

The fluids of this invention meet all the requirements for the synthetic type Central System Fluid Recommended Practice SAE 71–R–2. Since the central system fluids are required to function in a variety of hydraulically operated equipment under a broad range of conditions, the requirements for such fluids must be more rigorous than the requirements for a hydraulic fluid designed for a single operation, such as a brake fluid. For example, the viscosity at 210° F. of a central system fluid must be not less than 4.5 cs. as compared to 1.3 cs. at the same temperature for an SAE 70–R–1 brake fluid while at the same time in a central system fluid the viscosity at −40° F. must be not more than 1800 cs.

A maximum slope of the viscosity-temperature curve for an SAE brake fluid is 0.99 whereas in a central system power fluid the slope is limited to 0.645 (max.). Likewise, cold test requirements for central system fluids are more rigorous than for current fluids, such as brake fluids, as shown by the fact that adequate fluidity must be retained at −50° F. rather than at −40° F. in the six-day cold test and at −70° F. rather than at −60° F. in the six-hour cold test.

Increased lubricity is required for the central system fluid to function in a standard power steering pump (roller vane type) while in contrast brake fluids are required only to lubricate sliding metal and rubber surfaces. This represents the difference between load-bearing and no-load lubrication. The lubricating base in the central system fluid must maintain its viscosity under the shearing action of the pump. These fluids must be oxidatively stable in the presence of a steel-copper catalyst at 275° F. and in the presence of a stream of air. Suitable fluids must operate satisfactorily in a standard automotive automatic transmission unit and they must also meet the current SAE 70–R–3 hydraulic brake fluid specification.

Lubricant portion

The lubricant portion of the novel compositions of this invention are prepared by condensing simultaneously a mixture of about 35 to about 65 weight percent ethylene oxide and from about 65 to about 35 weight percent propylene oxide with tripentaerythritol to form a compound having attached, at the site of each hydroxyl group of the tripentaerythritol, a heteric oxyalkylene chain terminated by free hydroxyl group. In such a heteric oxyalkylene chain the different oxyalkylene units or groups are distributed randomly throughout the entire chain and the chain is terminated by hydroxyl group. In the heteric chains of the compounds (i.e., adduct) useful as lubricants in this invention, the average weight percent of the oxyethylene units in each of the chains will be about 35 to about 65, based on the total weight of all the oxyalkylene units present in the chain. Another requirement of the random adduct of tripentaerythritol with a mixture of ethylene oxide and propylene oxide is that the viscosity at 100° F. must be between 800 and 1400 centistokes and the adduct must exhibit a pour-point not higher than −15° F. (ASTM D–97–57).

The base or lubricant portion of the novel compositions of this invention will form from about 18 to about 30 percent, based on the total weight of the hydraulic fluid composition.

In preparing the heteric polyoxyalkylene adducts of tripentaerythritol, which form the lubricant or base fluid of the novel compositions of this invention, a mixture of ethylene oxide and propylene oxide is brought into intimate contact with the starting tripentaerythritol dissolved in a suitable solvent, throughout which an alkaline catalyst, such as potassium hydroxide or sodium hydroxide, is uniformly dispersed. The quantity of catalyst utilized generally will be from about 0.15 to about 1.0 percent by weight of the reactants. Preferably, the reaction temperature will range from about 80° C. to about 180° C. while the reaction time will be from about 1 to 20 hours or more depending upon the particular reaction conditions employed. The process by which such adducts can be prepared is well known in the art and is more completely described in U.S. Patent 2,425,845.

Diluent portion

The diluent portion of the novel fluids is composed of two materials. The first of these is a glycol alcohol ether of the formula

$$RO(R'O)_mH$$

wherein R is alkyl of from 1 to 4 carbon atoms, R' is alkylene of from 2 to 3 inclusive carbon atoms, and *m* is an integer of from 2 to 4 inclusive. Useful glycol alcohol ethers include diethylene glycol methyl ether, diethylene glycol ethyl ether, diethylene glycol propyl ether, triethylene glycol methyl ether, triethylene glycol ethyl ether, tetraethylene glycol ethyl ether, tetraethylene glycol propyl ether, etc. If desired, a mixture of the useful glycol alcohol ethers can be employed. Generally, the novel fluids of this invention will contain from about 40 to about 71.5 weight percent, based on the total weight of the fluid composition, of the glycol alcohol ether.

The second material employed as a diluent in the novel fluids of this invention is a formal of the formula:

$$R''O(CH_2CH_2O)_n—CH_2—(OCH_2CH_2)_mOR''$$

wherein R'' is alkyl of from 1 to 3 carbon atoms, and *n* and *m* are each an independently selected integer of from 1 to 3 inclusive.

From about 10 to about 25 weight percent of the formal, based on the total weight of the fluid composition, will be included in the novel fluid compositions of this invention.

Suitable formals include:

$CH_3O(CH_2CH_2O)—CH_2—(OCH_2CH_2)OCH_3$,
$C_2H_5O(CH_2CH_2O)—CH_2—(OCH_2CH_2)OC_2H_5$,
$C_3H_7O(CH_2CH_2O)—CH_2—(OCH_2CH_2)OC_3H_7$,
$CH_3O(CH_2CH_2O)_2—CH_2—(OCH_2CH_2)_2OCH_3$,
$C_2H_5O(CH_2CH_2O)_2—CH_2—(OCH_2CH_2)_2OC_2H_5$,
$C_3H_7O(CH_2CH_2O)_2—CH_2—(OCH_2CH_2)_2OC_3H_7$,
$CH_3O(CH_2CH_2O)_3—CH_2—(OCH_2CH_2)_3OCH_3$,
$C_3H_7O(CH_2CH_2O)_3—CH_2—(OCH_2CH_2)_3OC_3H_7$, etc.

Mixtures of the useful formals can be utilized, if desired.

Formals can be prepared by methods well known in the art. For example, the formal of the methyl ether of triethylene glycol can be prepared by reacting at reflux temperature paraformaldehyde with the methyl ether of triethylene glycol in the presence of benzene and boron trifluoride ethyl ether catalyst.

Additives

Alkaline inhibitors for pH and corrosion control are generally added in an amount sufficient to maintain alkaline conditions in the fluid compositions, e.g., a pH value of from about 7.0 to about 11.5. Useful alkaline inhibitors include alkali metal borates, such as potassium borate, sodium tetraborate, etc.; alkali metal salts of fatty acids, such as potassium oleate, the potassium soap of rosin or tall oil fatty acids; amines such as morpholine, phenyl morpholine, ethanolamine, triethanolamine, etc.; amine salts, such as mono- or dibutyl ammonium borates, dibutylamine phosphate; and alkylene glycol condensates of alkali metal borates, such as the ethylene glycol condensate of potassium tetraborate. These alkaline inhibitors are generally added in an amount of from about 0.2 to about 2.0 percent by weight based on the total weight of the fluid composition.

The fluid compositions of this invention will also contain one or more antioxidants in a total amount of from about 0.1 to about 1.5 weight percent, based on the total weight of the fluid composition. Typical antioxidants include compounds such as 2,2-di-(4 hydroxyphenyl) propane, phenothiazine, and polymerized trimethyldihydroquinoline and the like, amines such as phenyl-alpha-naphthylamine, phenyl-beta-naphthylamine, dioctyl diphenylamine, etc., hindered phenols such as dibutyl cresol, dibutylated 2,2-di-(4-hydroxyphenyl) propane, N-butylated amino phenol, butylated hydroxyanisole, etc.

Formulation of the novel fluid of this invention is accomplished by blending the components to a homogeneous stage in a mixing vessel. The preferable blending temperature is from 50–125° F. It is preferable to warm the solution during preparation to facilitate dissolution. The blending of the compounds takes place at atmospheric pressure.

In general, any suitable method can be used in preparing the liquid compositions of this invention. The components can be added together or one at a time, in any desired sequence. It is preferable, however, to add the antioxidant and alkaline inhibitor as a solution in the glycol alcohol ether component. All compoenents are mixed until a single phase composition is obtained.

Embodiments of the fluid composition of this invention are shown in the following examples which are to be considered not limitative.

Potassium soap of rosin can be prepared by reacting potassium hydroxide with rosin in the presence of methyl ether of triethylene glycol, etc. Hydrogenated rosin can also be utilized to prepare such potassium soaps. Typical properties of hydrogenated rosin are: acid number, 164; softening point (ASTM E28 51T), 154° F.; refractive index at 100° F., 1.5002; and density at 20° C., 1.045.

Example I

	Percent by weight
Adduct of tripentaerythritol with a mixture of 50 percent by weight of ethylene oxide and 50 percent by weight propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	20.0
Formal of methyl ether of ethylene glycol	16.5
Methyl ether of triethylene glycol	61.5
Condensate of 10.4 moles of ethylene glycol with 1.2 moles potassium tetraborate	1.0
Dioctyl diphenyl amine	0.20
Phenothiazine	0.80
	100.00

Example II

	Percent by weight
Adduct of tripentaerythritol with a mixture of 50 percent by weight of ethylene oxide and 50 percent by weight propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	20.0
Formal of methyl ether of ethylene glycol	16.5
Methyl ether of diethylene glycol	1.8
Methyl ether of triethylene glycol	55.2
Methyl ether of tetraethylene glycol	4.9
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	0.50
Potassium soap of rosin	0.50
Dioctyl diphenyl amine	0.20
Phenothiazine	0.80
	100.00

Example III

	Percent by weight
Adduct of tripentaerythritol with a mixture of 60 percent by weight of ethylene oxide and 40 percent by weight of propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	18.02
Formal of methyl ether of diethylene glycol	31.25
Methyl ether of triethylene glycol	48.93
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	0.45
Potassium soap of rosin	0.45
Dioctyl diphenylamine	0.18
Phenothiazine	0.72
	100.00

Example IV

	Percent by weight
Adduct of tripentaerythritol with a mixture of 50 percent by weight of ethylene oxide and 50 percent of propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	20.0
Formal of methyl ether of ethylene glycol	16.5
Methyl ether of diethylene glycol	15.4
Methyl ether of triethylene glycol	46.1
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	0.5
Potassium soap of rosin	0.5
Dioctyl diphenylamine	0.2
Phenothiazine	0.8
	100.0

The physical properties of the fluid of Example I are shown in Table 1. As these results indicate this fluid composition meets fully the requirement for Society of Automotive Engineers Synthetic Type Central System Fluid (SAE 71–R–2).

TABLE 1

Test	Requirements for SAE 71–R–2 Fluids	Fluid Composition of Example I
Viscosity, Kinematic, 210° F., cs.	4.5 min.	5.7.
Viscosity, Kinematic, —40° F., cs.	1800 max.	1705.
Shear Test, 20 hours Pump Test:		
Viscosity after test, 210° F.	4.5 min.	5.6.
Viscosity after test, —40° F.	1,800.	1,750.
Flash Point, ° F., (C.O.C.)	205 min.	275.
Boiling Point, ° F., (reflux)	400 min.	424.
Cold Test (A) 6 days at —50° F.	Shall flow, no separation.	Clear fluid.
Cold Test (B) 6 hours at —70° F.	Shall flow.	Clear fluid.
Antiwear, 100 hours, Power Steering Pump.		No visible wear.
Corrosion Resistance, 120 hours at 210° F., mg. loss per sq. cm.:		
Tinned Iron	0.2 max.	0.0.
Steel	0.2.	0.0.
Aluminum Alloy	0.1.	0.0.
Cast Iron	0.2.	0.0.
Brass	0.5.	0.0.
Copper	0.5.	0.0.
Fluid appearance	No gel.	Clear fluid.
pH, before corrosion test	7–11.	11.
pH, after corrosion	6–11.	10.
Seal Compatibility (Rubber Swelling):		
Natural rubber cups 1¼"	0.005" to 0.055".	0.021".
SBR rubber cups 1⅛"	0.005" to 0.055".	0.035".
Lubrication	Shall pass SAE 71–R–3 test.	Passed.
Water Tolerance	Shall pass SAE 71–R–3 test.	Do.
Compatibility	Shall pass SAE 71–R–3 test.	Do.

What is claimed is:

1. A fluid composition consisting essentially of (A) from about 18 to about 30 percent by weight, based on the total weight of the fluid composition of a heteric polyoxyalkylene adduct of tripentaerythritol formed by reacting a mixture of about 35 to about 65 weight percent of ethylene oxide and about 65 to about 35 weight percent of propylene oxide, with tripentaerythritol, the said adduct having a viscosity at 100° F. of between 800 and 1400 centistokes and having a pour-point not higher than —15° F.; (B) from about 40 to about 71.5 percent by weight, based on the total weight of the fluid composition, of a glycol alcohol ether of the formula:

$$RO(R'O)_mH$$

wherein R is alkyl of from 1 to 4 carbon atoms, R' is alkylene of from 2 to 3 inclusive, and *m* is an integer of from 2 to 4 inclusive; (C) from about 10 to about 25 percent by weight, based on the total weight of the fluid composition, of a formal of the formula:

$$R''O(CH_2CH_2O)_n—CH_2—(OCH_2CH_2)_mOR''$$

wherein R'' is alkyl of from 1 to 3 carbon atoms and *n* and *m* are each an independently selected integer of from 1 to 3 inclusive; (D) from about 0.1 to about 1.5 weight percent, based on the total weight of the fluid composition, of an antioxidant, selected from the group consisting of 2,2-di-(4-hydroxyphenyl)-propane, phenothiazine, polymerized trimethyldihydroquinoline, phenyl-alpha-naphthylamine, phenyl-beta-naphthylamine, dioctyl diphenylamine, dibutyl cresol, dibutylated 2,2-di-(4-hydrophenyl)-propane, N-butylated amino phenol and butylated hydroxyanisole and (E) from about 0.2 to about 2.0 weight percent based on the total weight of the fluid composition of an alkaline inhibitor selected from the group consisting of an alkali metal borate, an alkali metal salt of a fatty acid, morpholine, phenyl morpholine, ethanolamine, triethanolamine, monobutyl ammonium borate, dibutyl ammonium borate, dibutylamine phosphate and an alkylene glycol condensate of an alkali metal borate.

2. The fluid composition of claim **1** wherein the said antioxidant consists essentially of, in combination, dioctyl diphenyl amine and phenothiazine.

3. The fluid composition of claim **1** wherein the said alkaline inhibitor consists essentially of, in combination, an ethylene glycol borate condensate formed by condensing 10.4 moles of ethylene glycol with 1.2 moles of potassium tetraborate and potassium soap of rosin.

4. The fluid composition consisting essentially of the following ingredients in the approximate percentages indicated:

	Percent by weight
Adduct of tripentaerythritol with a mixture of 50 percent by weight of ethylene oxide and 50 percent by weight propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	20.00
Formal of methyl ether of ethylene glycol	16.50
Methyl ether of triethylene glycol	61.50
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	1.00
Dioctyl diphenyl amine	0.20
Phenothiazine	0.80
	100.00

5. The fluid composition consisting essentially of the following ingredients in the approximate percentages indicated:

	Percent by weight
Adduct of tripentaerythritol with a mixture of 50 percent by weight of ethylene oxide and 50 percent by weight propylene oxide (random addition product). Viscosity at 100° *F.*—1050 cs.	20.0
Formal of methyl ether of ethylene glycol	16.5
Methyl ether of diethylene glycol	1.8
Methyl ether of triethylene glycol	55.2
Methyl ether of tetraethylene glycol	4.9
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	0.50
Potassium soap of rosin	0.50
Dioctyl diphenyl amine	0.20
Phenothiazine	0.80
	100.00

6. The fluid composition consisting essentially of the following ingredients in the approximate percentages indicated:

	Percent by weight
Adduct of tripentaerythritol with a mixture of 60 percent by weight of ethylene oxide and 40 percent by weight of propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	18.02
Formal of methyl ether of diethylene glycol	31.25
Methyl ethyl of triethylene glycol	48.93
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	0.45
Potassium soap of rosin	0.45

	Percent by weight
Dioctyl diphenylamine	0.18
Phenothiazine	0.72
	100.00

7. The fluid composition consisting essentially of the following ingredients in the approximate percentages indicated:

	Percent by weight
Adduct of tripentaerythritol with a mixture of 50 percent by weight of ethylene oxide and 50 percent of propylene oxide (random addition product). Viscosity at 100° F.—1050 cs.	20.0
Formal of methyl ether of ethylene glycol	16.5
Methyl ether of diethylene glycol	15.4
Methyl ether of triethylene glycol	46.1
Condensate of 10.4 moles ethylene glycol with 1.2 moles potassium tetraborate	0.5
Potassium soap of rosin	0.5
Dioctyl diphenylamine	0.2
Phenothiazine	0.8
	100.0

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