This invention relates to fluorene-containing organophosphorus compounds and more particularly provides new and valuable (perfluoroalkyl)phenyl esters of certain phosphinates and the method of preparing the same. The invention also provides improved functional fluids comprising the new compounds, and hydraulic pressure devices and methods of actuating the devices by employing said fluids.

The operation of hydraulic mechanisms generally requires a combination of properties which most liquids do not possess. This is particularly true when the hydraulic system is designed for use in widely differing environments. The hydraulic fluid must often remain liquid over wide temperature ranges, e.g., at temperatures which may be below, say, −40°F and above, say, 400°F. In many applications, fire-resistance of the fluid is of great concern; and, of course, the fluid should not ignite spontaneously at the operating temperature. In numerous applications, it is important that the hydraulic fluid resist attack by water and/or oxygen and that it be non-corrosive to the mechanical components with which it may come into contact.

The many rigorous requirements have resulted in the provision of numerous specialty compositions whereby, much as in the lubricant and motor fuel arts, additives of various kinds have been admixed with the base fluid for the purpose of imparting to it one or more of the properties in which the base stock is deficient. However, properties such as thermal stability and resistance to hydrolysis generally cannot be conferred upon a fluid by the use of an additive; and although fire-retardant additives for fluids are known, often such additives are of little value.

Now we have found that the hereinafter defined fluorene-containing esters of phosphonic acids are very useful as operative fluids for hydraulic systems in that they simultaneously possess high thermal stability, are fire-retardant, and resist hydrolysis. The present invention thus provides a hydraulic pressure device and method wherein a displacing force is transmitted to a displaceable member by means of a hydraulic fluid which comprises essentially a compound of the formula

\[
\begin{align*}
\text{R} & \text{O} \rightarrow \text{P} \rightarrow \text{CF}_{3} \rightarrow \text{Y} \\
\text{R} & \text{O} \rightarrow \text{P} \rightarrow \text{CF}_{3} \rightarrow \text{X}
\end{align*}
\]

wherein R and R' are hydrocarbyl radicals free of olefinic and acetylenic unsaturation and containing from 1 to 12 carbon atoms; Y is a perfluoroalkyl radical of from 1 to 8 carbon atoms, and n is a number of from 1 to 2.

Compounds of the above formula are readily prepared by the reaction of an appropriate perfluoroalkyl-substituted phenol with an appropriate dihydroxyalkylphosphinic halide. For example, with a (trifluoromethyl) phosphon, reaction takes place substantially according to the scheme

\[
\begin{align*}
\text{CF}_{3} \text{O} \rightarrow \text{P} \rightarrow \text{HO} + \text{HX} \\
\text{CF}_{3} \text{O} \rightarrow \text{P} \rightarrow \text{R} \rightarrow \text{HX}
\end{align*}
\]

The presently useful dihydroxyalkylphosphinic halides include the simple or mixed dialkyl- or diaryl- or dicycloalkyl- or bis(arylalkyl) phosphinic chlorides, bromides or iodides or compounds in which there are present two diverse hydrocarbon radicals attached to phosphorus, i.e., the alkylalkylphosphinic or the alkylcycloalkylphosphinic or the alkylarylphosphinic chlorides, bromides or iodides. The phenol reactant may have one or two perfluoroalkyl radicals present at the benzene ring, e.g., the trifluoromethyl-, the perfluoroethyl-, the perfluoropropyl-, the perfluorobutyl-, the perfluoropentyl-, the perfluorohexyl-, the perfluoroheptyl, or the perfluorooctyl radical. When two such radicals are present, they may be the same or different.

Examples of dihydroxyalkylphosphinates provided by this invention are o-, m-, or p-(trifluoromethyl)phenyl dimethylphosphinate which is obtained from o-, m-, or p-(trifluoromethyl) phenol and dimethylphosphinic chloride or iodide; the o-, m-, or p-(perfluoroethyl) phenol dibutylyphosphinate which is prepared from o-, m-, or p-(perfluoroethyl) phenol and dibutylphosphinic bromide or chloride; the o-, m-, or p-(trifluoromethyl) phenol dipropylphosphinate which is formed from the appropriate (trifluoromethyl) phenol and dipropylphosphinic chloride or iodide; the o-, m-, or p-(trifluoromethyl) phenyl dicyclohexylphosphinate which is obtained from the appropriate (trifluoromethyl) phenol and dicyclohexylphosphinic bromide or chloride; the o-, m-, or p-(perfluoropropyl) phenyl bis(2-ethylhexyl) phosphinate which is prepared from o-, m-, or p-(perfluoropropyl) phenol and bis(2-ethylhexyl) phosphinic chloride or iodide; the o-, m-, or p-(perfluorobutyl) phenyl butylethylphosphinate which is obtained from o-, m-, or p-(perfluorobutyl) phenol and butylethylphosphinic chloride or bromide; the o-, m-, or p-(trifluoromethyl) phenyl decyethylphosphinate which is prepared from o-, m-, or p-(trifluoromethyl) phenol and decyethylphosphinic chloride or bromide; the 2-(perfluorobutyl)-6-(trifluoromethyl) phenyl dipentylphosphinate which is prepared from 2-(perfluorobutyl)-6-(trifluoromethyl) phenol and dipentylphosphinic chloride or bromide; the 3,4-bis(perfluoropenty1) phenyl butycyclopropylphosphinate which is prepared from 3, 4-bis(perfluoropentyl) phenol and butycyclopropylphosphinic chloride or iodide, etc.

Examples of aromatic or of aromatic/aliphatic phosphinates of this invention include the o-, m-, or p-(trifluoromethyl) phenyl ester of diphenylphosphinic acid, of dibenzylphosphinic acid, of di-isopropylphenylphosphonic acid, of bis(phenylpropyl) phosphonic acid, of bis(3-phenylpropyl) phosphonic acid, of bis(4-phenylbutyl) phosphonic acid, of bis(1-methyl-3-phenylpropyl) phosphonic acid, of bis(o-, m-, or p-toly1)phosphonic acid, of bis(o-, m-, or p-(2-hexyl)phenylphosphonic acid, etc. The invention also provides the o-, m-, or p-(perfluoroalkyl) aryl dihydroxyalkylphosphinates such as the o-, m-, or p-(perfluoroethyl) phenyl or o-, m-, or p-(perfluorooctyl) phenyl ester of diphenyl- or bis(toly1) phosphonic acid or of bis[3-(o-, m-, or p-ethylphenyl) propyl] phosphonic acid, or of bis[4-(1-tetramethylbutyl)phenyl] phosphonic acid, etc. The radicals attached to the phosphorus atom may be the same or different, e.g., there may be present one alkyl radical and one aralkyl or (alkylaryl)alkyl radical attached to the phosphorus atom, as in the benzyl-2-phenylphosphinates or the methyl-2-(1-methyl) ethylphosphinates.

Other examples include such phosphinates as the o-, m-, or p-(trifluoromethyl) phenol cyclohexylphosphinylphosphinate obtained from o-, m-, or p-trifluoromethylphenol and cyclohexylphosphinic bromide; the 3,5-bis(tri-
fluoromethyl)phenyl dibenzylphosphinite which is obtained from 3,5-bis(trifluoromethyl)phenol and dibenzylphosphinic chloride; and the 3,4-bis(perfluoroalkyl)phenyl dibenzylphosphinite which is obtained from 3,4-bis(perfluoroalkyl)phenol and ethyl-3-[(4-pentylenphenyl)propyl]phosphinic bromide. Reaction of the phosphinic halide with the (perfluoroalkyl)substituted phenol takes place by simply contacting the halide with the phenol at ambient temperature or with heat. In some instances, the reaction rate is accelerated by heating; and, particularly when working with the higher molecular weight halides, temperatures of from, say, 50°C to below the decomposition temperature of either the reactants or the ester product are employed. The reaction may be slightly exothermic; so that for smooth reaction, extraneous cooling may be desirable. Generally, depending upon the nature of the individual reactants, temperatures of from, say, 0°C to 150°C, and preferably of from, about 15°C to 125°C, are useful.

The reaction may or may not be conducted in the presence of an inert, organic liquid diluent or solvent, e.g., a halogenated alkane such as chloroform, carbon tetrachloride or ethylene chloride; an ether such as ethyl ether, dioxide or diethylene glycol dimethyl ether; an amide such as dimethylformamide or dimethylacetamide, etc. This solvent may or may not be used in the presence of a basic agent is recommended, since the latter serves as scavenger for the by-product hydrogen halide. The basic agent may be inorganic or organic, e.g., it may be tertiary alkylamine such as triethylamine or tributylamine; a heterocyclic nitrogen base such as N-methylmorpholine or pyridine; an alkali or alkaline earth metal oxide or the basic salt thereof such as sodium, potassium, lithium, calcium or magnesium oxide, carbonate or acetate, etc.

All of the reaction conditions, i.e., whether or not a diluent and/or a basic agent is employed and the nature of the diluent or of said agent if it is used, temperature, pressure, reaction time, reactant proportions, etc., can be readily arrived at by easy experimentation. Thus, arrival at optimum reaction conditions is simply a matter of routine procedure by one skilled in the art. Reaction is generally rapid and is usually evidenced by evolution of hydrogen halide if no scavenger is used. When an organic amine is employed as scavenger, reaction is frequently evidenced by copious precipitation of the amine hydrohalide. To assure complete reaction in experimental runs, it is generally recommended that after initial reaction has appeared to subside, the reaction mixture be allowed to stand at ambient temperature until the time of working up the product or that the temperature of the reaction mixture be increased after sufficient time has elapsed for any exothermic reaction to have occurred.

As has already been pointed out, formation of the presently provided tris(perfluoroalkyl)-substituted phenyl dihydrocarbylphosphinites takes place by condensation of one mole of the dihydrocarbylphosphinic halide with one mole of the (tris(perfluoroalkyl)phenol or bis(tris(perfluoroalkyl)phenol. Hence the reactants are advantageously employed in such stoichiometric proportions. However, an excess of the phenol may be employed, and such excess is removed when it is desired to assure complete reaction of a comparatively more difficultly available dihydrocarbylphosphinic halide reactant. Any excess reactant is readily recovered from the final reaction mixture, e.g., by distillation. When a basic scavenger is used, the phosphinite product can be obtained by simply isolating from the reaction mixture by first removing the hydrohalide by-product, e.g., through water-washing, and then fractionally distilling the residual organic phase in order to remove any unreacted reactant, organic base, diluent, etc., that may be present. When operating in the absence of a base, it is advantageous, in order to obtain optimum yields, to provide for mechanical removal of the by-product hydrogen halide, e.g., by rigorous agitation of the reaction mixture, dephlegmation, etc.

The presently provided perfluoroalky-substituted phenyl dihydrocarbylphosphinic acids, the invention provides improved hydraulic systems wherein said compounds are employed as the operative fluids. Such systems comprise a displaceable member and a displacing force which is transmitted to said member by means of said fluid, as shown in the schematic diagram of FIGURE 1 of the drawings. Here, a displacing force is applied to piston 1 and transmitted through the fluid 2 contained in cylinder 3 whence it travels through line 4 into cylinder 5 where it acts on the displaceable member 6. In such a system, actuation of a movable member by the presently provided fluid gives performance characteristics which are outstanding because of the physical properties of the fluid. While the reaction mixture will contain such elements as pumps, valves, cylinders and pistons, the efficacy of the system necessarily depends upon the fluid, since the fluid must be one which can withstand pressure and remain fluid under the conditions of use. FIGURE 2 of the drawings is a schematic diagram which well illustrates the indispensable role of the fluid in cooperation with other components of a hydraulic system. Here the fluid is stored.
in reservoir 21, and is pumped therefrom by means of pump 22 and through the directional control valve 23 into either end of cylinder 24, where it acts on piston 25 connected by shaft 26 to a motor (not shown) or other device which converts the hydraulic pressure applied to piston 25 into mechanical energy. Action of the fluid on piston 25 displaces the piston until it reaches the end of its travel. The piston may be caused to travel in either direction by adjustment of the directional valve 23. Valve 23 provides for return of the fluid from the opposite side of the piston, back to reservoir 21. Relief valve 28 is provided to maintain a constant hydraulic pressure within the system. When a predetermined pressure is reached, the fluid will flow back to reservoir 21 by functioning of said relief valve.

Owing to their very good fire-retardant properties, the perfluoroalkyl substituted phenyl esters of the dihydrocarbarylphosphinic acids are particularly useful in hydraulic pressure devices that are employed under conditions wherein any leak or break in the hydraulic system could provide great danger from fire. The exceptionally low pour points of many of the present compounds permit fabrication of pressure devices which are destined for use in extremely cold climates, and their very good vapor pressure characteristics and stability to heat allows use of the same devices in hot environments. The viscosity characteristics and ASTM slopes of the fluids make them of great utility for the transmission of power in a hydraulic system having a pump therein which supplies power for the system, e.g., in a fluid motor comprising a constant- or variable-discharge piston pump which is caused to rotate by the pressure of the hydraulic fluid of the system. The present fluid likewise serves to lubricate the frictional, moving parts of such hydraulic systems.

For use in a conventional automatic transmission, the presently provided hydraulic fluid is contained in the outer casing of the transmission device, which casing is attached to the usual engine crankshaft and flywheel and rotates therewith. Within the fluid is a coupling comprising an impeller connected to said casing and a turbine which is connected to the drive shaft of the vehicle. The turbine is driven by the motion of the fluid in response to the rotation of the impeller, as the casing to which the impeller is attached is actuated by the crankshaft and flywheel.

The presently described (perfluoroalkyl)phenyl esters are particularly suited for use as the operative fluids in hydraulic braking devices owing to their very good vapor pressure characteristics. Under current, severe operating conditions heat build-up within the brake system is frequently encountered. Unless the fluid remains liquid at the high temperatures thus developed, the hydraulic brake system becomes inoperative since the vaporized fluid becomes compressible. Although much effort has been expended in providing high boiling hydraulic brake fluids, generally materials which are high boiling congeal at low temperatures.

The presently provided fluids have boiling points which are well over 400° F. and some of them do not boil until over 600° F. Hence hydraulic brake systems in which these fluids are used withstand the dangers ensuing from heat build-up. At the same time, owing to the low pour points of the fluids, the system is one which is operable in very cold environment. The present invention thus provides an improved method for applying pressure to a hydraulic brake of the impeller type with a fluid.

The presently provided compounds and mixtures are useful as the hydraulic fluids of hydraulic machines, generally, e.g., lifts, hoists, jacks, lockgates, presses, etc. The invention is further illustrated by, but not limited to, the following examples:

**Example 1**

To a solution of 65.5 g. (0.38 mole) of m-(trifluoromethyl)phenol. Precipitation began immediately, and the exothermic reaction carried the temperature to ca. 65° C. After standing at room temperature for 18 hours, the reaction mixture was poured into ice-hydrochloric acid, and then extracted with chloroform. The organic layer was washed successively with dilute hydrochloric acid, water, 5% aqueous sodium hydroxide and finally with water to neutrality. It was then dried by azeotropic distillation and stripped of solvent. Fractionation of the residue through a 15" Vigreux column gave 80.0 g. (75.5% yield) of the substantially pure m-(trifluoromethyl)phenyl dibutylphosphinate, a water-white liquid, B.P. 118° C./0.1 mm., nD20 1.4634, and analyzing as follows:

**Found:** % C, 55.73; % H, 7.01; % F, 18.05. Calc. for C12H23F2OP2: % C, 52.90; % H, 6.88; % F, 17.69.

The pour point of the m-(trifluoromethyl)phenyl dibutylphosphinate was found to be −70° F. The following kinematic viscosities were determined at the temperature shown below:

<table>
<thead>
<tr>
<th>°F</th>
<th>Centistokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>119.1</td>
</tr>
<tr>
<td>100</td>
<td>10.97</td>
</tr>
<tr>
<td>150</td>
<td>4.4</td>
</tr>
<tr>
<td>210</td>
<td>2.16</td>
</tr>
</tbody>
</table>

The ASTM slope was 0.96 for the 100–210° F. range. Temperatures for vapor pressure equal to certain pressures of mercury were determined to be as follows:

<table>
<thead>
<tr>
<th>Temperature, °C</th>
<th>Pressure, mm. Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>178</td>
<td>424</td>
</tr>
<tr>
<td>307</td>
<td>317</td>
</tr>
</tbody>
</table>

The decomposition temperature was found to be 633° F.; and the flash point, 432° F. The fire point of 547° F. which was determined was not a continuous one; rather, it fired only for about 7 seconds. In the molten metal test at 1300° F., there was no burning in absence of spark.

The autoignition temperature was found to be 925° F. for 0.15 ml. with a lag of 3 seconds.

**Example 2**

Pentylproplyphosphinic acid was prepared from an equimolar mixture of n-pentyl- and n-propyl-magnesium halides (1.5 moles) using the procedure described for the preparation of dibutylphosphinic acid by Kosolappo et al. (J. Chem. Soc. (1959), page 3950). The crude pentylproplyphosphinic acid (0.8 mole), a syrupy mass, was reacted with 0.84 mole of phosphorus pentachloride in benzene to give the crude pentylproplyphosphinic chloride B.P. 73–110° C./0.4–0.3 mm., nD20 1.4621, in 93% yield.

A solution of 59.0 g. (0.30 mole) of the pentylproplyphosphinic chloride in 75 ml. of pyridine was treated with stirring at about 0° C., with 48.6 g. (0.3 mole) of m-(trifluoromethyl)phenol. Stirring was continued, first with cooling for about 0.5 hour and subsequently, overnight at room temperature. The reaction mixture was then diluted with an equal volume of benzene, poured onto 1 liter of ice containing 100 ml. of concentrated hydrochloric acid, and stirred occasionally until the ice melted. The benzene layer was washed with three portions of ice-cold, in portions of ice-cold, 5% hydrochloric acid, and finally with ice water to neutrality and dried. Fractionation of the dried material through a "Todd 42" Vigreux column gave a 73.4% theoretical yield of product, B.P. 117–135° C./0.18–0.23 mm., nD20 1.4628, mostly m-(trifluoromethyl)phenyl pentylproplyphosphinate.

Nuclear magnetic resonance analysis for P11 and F19 showed single peaks at −58.4 and −16.4 p.p.m., respectively, and thus substantiated the assigned structure.
The m-(trifluoromethyl)phényl pentylpropylphosphinate was found to have a pour point of −60°F.

**Example 3**

To a solution of 18.7 g. (0.095 mole) of dibutylphosphinic chloride in 100 ml. of pyridine at about 0°C there was added 25 g. (0.11 mole) of 3,5-bis(trifluoromethyl)phenol in two portions. When the slight exothermic reaction (to ca. 35°C) had subsided, the mixture was heated to about 65°C and then allowed to stand at room temperature for several days. It was then poured onto ice- hydrochloric acid, acidified with hydrochloric acid, and extracted with chloroform. Washing of the organic phase to neutrality, employing 5% aqueous sodium hydroxide before the final water-washing, drying over sodium sulfate, distillation to remove the solvent and fractionation of the residue gave 28.6 g. of the substantially pure 3,5-bis(trifluoromethyl)phenyl dibutylphosphinate, a water-white liquid, B.P. 100–103°C./0.03–0.05 mm., nD20 1.4357, and analyzing as follows:

Found: %C, 49.24; %H, 5.64; %P, 7.83. Calc. for C26H20F2O2P: %C, 49.23; %H, 5.42; %P, 7.94.

Nuclear magnetic resonance analysis for PII, versus H2PO, gave a chemical shift of −59.5 p.p.m., which is consistent with the phosphinate structure. For PIII, versus PF2COOH, there was obtained a single, sharp resonance at −14.7 p.p.m., which is consistent with the grouping an-CF2-

The pour point of the 3,5-bis(trifluoromethyl)phenyl dibutylphosphinate was −55°F. The following kinematic viscosities were determined at the temperatures shown below:

<table>
<thead>
<tr>
<th>Centistokes</th>
<th>743.0</th>
<th>12.90</th>
<th>2.29</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.</td>
<td>0</td>
<td>100</td>
<td>210</td>
</tr>
</tbody>
</table>

The ASTM slope was 0.98 within the 100–210°F range, and the compound had a flash point of 370°F and a fire point of 570°F.

**Example 4**

Bis(3-phenylpropyl)phosphinic chloride was prepared as follows: To an ethereal solution of 3-phenylpropylmagnesium chloride prepared from 300 g. (2.0 moles) of 3-phenylpropyl chloride and 49 g. (2.0 moles) of magnesium turnings in 1000 ml of anhydrous ether there was added, with vigorous stirring and under nitrogen, 90 g. (0.65 mole) of diethlyphosphonate. The addition required 4.5 hours and the temperature during this time was maintained at 20–30°C. by occasional ice-water cooling. The whole was then allowed to stand for 18 hours, and then 500 ml of water was added dropwise while allowing the ether to distill off rapidly. It was then brought to pH 2 by treatment with 180 ml of concentrated hydrochloric acid. The ether was removed by warming the reaction mixture to about 50°C, then cooling and adding water aspirator vacuum. Bromine (104 g., 0.65 mole) was added dropwise over a 3-hour period to the stirred aqueous solution maintained at about 10°C. The excess bromine was decomposed by addition of sodium metabisulfite. Precipitation occurred; and after adding 500 ml of ether, the solids were filtered off and dried to give 146 g. (74.4% theoretical yield) of the substantially pure bis(3-phenylpropyl)phosphinic acid, M.P. 99–101°C. The PII nuclear magnetic resonance spectrum showed a single peak at −55.3 p.p.m. versus 85% phosphoric acid, which is consistent with the phosphinic acid structure. Conversion to the phosphonic chloride was effected by mixing 142 g. (0.47 mole of the phosphonic acid) with 500 ml of benzene, then distilling off 75 ml of the benzene from the mixture to assure an anhydrous system, adding 97 g. (0.46 mole) of phosphorus pentachloride in two portions to the cooled residue, refluxing for 3 hours, and removing benzene and by-product phosphorus oxychloride by heating to a pot temperature of 150°C to obtain the bis(3-phenylpropyl)phosphinic chloride as residue.

The bis(3-phenylpropyl)phosphinic chloride was used, without purification, for preparation of the m-(trifluoromethyl)phenyl bis(3-phenylpropyl)phosphinate. Substantially equimolar quantities of said chloride and m-(trifluoromethyl)phenol were reacted in pyridine according to the procedure described in Example 1, except that in this case the dibutylphosphinic chloride of Example 1 was replaced by the bis(3-phenylpropyl)phosphinic chloride. There was thus obtained the substantially pure m-(trifluoromethyl)phenyl bis(3-phenylpropyl)phosphinate, a pale yellow liquid, B.P. 210°C./0.05 mm., nD20 1.5382, and analyzing as follows:

Found: %C, 67.51; %H, 6.10; %F, 13.17. Calc. for C26H20F2O2P: %C, 67.25; %H, 5.87; %F, 12.77.

Nuclear magnetic resonance analysis for PIII versus 85% aqueous phosphoric acid gave a single peak at −57.8 p.p.m.; thus confirming the phosphinate structure. The following kinematic viscosities were determined for the m-(trifluoromethyl) bis(3-phenylpropyl)phosphinate:

<table>
<thead>
<tr>
<th>Centistokes</th>
<th>153.8</th>
<th>130</th>
<th>72.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.</td>
<td>100</td>
<td>150</td>
<td>210</td>
</tr>
</tbody>
</table>

The ASTM slope for the 100–210°F range was 0.90. The m-(trifluoromethyl)phenyl bis(3-phenylpropyl)phosphinate was found to have an autoignition temperature of 1010°F for 0.01 ml with a 35 seconds lag. It had a decomposition temperature of 595°F, a flash point of 565°F, and a fire point of 716°F. In the 1300°F. molten metal test, it did not burn without spark.

**Example 5**

In this example there is compared the effect of various fluids on O rings, i.e., gaskets or seals, made of "Buna N" (butadiene/acrylonitrile) synthetic rubber. O rings of substantially the same dimension and composition (Proceed Rubber Products AN622–19) were immersed in the fluids shown below for 168+1 hours at a temperature of 158±2°F, the ultimate percent elongations of the thus-treated rings were then determined. The following results are averages of three determinations made with each fluid:

Test fluid: Ultimate elongation, percent
None (O rings before immersion) 234 m-(trifluoromethyl)phenyl dibutylphosphinate, 210 Tri-xylyl phosphate (MIH-H-19457) 22

From the above it is apparent that the elasticity of the Buna N O rings is not significantly decreased by the long immersion in the m-(trifluoromethyl)phenyl dibutylphosphinate, whereas immersion in the commercial fluid, tri-xylyl phosphate, reduces the elasticity to less than onetenth of the original value. This is surprising, since both compounds are phosphorus esters.

The operative fluid of the present hydraulic systems and methods may be a mixture of one or more (perfluoroalkyl)phenyl dihydrocarboxyl phosphonates. In some instances, it will be found that those of the compounds having meta- and/or ortho substitution at the phenyl nucleus possess better fluidity than do the para-substituted compounds. The presently provided perfluoroalkyl-substituted phosphonates may also be mixed with known hydraulic fluids, e.g., the trialkyl phosphates or the dialkyl arylphosphonates or the aromatic polyethers, so long as the properties of the resulting mixture meet the specifications required of a hydraulic fluid for the intended use. Obviously if the intended use places no limitation on such factors as either low- or high-temperature behavior, or if no fire-hazard
exists, the present compounds may be present in any proportion. However, if one or more of these factors is important, then care should be observed in preventing an undesired extent of dilution. Generally, at least a major component of the mixture should be the (perfluoroalkyl) phenyl dihydrocarbonylphosphinate.

Also, the usual fluid additives, e.g., corrosion inhibitors, antioxidants, viscosity-index improvers, etc., may be added to the presently provided fluid phosphinates, although for most purposes it will be found that such additives can be dispensed with.

The presently provided compounds are also useful as biological toxicants, e.g., as defoliants and as selective preemergent and foliage contact herbicides. They may be applied to soils or plants in the form of oil-in-water emulsions or in admixture with powdered carriers, adjuvants, etc.

It is to be understood that although the invention has been described with specific reference to particular embodiments thereof, it is not to be so limited since changes and alterations therein may be made which are within the full intended scope of the invention as defined by the appended claims.

What we claim is:

1. A compound of the formula

\[
\begin{array}{c}
\text{R} \\
\text{P} \\
\text{O} \\
\text{R'} \\
\end{array}
\]

\[
\begin{array}{c}
\text{Y} \\
\text{5} \\
\text{O} \\
\text{5} \\
\end{array}
\]

in which R and R' are hydrocarbyl radicals selected from the class consisting of alkyl, aryl, cycloalkyl, and aralkyl and containing from 1 to 12 carbon atoms, Y is a perfluoroalkyl radical of from 1 to 8 carbon atoms, and n is a number of from 1 to 2.

2. The compound defined in claim 1, further limited in the R and R' are alkyl.

3. The compound defined in claim 1, further limited in that R and R' are aralkyl.

4. The compound defined in claim 1, further limited in that R and R' are butyl.

5. The compound defined in claim 1, further limited in that R is pentyl and R' is propyl.

6. The compound defined in claim 1, further limited in that R and R' are 3-phenylpropyl.

7. m-(Trifluoromethyl)phenyl dibutylphosphinate.

8. 3,5-bis(trifluoromethyl)phenyl dibutylphosphinate.

9. m-(Trifluoromethyl)phenyl pentylogyropophosphinate.

10. m-(Trifluoromethyl)phenyl bis(3-phenylpropyl) phosphinate.

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