

[54] FUNCTIONAL FLUIDS

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[57]

ABSTRACT

Production of functional fluids, including aircraft hydraulic fluids and aircraft engine lubricants of improved fire resistance, comprising a functional fluid base stock consisting essentially of a phosphate ester, e.g., tri-n-butyl phosphate, di-n-butyl phenyl phosphate, or mixtures thereof, and a polyalkylene glycol material, e.g., polypropylene glycol or a polypropylene glycol diether, having a molecular weight ranging from about 500 to about 2,000, and which can optionally include a dicarboxylic acid ester, e.g., a diester of adipic acid such as diisodecyl adipate, and a small amount of an organic iodo compound additive such as iodobiphenyl or iodonaphthalene incorporated in such base stock.

24 Claims, No Drawings

FUNCTIONAL FLUIDS

This invention relates to functional fluid compositions having improved fire resistance and is particularly directed to compositions comprising certain functional fluids and an additive amount sufficient to improve fire resistance, of certain organic iodo compounds.

Many different types of materials are employed as functional fluids and functional fluids are utilized in a wide variety of applications. Thus, such functional fluids have been utilized as electronic coolants, diffusion pump fluids, lubricants, damping fluids, power transmission and hydraulic fluids, heat transfer fluids and heat pump fluids. A particularly important application of such functional fluids has been their utilization as hydraulic fluids and engine lubricants in aircraft, requiring successful operation of such fluids over a wide temperature range, a particularly important and highly desirable property of such fluids being fire resistance.

Functional, e.g., hydraulic fluids, employed in many industrial applications and particularly hydraulic fluids for aircraft must meet a number of important requirements. Thus, such hydraulic fluids particularly for aircraft use, should be operable over a wide temperature range, should have good stability at relatively high temperatures and preferably have lubricating characteristics. In addition to having the usual combination of properties making it a good lubricant or hydraulic fluid, such fluid should also have relatively low viscosity at extremely low temperatures and an adequately high viscosity at relatively high temperatures, and must have adequate stability at the high operating temperatures of use. Further, it is of importance that such fluids be compatible with and not adversely affect or corrode materials including metals and non-metals such as elastomeric seals of the system in which the fluid is employed. It is particularly important in aircraft hydraulic fluids and lubricants that such fluids have as high a fire resistance as possible to prevent ignition if such fluids are accidentally or as result of damage to the hydraulic system, sprayed onto or into contact with surfaces or materials of high temperature.

While many functional and hydraulic fluid compositions have been developed having most of the aforementioned required properties, many of these compositions do not have the requisite high fire resistance and corresponding high autoignition temperature desired particularly for use of such functional fluid or hydraulic fluid compositions in modern high speed aircraft or in a hydraulic system located near a high temperature jet-turbine power plant of a jet-turbine aircraft.

It has now been found in accordance with the present invention that the fire resistance, or autoignition temperature, of functional fluid or hydraulic fluid compositions containing as base stock a mixture of a phosphate ester and a polyalkylene glycol material, e.g., polypropylene glycol or a polypropylene glycol diether, and which may optionally also include a dicarboxylic acid diester, e.g., diisodecyl adipate, can be significantly improved by the addition to such compositions of a small amount of certain organic iodo compounds, e.g., in the form of certain alkyl or aryl iodides, especially aryl iodides, defined in greater detail hereinafter. The inclusion of such iodide additives in the above functional and hydraulic fluid compositions generally does not adversely affect any of the above-noted important characteristics of such fluids, particularly aircraft hydraulic

fluids, including their desirable viscosity characteristics.

It has been found that certain aryl and alkyl iodides, and particularly the aryl iodides of the invention described below, e.g., iodobiphenyl or idonaphthalene, not only function to substantially increase autogenous ignition (autoignition) temperature and reduce flammability of functional fluids and hydraulic fluids containing a combination of phosphate ester and polyalkylene glycol material base stock, as described above, but in addition have the advantageous properties of being thermally stable, free from toxicity, cause substantially no corrosion of metal parts such as aluminum, iron, copper and titanium, do not have an objectionable odor, are only very slightly colored, and have sufficient solubility in the above functional and hydraulic fluids to effectively function therein as flame inhibitors. In addition, the organic iodo compounds hereof, particularly the aryl derivatives, employed according to the invention, have no adverse effect on low temperature viscosity of the functional fluids, particularly when employed as hydraulic fluids in aircraft, do not adversely affect the thermal stability of the fluid, and are of relatively low cost.

Effective organic iodo compounds for use as additive in the phosphate ester-polyalkylene glycol material functional or hydraulic fluids to reduce flammability and increase autoignition temperature of the fluid, according to the invention, are compounds having the formula RI_n , where R is selected from the group consisting of alkyl, aryl, and alkaryl radicals, such alkyl radical containing from about 1 to about 10 carbon atoms, such aryl and alkaryl radicals containing from about 6 to about 15 carbon atoms, and n is an integer of from 1 to 3.

Thus, where R is alkyl, such alkyl radical can be straight chain or branched chain, and can include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, amyl, isoamyl, hexyl, isohexyl, octyl, isooctyl, nonyl, isononyl, decyl and isodecyl. Examples of alkyl iodides which are suitable include methyl iodide, ethyl iodide, isopropyl iodide, n-butyl iodide, n-hexyl iodide, n-nonyl iodide, 1,4-diiodobutane, 1,6-diiodohexane, 1,9-diiodononane, 1,10-diiododecane, 1,4,7-triiodoheptane, 1,6,10-triiododecane and 2,4,6-triiodooctane. Alkyl iodides wherein n is 1 to 2 are preferred.

Aryl iodides which can be employed include iodo compounds of the above formula wherein R can be phenyl, biphenyl, and naphthyl. Examples of such aryl iodides include 4-iodobiphenyl, 2-iodobiphenyl, 4,4'-diiodobiphenyl, 2,4,4'-triiodobiphenyl, iodobenzene, 1,4-diiodobenzene, 1-iodonaphthalene, 2-iodonaphthalene, 1,4-diiodonaphthalene, 1,4,8-triiodonaphthalene, and 1,3,5-triiodonaphthalene. Of the aryl iodides, those wherein n is 1 to 2 are also preferred, the monoiodides thereof being found particularly advantageous.

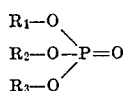
The alkaryl iodides which can be employed include alkyl phenyl, alkyl biphenyl, and alkyl naphthalene compounds. The alkyl portion of such alkaryl compounds can contain from 1 to about 9 carbon atoms, either straight chain or branched chain, e.g., methyl, ethyl, propyl, isopropyl, butyl, amyl or pentyl, hexyl, heptyl, octyl or nonyl. There can be one or more alkyl groups connected to an aryl, e.g., phenyl or biphenyl nucleus. Thus, such alkaryl radicals can include tolyl,

xylyl, ethyl phenyl, propyl phenyl, isopropyl phenyl, methyl naphthyl, ethyl naphthyl, methyl biphenyl, ethyl biphenyl, 4,4'-diethyl biphenyl, and the like. One to three iodo radicals can be connected either to the aryl nucleus or the alkyl substituent on the aryl nucleus, preferably the former. Examples of alkaryl additives which can be employed include 2-iodotoluene, 4-iodotoluene, 4-iodoethylbenzene, 4-iodo ortho xylene, 5-iodo meta xylene, 2-iodo para xylene, mixtures of such iodo xylene compounds which can be produced by iodinating a commercial xylene mixture, 4-iodo isopropyl benzene, benzyl iodide, 1-iodo-4-methyl naphthalene, 1-iodo-4-ethyl naphthalene, 4-iodo-4'-methyl biphenyl, 4-iodo-4'-isopropyl biphenyl, 1,5-diiodo-2,6-dimethyl naphthalene, 1,8-diiodo-4,5-dimethyl naphthalene, and 1,4,5-triiodo-8-methyl naphthalene.

Aryl iodides which have been found particularly effective are 4-iodobiphenyl and 1-iodonaphthalene.

As previously noted, functional fluids whose flammability characteristics are substantially improved by incorporation of the organic iodo compounds according to the invention, are base stocks consisting essentially of a mixture of a phosphate ester and a polyalkylene glycol material. These include combinations of (1) a phosphate ester or mixtures of phosphate esters, and (2) a polyalkylene glycol material or mixtures of the latter glycol materials, and which may, but not necessarily, also include a dicarboxylic acid ester or esters.

Phosphates which can be employed according to the invention have the general formula:



where R_1 , R_2 and R_3 can be the same or different, and each can be aryl such as phenyl and naphthyl, alkaryl such as cresyl, xylyl, ethyl phenyl, propyl phenyl, isopropyl phenyl, and the like, said aryl and alkaryl radicals preferably containing from 6 to about 8 carbon atoms, alkyl, both straight chain and branched chain of from about 3 to about 10 carbon atoms such as n-propyl, n-butyl, n-amyl, n-hexyl, isopropyl, isobutyl, and the like, and alkoxyalkyl having from about 3 to about 8 carbon atoms such as methoxy methyl, methoxy ethyl, ethoxy ethyl, methoxy propyl, and the like.

Preferred phosphate esters are the dialkyl aryl, triaryl, trialkyl and alkyl diaryl phosphates.

Examples of such phosphate esters are the dialkyl aryl phosphates in which the alkyl groups are either straight chain or branched chain and contain from about 3 to about 10 carbon atoms, such as n-propyl, n-butyl, n-amyl, n-hexyl, isopropyl, isobutyl, isoamyl, and the aryl radicals have from 6 to 8 carbon atoms and can be phenyl, cresyl or xylyl, particularly dialkyl phenyl phosphates including dibutyl phenyl phosphate, butyl amyl phenyl phosphate, butyl hexyl phenyl phosphate, butyl heptyl phenyl phosphate, butyl octyl phenyl phosphate, diamyl phenyl phosphate, amyl hexyl phenyl phosphate, amyl heptyl phenyl phosphate, and dihexyl phenyl phosphate.

Examples of triaryl phosphates which can be employed in the invention compositions are those in which the aryl radicals of such phosphates have from 6 to 8 carbon atoms, that is, may be phenyl, cresyl or xylyl, and in which the total number of carbon atoms in all

three of the aryl radicals is from 19 to 24, that is, in which the three radicals include at least one cresyl or xylyl radical. Examples of such phosphates include tricresyl, trixylyl, phenyl dicresyl, and cresyl diphenyl phosphates.

Examples of trialkyl phosphates employed according to the invention include phosphates having alkyl groups which are either straight chain or branched chain with from about 3 to about 10 carbon atoms, such as n-propyl, n-butyl, n-amyl and n-hexyl, particularly tri-n-butyl phosphate, tri(2-ethyl hexyl) phosphate, the straight chain alkyl groups preferably containing from 4 to 6 carbon atoms.

Examples of alkyl diaryl phosphates which can be employed to produce the invention compositions include those in which the aryl radicals of such phosphates may have from 6 to 8 carbon atoms and may be phenyl, cresyl or xylyl, and the alkyl radical may have from about 3 to about 10 carbon atoms, examples of which are given above. Examples of the alkyl diaryl phosphates include butyl diphenyl, amyl diphenyl, hexyl diphenyl, heptyl diphenyl, octyl diphenyl, 6-methyl heptyl diphenyl, 2-ethylhexyl diphenyl, butyl phenyl cresyl, amyl phenyl xylyl, and butyl dicresyl phosphates.

Any phosphate ester can be employed which is normally liquid between about -65°F and 210°F . Preferably, the above-noted trialkyl phosphates and dialkyl aryl phosphates such as tributyl phosphate and dibutyl phenyl phosphate, are employed, as such phosphates are particularly effective in achieving low viscosity at low temperature. However, for improved higher viscosity at high temperature of the order of 210°F , it is desirable to employ triaryl phosphates as illustrated above, e.g., tricresyl phosphate, particularly in combination with the above-noted trialkyl phosphates. The above-noted dialkyl aryl phosphate such as dibutyl phenyl phosphate, preferably is employed in combination with a trialkyl phosphate such as tributyl phosphate.

The second essential component of the functional fluid base stock, the flammability resistance of which is improved according to the invention, is a polyalkylene glycol material. The polyalkylene glycol materials employed are compatible with the above-noted phosphate esters.

Polyalkylene glycol materials which can be employed include polyalkylene glycols, e.g., polypropylene glycol. Another type of preferred polyalkylene glycol material is that in which one or both of the terminal hydroxy groups have been modified to form ether groups, providing mono- or diether derivatives, or combinations thereof. The most desirable polyalkylene glycol ethers for purposes of the invention are the diethers. A particularly satisfactory material of the latter type has been found to be the butyl, methyl diether of polypropylene glycol.

The polyalkylene glycol materials employed in the invention composition preferably are substantially hydrophobic materials. It is preferred not to employ those polyalkylene glycol materials that are to any significant extent water miscible and which would accordingly tend to dissolve water at one temperature and crystallize water out at lower temperatures. Also, in order to maintain as low a viscosity of the functional fluid as possible at low temperatures, the glycols employed should be of low to medium molecular weight, and accordingly should have a molecular weight ranging from

about 500 to about 2,000, usually from about 600 to about 1,200. Also, it is desirable that the polyalkylene glycol component employed be of a type which tends to supercool and to maintain a low viscosity at temperatures down to about -65°F .

The ether end groups which preferably are present on the polyalkylene glycol ether materials are preferably oxyalkyl groups, the alkyl radicals of which can range from 1 to about 8 carbon atoms in length. The longer chain alkyl groups having in excess of 4 carbon atoms, e.g., pentyl, hexyl, heptyl and octyl, are not preferred because polyalkylene glycol ethers of this type have increased viscosity. It is preferred to employ one or more end alkyl groups in the polyalkylene glycol mono- or diether, which have from 1 to 4 carbon atoms. Thus, preferred end alkyl groups are, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, and the like. It is often desirable that one of the end alkyl groups be a methyl or an ethyl radical, while the other end alkyl group of the diether be, for example, a propyl or butyl radical.

The alkylene groups of the polyalkylene glycol material can be an ethylene or propylene group, or mixtures thereof, that is, copolymers containing ethylene and propylene groups. The propylene polymers are preferred over the ethylene polymers, because of the increased water solubility of the ethylene polymers.

Particularly satisfactory polyalkylene glycol materials for purposes of the invention are polypropylene glycol, and the n-butyl methyl, n-butyl ethyl, isobutyl ethyl, n-propyl ethyl and isopropyl ethyl diethers of polypropylene glycol.

The preferred polyalkylene glycol materials employed in the invention composition can be produced in known manner from the 1,2-alkylene glycols. Thus, for example, polypropylene glycol materials are prepared by reacting 1,2-propylene oxide and the corresponding alkylene glycol to form poly-1,2-propylene glycol derivatives, and one or both terminal hydroxy groups can be removed to provide the above-noted ether groups, either during or after polymerization. The term "polypropylene glycol" employed in the specification and claims is intended to denote and include the above-noted poly-1,2-propylene glycol derivatives.

It will be understood that mixtures of the above polyalkylene glycol materials, e.g., mixtures of polypropylene glycol diethers can be used.

Although employed as an optional component, in many instances it is preferred to incorporate into the functional fluid base stock whose autoignition temperature is improved according to the invention, a dicarboxylic acid ester. Preferred types of the latter compounds are the aliphatic dicarboxylic acid esters, particularly the alkyl diesters of adipic and sebacic acid, that is the diester adipates and sebacates. Such esters can contain alkyl groups, either straight chain or branched chain, containing from about 4 to about 12 carbon atoms including butyl, isobutyl, amyl, pentyl, hexyl, isohexyl, nonyl, decyl and isodecyl groups. Specific examples of these diesters are dihexyl, di 2-ethylhexyl, dioctyl, dinonyl, didecyl and diisodecyl adipate, and the corresponding sebacates. Also, the diesters of the aromatic dicarboxylic acids, particularly the diesters of phthalic acid, that is the phthalate diesters, can be employed as base stocks. The diesters of such aromatic acids can contain alkyl groups of from 4 to 12 carbon atoms, examples of which are given above with

respect to the diesters of the aliphatic dicarboxylic acids, adipic and sebacic acid. Illustrative examples of the diester phthalates which can be employed are di-n-butyl phthalate, dihexyl phthalate, dioctyl phthalate, dinonyl phthalate, didecyl phthalate, and diisodecyl phthalate.

The above optional dicarboxylic acid ester component is often employed as an aid in lowering the viscosity of the functional fluid at low temperatures. Accordingly, for these purposes, the aliphatic acid diesters are preferred, since the aromatic acid diesters are more viscous and have higher viscosities at low temperatures than the aliphatic acid diesters. Of the above-described diesters of adipic and sebacic acid, diisodecyl adipate and diisodecyl sebacate have been found particularly effective, especially diisodecyl adipate.

As will be pointed out more fully below, the above dicarboxylic acid ester component, when employed, is generally utilized in minor proportion in the functional fluid compositions treated according to the present invention. The combination of the dicarboxylic acid ester component and the polyalkylene glycol component provides improved lower viscosity characteristics at low temperature as compared to employment of the polyalkylene glycol component per se.

The phosphate ester component and glycol material are present in amounts such that the functional fluid composition has a viscosity at -65°F of not greater than 13,000 cs, preferably not greater than about 4,200 cs, and a viscosity at 210°F of not less than 2.25 cs, preferably not less than about 3.0 cs. Generally, the phosphate ester is employed in an amount ranging from about 15 to about 90%, preferably about 15 to about 70%, by weight of the functional fluid composition. The amount of polyalkylene glycol material, e.g., polypropylene glycol or polypropylene glycol diether, which can be employed can range from about 10 to about 85%, preferably about 30 to about 85%, by weight of the functional fluid composition. Compositions containing approximately equal weight proportions of the phosphate ester and polyalkylene glycol material, for example, have been found quite effective. When the optional dicarboxylic acid ester component, e.g., diisodecyl adipate, is incorporated into the fluid composition or base stock, an amount of diester component can be employed which is as low as 0.01% and up to about 200% by weight of the polyalkylene glycol material. Usually, such diester component is employed in an amount ranging from about 10 to about 50% by weight of the glycol material. In any event, whether or not the optional dicarboxylic acid ester component is employed, the minimum above-noted proportions of at least 15% phosphate ester and at least 10% of the polyalkylene glycol material, are present in the functional fluid, and when a dicarboxylic acid ester is employed, since the amount of phosphate ester present is at least 15%, the maximum amount of the combination of glycol material and dicarboxylic acid ester which can be present is 85% by weight of the composition.

The above described functional fluids can be blended to have suitably low viscosity at temperatures below -40°F , and down to -65°F , and suitably high viscosity at high temperature of 210°F , and above, and this can be accomplished without incorporating any polymeric viscosity index improver, such as polyalkyl acrylates or methacrylates. By avoiding the necessity for a viscosity index improver, the above described functional fluids

do not suffer from the disadvantage of deterioration of such polymeric additives used for viscosity improvement, and accumulation of molecular debris, leading to a shortening of the useful life of the fluid.

Also, the functional fluid compositions described above have good thermal and hydrolytic stability and have low densities of the order of 1.0 or less, an important property for aircraft hydraulic fluids.

The above functional fluid compositions are described and claimed in my copending application Ser. No. 230,131, filed Feb. 28, 1972.

It will be understood that other commonly employed functional fluid additives such as oxidation inhibitors, stabilizers, metal deactivators, and the like, such as epoxides, dialkyl sulfides, benzothiozole, phenyl alpha naphthylamine and phenolic oxidation inhibitors, can be incorporated into the base stock.

For greatest effectiveness in substantially reducing the flammability, and for correspondingly substantially increasing the autoignition temperature of the above functional fluid base stocks according to the invention, it is usually desirable to employ only a small amount of the invention additive, that is, alkyl or aryl, including alkaryl, iodide, as defined above, in the functional or hydraulic fluid base stock. Generally, there can be employed as little as 0.1% and up to about 5% of the alkyl iodide or aryl iodide additive of the invention, preferably from about 0.5 to about 2.5% of such iodide additive, in the functional fluid base stock, based on the weight of the composition.

The following are examples illustrating practice of the invention by incorporation of the alkyl and aryl iodides described herein as additives according to the invention, into functional fluid base stocks of the types described above. In the examples below, the term "AIT" means autoignition temperature, the autoignition temperature of the functional fluid compositions of the invention according to the examples below being determined in accordance with standard methods of test for autoignition temperature according to ASTM D 2155 procedure. All percentages are in terms of percent by weight of the functional fluid composition.

EXAMPLE 1

The following composition is prepared.

Fluid A

	Weight %
tri-n-butyl phosphate	41.0
polypropylene glycol (molecular weight about 500-600) marketed as "Ucon LB-285" by Union Carbide Chemical Company	22.2
diisodecyl adipate	32.9
4-iodobiphenyl	2.0
diepoxide oxidation inhibitor (Unox 221)	1.4
water	0.5
	100.0

The autoignition temperatures of Fluid A and of a control of Fluid A in the absence of any iodo compound are obtained, the AIT of Fluid A containing the 2.0% of 4-iodobiphenyl being 680°F, and substantially greater than the AIT of less than 500°F for the control.

Results of closed oxidation-corrosion tests at 250°F for 168 hours are set forth in Tables I and II below, the metals of Table I all being inserted in the same fluid

noted above and designated Fluid A, in one test, and the metals of Table II all being inserted in another portion of Fluid A in another test, the acid number of the Fluid A in each of the tests being determined after the 168 hour test period.

TABLE I

	Weight Change (mg/cm ²)					Acid Number
	Copper	Iron	Magnesium	Aluminum	Cadmium Plate	
Fluid A	0	0	+1.57	0	-0.08	0.48

TABLE II

	Weight Change (mg/cm ²)					Acid Number
	Bronze	Iron	Titanium	Aluminum	Cadmium Plate	
Fluid A	0	0	0	0	-0.12	0.93

From Tables I and II above, it is seen that Fluid A shows practically complete freedom from corrosive attack on the metals of such tables, except for magnesium, although the relatively small corrosive value in Table I for magnesium is well within aircraft specification standards, and a low acid number for Fluid A is obtained in both tests reported in Tables I and II.

EXAMPLE 2

The procedure of Example 1 is repeated, except employing in place of 2% of 4-iodobiphenyl in Fluid A, 2% of 1-iodonaphthalene.

An increase in AIT of the resulting fluid from an AIT of less than 500°F for the control, to about 680°F for the fluid containing the above concentration of 1-iodonaphthalene is achieved.

Also, substantially similar results are obtained with respect to substantial freedom from corrosive attack on the metals of Tables I and II, by the fluid containing the 1-iodonaphthalene, comparable to the results obtained in Example 1.

EXAMPLE 3

The following composition is prepared.

Fluid B

	Weight %
tri-n-butyl phosphate	37.0
n-butyl-methyl diether of polypropylene glycol (m.w. about 800) marketed as "Ucon DLB-140E" by Union Carbide Chemical Company	43.0
diisodecyl adipate	16.0
4-iodobiphenyl	1.8
diepoxide oxidation inhibitor (Unox 221)	1.7
water	0.5
	100.0

The procedure of Example 1 is repeated and the AIT of Fluid B above and of a control of such fluid in the absence of the 4-iodobiphenyl are obtained. The AIT of Fluid B is about 680°F, which is substantially higher than the AIT of less than 500°F for the control.

Corrosion tests of Fluid B on the metals of the tests of Example 1 are carried out employing Fluid B, and

substantially similar results are obtained as in Example 1 employing Fluid A, with respect to substantial freedom from corrosive attack of Fluid B on the metals of Tables I and II above, at the same time obtaining low acid numbers for Fluid B following the corrosion tests.

EXAMPLE 4

The procedure of Example 1 is repeated, except employing in place of 2% of 4-iodobiphenyl in Fluid A, 2% of 1,10-diiododecane.

An increase in AIT of the resulting fluid from an AIT of less than 500°F for the control, to about 680°F for the fluid containing the diiododecane is achieved.

Also, results comparable to those of Example 1 are obtained with respect to substantial freedom from corrosive attack on the metals of Tables I and II, employing the fluid of the present example containing the diiododecane additive.

EXAMPLE 5

The following functional fluid compositions C, D, and E are prepared, and their respective autoignition temperatures obtained.

Composition C	
	% by weight
tri-n-butyl phosphate	60.0
polypropylene glycol (m.w. about 700)	37.5
2-iodobiphenyl	2.5
Composition D	
tri-n-hexyl phosphate	50.0
dimethyl ether of polypropylene glycol (m.w. about 1,000)	48.0
iodobenzene	2.0
Composition E	
tri-(2-ethyl hexyl) phosphate	70.0
n-butyl-methyl diether of polypropylene glycol (m.w. about 700)	27.0
4-iodo-4'-isopropyl biphenyl	3.0

In each case the incorporation of the respective iodo compounds into the functional fluid base stock of functional fluid compositions C, D and E above, substantially increases autoignition temperature to between about 650° and about 800°F, as compared to the AIT of less than 500°F for each of the respective functional fluid base stocks of compositions C through E, in the absence of the iodo compound, the AIT of the resulting fluid generally increasing in relation to the increase in concentration from 2 to 3% of the iodo compounds of compositions C to E.

EXAMPLE 6

The procedure of Example 1 is repeated, except employing in place of 2% of 4-iodobiphenyl in Fluid A, 2% of n-hexyl iodide.

An increase in AIT of the resulting fluid from an AIT of less than 500°F for the control, to about 680°F for the fluid containing the n-hexyl iodide is achieved.

Also, results comparable to those of Example 1 are obtained with respect to substantial freedom from corrosive attack on the metals of Tables I and II, employing the fluid of the present example containing the n-hexyl iodide.

EXAMPLE 7

Functional fluid compositions F, G and H, set forth below, are prepared, and the autoignition temperatures of such compositions in relation to their controls in the absence of the respective iodo compounds, are obtained.

Composition F	
	% by weight
tri-n-butyl phosphate	60.0
n-butyl-methyl diether polypropylene glycol (m.w. about 1,100)	39.0
para diiodobenzene	1.0
Composition G	
di-(2-ethyl hexyl) phenyl phosphate	35.0
Ucon DLB-140E	27.0
iodinated commercial xylene mixture (mixture of 4-iodo ortho xylene, 5-iodo meta xylene and 2-iodo para xylene)	3.0
Composition H	
diphenyl-(2-ethyl hexyl) phosphate	25.0
Ucon DLB-140E	34.5
dioctyl adipate	40.0
diiodobenzene	0.5

For each of the compositions F, G and H above, the autoignition temperature is substantially increased to the range of between 650° and 800°F in the presence of iodo compounds, as compared to corresponding autoignition temperatures of less than 500°F for the respective compositions F, G and H, in the absence of the respective iodo compounds, the AIT of the compositions F, G and H generally varying in relation to the concentration of iodo compound therein, the AIT of composition G containing the relatively high concentration of 3% being substantially greater than for composition H containing only 0.5% of the iodo compound thereof.

EXAMPLE 8

Functional fluid compositions J, K and L, set forth below, are prepared, and the autoignition temperatures of such compositions in relation to their controls, in the absence of the respective iodo compounds, are obtained.

Composition J	
	% by weight
tri-n-hexyl phosphate	60.0
n-butyl-methyl diether polypropylene glycol (m.w. about 1,000) marketed as Ucon DLB-200E by Union Carbide Chemical Company	38.5
hexyl iodide	1.5
Composition K	
tri-n-butyl phosphate	73.0
Ucon LB-285	25.5
nonyl iodide	1.5
Composition L	
tri-n-butyl phosphate	40.0
Ucon DLB-200E	59.5
methyl iodide	0.5

The autoignition temperature obtained for each of compositions J through L above is substantially increased and in the range of about 650° to about 800°F, as compared to autoignition temperatures of less than 500°F, for the respective compositions in the absence of the respective iodo compounds therein. The autoignition temperatures of the compositions K through L generally increase with increase in concentration of iodo compound from the 0.5% of iodo compound employed in composition L, to the 1.5% concentration of compositions J and K.

The following example illustrates still other functional fluid compositions containing an iodo compound additive according to the invention.

EXAMPLE 9

Composition M	
	% by weight
tri-n-butyl phosphate	39.1
Ucon DLB-200E	28.0
Ucon DLB-62E	6.6
diisodecyl adipate	23.0
1-iodonaphthalene	1.3
diepoxide oxidation inhibitor (Unox 221)	1.5
water	0.5
	100.0
Composition N	
tri-n-butyl phosphate	40.0
di-n-butyl phenyl phosphate	6.0
Ucon DLB-200E	30.0
diisodecyl sebacate	20.0
hexyl iodide	2.0
diepoxide oxidation inhibitor	2.0
	100.0
Composition O	
tri-n-butyl phosphate	40.0
tri cresyl phosphate	15.0
n-butyl ethyl diether of polypropylene glycol (m.w. — 800)	43.5
1,9-diiodononane	1.5
	100.0
Composition P	
tri cresyl phosphate	35.0
Ucon DLB-62E	45.0
dihexyl adipate	17.5
4-iodo-4'-methyl biphenyl	2.5
	100.0

From the foregoing, it is seen that the invention provides novel functional fluid compositions containing certain organic iodo compounds, more particularly certain alkyl or aryl iodides, which function efficiently as flame retardants or flame inhibitors in functional fluids containing as base stock a mixture of a phosphate ester and a polyalkylene glycol material, and which may also include a dicarboxylic acid ester, while at the same time rendering such fluids essentially non-corrosive to certain metal, particularly iron, aluminum, copper and titanium, widely employed as hydraulic fluid system components and engine components requiring lubrication, in jet-turbine power plants of jet aircraft.

While many of the above-described functional fluids are particularly effective for use as hydraulic fluids in jet aircraft, particularly because of their desirable viscosity characteristics, including relatively low viscosity at low temperature and relatively high viscosity at ele-

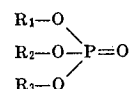
vated temperature, many of the above described functional fluids are of particular utility as industrial functional fluids, for example as engine lubricants.

Applicant is aware of U.S. Pat. No. 3,287,275 which discloses the addition of 2-iodobiphenyl to an organic phosphinate, for reducing corrosion of such phosphinate on iron. However, there is no suggestion or teaching in this patent that the incorporation of a small amount of an organic iodo compound into a composition having as base stock a phosphate ester and a polyalkylene glycol material, e.g., polypropylene glycol or polypropylene glycol diether, or mixtures thereof, with or without a dicarboxylic acid ester, materially reduces the flammability of such base stock and correspondingly increases autoignition temperature thereof, while at the same time functioning to reduce corrosion of such fluids on a variety of metals including the above-noted copper, aluminum, titanium, bronze and cadmium plate.

While I have described particular embodiments of my invention for purposes of illustration, it will be understood that various changes and modifications within the spirit of the invention can be made, and the invention is not to be taken as limited except by the scope of the appended claims.

I claim:

1. A functional fluid composition consisting essentially of a base stock, said base stock consisting essentially of (1) a phosphate ester having the general formula:



where R_1 , R_2 and R_3 are each a member selected from the group consisting of aryl, alkaryl, alkyl of from about 3 to about 10 carbon atoms, and alkoxyalkyl having from about 3 to about 8 carbon atoms, and (2) a polyalkylene glycol material having terminal groups selected from the class consisting of free hydroxyl and ether groups, said ether groups being oxyalkyl groups wherein the alkyl radicals contain from 1 to about 8 carbon atoms, said alkylene groups being selected from the class consisting of ethylene and propylene radicals, and mixtures thereof, said polyalkylene glycol material having a molecular weight ranging from about 500 to about 2,000, said phosphate ester being present in an amount ranging from about 15 to about 90%, and said glycol material being present in an amount ranging from about 10 to about 85%, by weight of said composition; and a small amount of organic iodo compound sufficient to enhance the autoignition temperature of said base stock, said iodo compound being selected from the group consisting of aryl and alkaryl mono, di and triiodides, said aryl and alkaryl radicals containing from about 6 to about 15 carbon atoms.

2. A functional fluid composition as defined in claim 1, wherein said iodo compound is present in an amount ranging from about 0.1 to about 5%, by weight of said composition.

3. A functional fluid composition as defined in claim 1, wherein said iodo compound is present in an amount ranging from about 0.5 to about 2.5%, by weight of said composition.

4. A functional fluid composition as defined in claim 1, wherein said iodo compound is an aryl iodide.

5. A functional fluid composition as defined in claim 2, wherein said iodo compound is selected from the group consisting of phenyl, biphenyl and naphthyl iodides.

6. A functional fluid composition as defined in claim 5, wherein said iodo compound is a monoiodide.

7. A functional fluid composition as defined in claim 2, wherein said iodo compound is selected from the group consisting of monoiodo biphenyl, monoiodo xylene and monoiodo naphthalene.

8. A functional fluid composition as defined in claim 1, wherein said phosphate ester is selected from the group consisting of dialkyl aryl, triaryl, trialkyl, and alkyl diaryl phosphate.

9. A functional fluid composition as defined in claim 1, said glycol material being a polypropylene glycol diether having a pair of said ether groups.

10. A functional fluid composition as defined in claim 1, said glycol material being selected from the group consisting of a polypropylene glycol diether having a pair of terminal oxyalkyl groups wherein the alkyl radicals contain from 1 to about 4 carbon atoms, and polypropylene glycol.

11. A functional fluid composition as defined in claim 2, wherein said phosphate ester is selected from the group consisting of dialkyl aryl, triaryl, trialkyl and alkyl diaryl phosphates, said glycol material being selected from the group consisting of a polypropylene glycol diether having a pair of terminal oxyalkyl groups wherein the alkyl radicals contain from 1 to about 4 carbon atoms, and polypropylene glycol, said polypropylene glycol material having a molecular weight ranging from about 600 to about 1,200.

12. A functional fluid composition as defined in claim 11, said phosphate ester being present in an amount ranging from about 15 to about 70%, and said glycol material being present in an amount ranging from about 30 to about 85%, by weight of said composition.

13. A functional fluid composition as defined in claim 11, wherein said iodo compound is selected from the group consisting of phenyl, biphenyl and naphthyl iodides.

14. A functional fluid composition as defined in claim 11, wherein said iodo compound is selected from the group consisting of monoiodo biphenyl, monoiodo xylene and monoiodo naphthalene.

15. A functional fluid composition as defined in claim 14, wherein said glycol material is selected from the group consisting of an n-butyl methyl diether of polypropylene glycol having a molecular weight ranging from about 600 to about 1,200, and polypropylene glycol, and said phosphate ester is selected from the group consisting of tributyl phosphate, dibutyl phenyl phosphate and tri-n-hexyl phosphate.

16. A functional fluid composition as defined in claim 1, additionally including an amount sufficient to

lower the viscosity of said fluid of a dicarboxylic acid ester selected from the group consisting of the alkyl diesters of adipic and sebacic acid, containing alkyl groups of from about 4 to about 12 carbon atoms, and an alkyl diester of phthalic acid containing alkyl groups of from about 4 to about 12 carbon atoms.

17. A functional fluid composition as defined in claim 16, said dicarboxylic acid ester being present in an amount ranging from about 0.01 to about 200% by weight of said glycol material, the total amount of said glycol material and said dicarboxylic acid ester being not greater than 85% by weight of said composition.

18. A functional fluid composition as defined in claim 11, additionally including a minor proportion of a dicarboxylic acid ester selected from the group consisting of the alkyl diesters of adipic and sebacic acid, containing alkyl groups of from about 4 to about 12 carbon atoms, and an alkyl diester of phthalic acid containing alkyl groups of from about 4 to about 12 carbon atoms, said dicarboxylic acid ester being present in an amount ranging from 0.01 to about 200% by weight of said glycol material, the total amount of said glycol material and said dicarboxylic acid ester being not greater than 85% by weight of said composition.

19. A functional fluid composition as defined in claim 17, said dicarboxylic acid ester being an aliphatic dicarboxylic acid diester selected from the group consisting of the alkyl diesters of adipic and sebacic acid, containing alkyl groups of from about 4 to about 12 carbon atoms.

20. A functional fluid composition as defined in claim 18, wherein said iodo compound is selected from the group consisting of phenyl, biphenyl and naphthyl iodides.

21. A functional fluid composition as defined in claim 18, wherein said iodo compound is selected from the group consisting of monoiodo biphenyl, monoiodo xylene and monoiodo naphthalene.

22. A functional fluid composition as defined in claim 15, additionally including about 0.01 to about 200% by weight of said glycol material, of an alkyl diester of adipic acid containing alkyl groups of from about 4 to about 12 carbon atoms, the total amount of said glycol material and said dicarboxylic acid ester being not greater than 85% by weight of said composition.

23. A functional fluid composition as defined in claim 22, wherein said phosphate ester is tributyl phosphate, said glycol material is polypropylene glycol having a molecular weight of about 500, said alkyl diester is diisodecyl adipate, and said iodo compound is selected from the group consisting of 4-iodobiphenyl, iodo xylene and 1-iodonaphthalene, and said iodo compound is present in an amount ranging from about 0.5 to about 2.5%, by weight of said composition.

24. A functional fluid composition as defined in claim 19, consisting essentially of tri-n-butyl phosphate, octyl diphenyl phosphate, dioctyl adipate, a polypropylene glycol and iodo xylene.

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