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(54) Titre : LES 5,5-BIS-(PERFLUOROALKYLHETEROMETHYL)-2-HYDROXY-2-OXO-1,3,2-DIOXAPHOSPHORINANES, ACIDES ACYCLIQUES PHOSPHORES DERIVES, OU LEURS SELS OU ESTERS  
(54) Title: 5,5-BIS(PERFLUOROALKYLHETEROMETHYL)-2-HYDROXY-2-OXO-1,3,2-DIOXAPHOSPHORINANES, DERIVED ACYCLIC PHOSPHORUS ACIDS AND SALTS OR ESTERS THEREOF

(57) **Abrégé/Abstract:**

5,5-Bis(perfluoroalkylheteromethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinanes, derived acyclic phosphorus and phosphoric acids obtained by ring-opening, and salts or esters thereof are prepared from heteroatom containing perfluoroalkyl terminated neopentyl glycols of the formula  $\text{HO}[\text{CH}_2\text{C}(\text{CH}_2\text{-X-E}_n\text{-R}_f)_2\text{CH}_2\text{O}]\text{H}$  by cyclization with appropriate phosphorus containing esters or acids, or hydrolysis. These compositions provide improved thermal stability, and useful low surface energy oil and water repellent coatings for textiles, glass, paper, leather and other materials. Another aspect of this invention relates to the use of the phosphite group containing products as polymer stabilizers.

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Derived Acyclic Phosphorus Acids and Salts or Esters Thereof

Abstract of the Disclosure

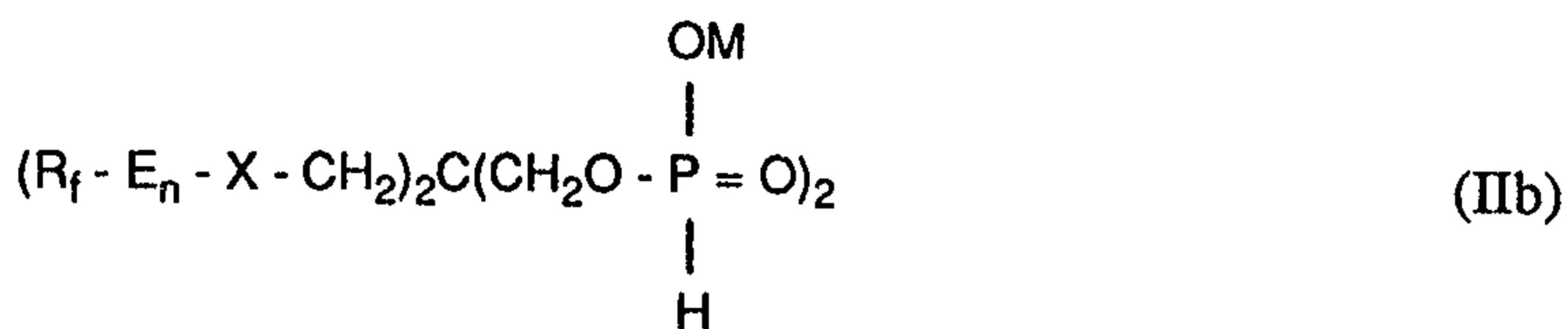
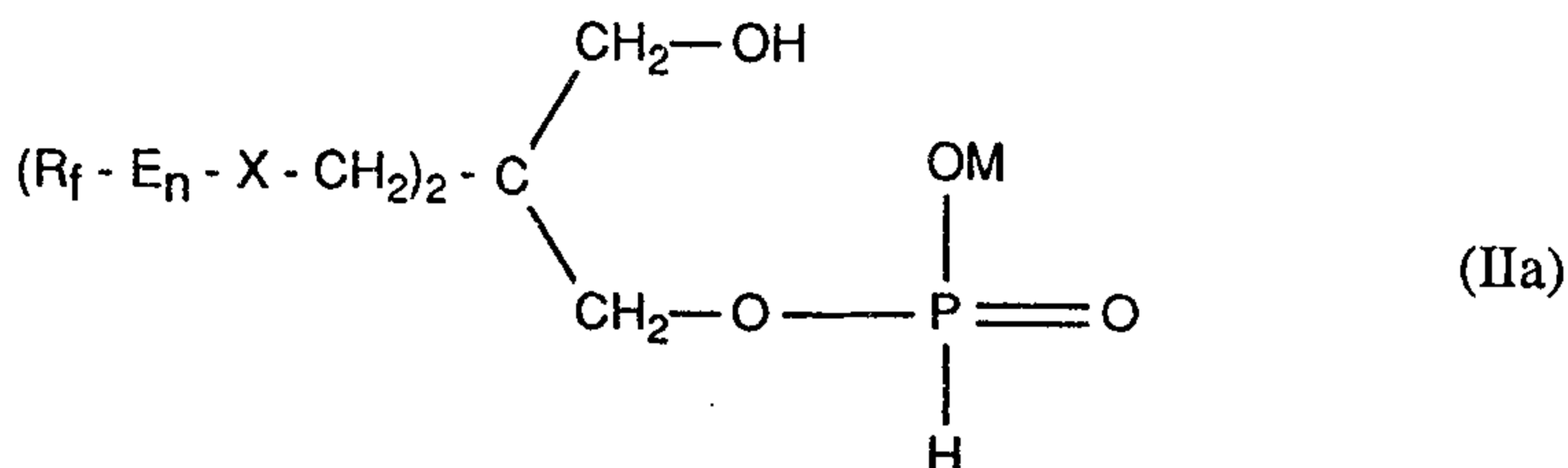
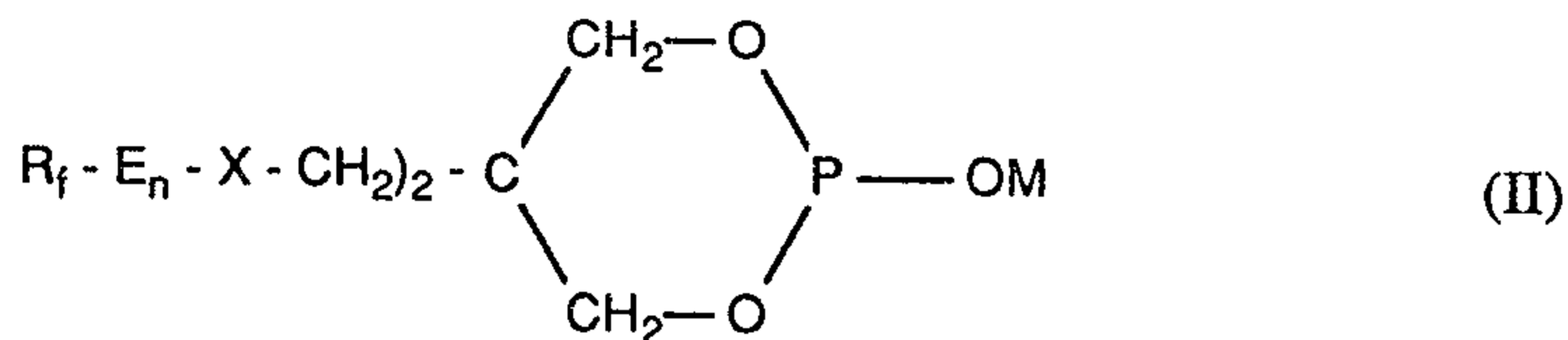
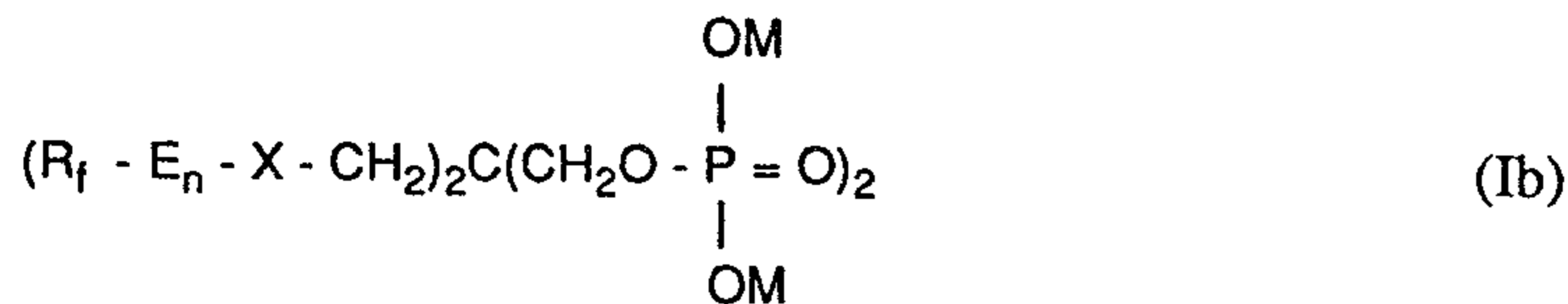
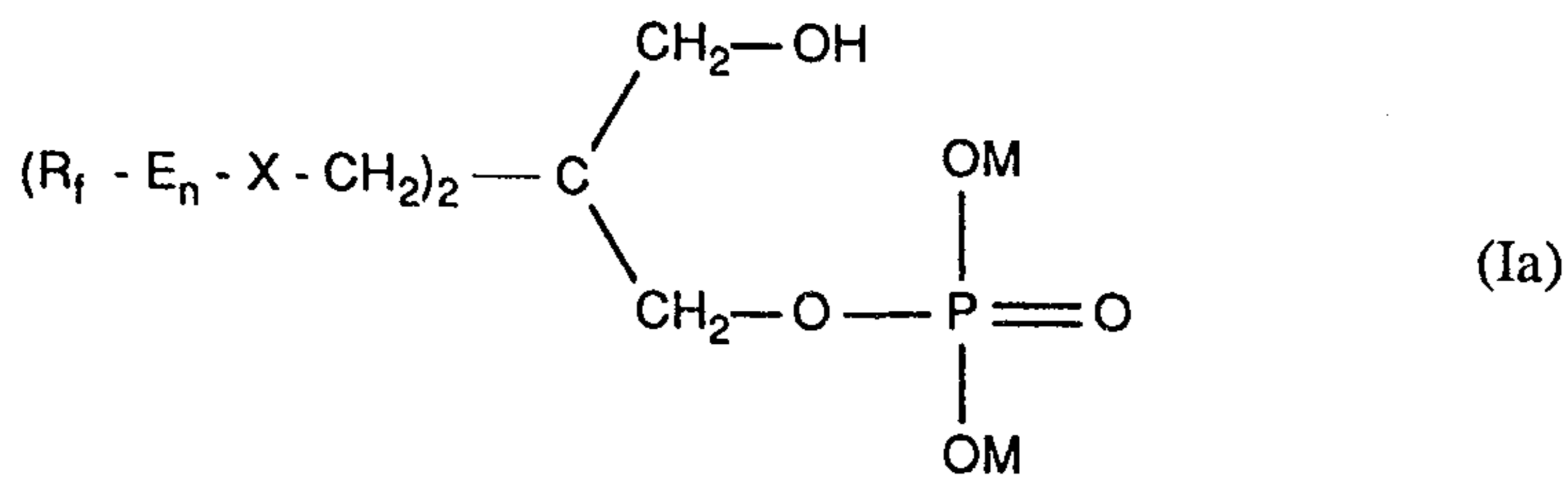
5,5-Bis(perfluoroalkylheteromethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinanes, derived acyclic phosphorus and phosphoric acids obtained by ring-opening, and salts or esters thereof are prepared from heteroatom containing perfluoroalkyl terminated neopentyl glycols of the formula  $\text{HO}[\text{CH}_2\text{C}(\text{CH}_2\text{-X-E}_n\text{-R}_f)_2\text{CH}_2\text{O}]\text{H}$  by cyclization with appropriate phosphorus containing esters or acids, or hydrolysis.

These compositions provide improved thermal stability, and useful low surface energy oil and water repellent coatings for textiles, glass, paper, leather and other materials.

Another aspect of this invention relates to the use of the phosphite group containing products as polymer stabilizers.



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wherein  $\text{R}_f$  is a straight or branched chain perfluoroalkyl of 2 to 12 carbon atoms or perfluoroalkyl of 2 to 6 carbon atoms substituted by perfluoroalkoxy of 2 to 6 carbon atoms,

$n$  is 1 or 0, and when  $n$  is 1,

$\text{E}$  is a branched or straight chain alkylene of 2 to 10 carbon atoms or said alkylene interrupted by one to three groups selected from the group consisting of  $-\text{NR}-$ ,  $-\text{O}-$ ,  $-\text{S}-$ ,  $-\text{SO}_2-$ ,  $-\text{COO}-$ ,  $-\text{OOC}-$ ,  $-\text{CONR}-$ ,  $-\text{NRCO}-$ ,  $-\text{SO}_2\text{NR}-$  and  $-\text{NRSO}_2-$ , or terminated at the  $\text{R}_f$  end with  $-\text{CONR}-$  or  $-\text{SO}_2\text{NR}-$ , where  $\text{R}_f$  is attached to the carbon or sulfur atom,

$\text{X}$  is  $-\text{S}-$ ,  $-\text{O}-$ ,  $-\text{SO}_2-$ , or  $-\text{NR}-$ , and when  $n = 0$ ,  $\text{X}$  is a direct bond,  $-\text{CONR}-$  or  $-\text{SO}_2\text{NR}-$ ,

where  $R_f$  is attached to the carbon or sulfur atom, and where R is independently hydrogen, alkyl of 1 to 6 carbon atoms or hydroxyalkyl of 2 to 6 carbon atoms, M is independently hydrogen, lower alkyl, an alkyl- or mixed polyalkyl-substituted aromatic group, or represents an ammonium, organo-ammonium, alkali metal or alkaline earth metal salt of the respective phosphite or phosphate group.

It is understood that the  $R_f$  group usually represents a mixture of perfluoroalkyl moieties. When the  $R_f$  group is identified as having a certain number of carbon atoms, said  $R_f$  group also usually concomitantly contains a small fraction of perfluoroalkyl groups with a lower number of carbon atoms and a small fraction of perfluoroalkyl groups with a higher number of carbon atoms. Commonly, the perfluoroalkyl group is preferably a mixture of  $C_4F_9$ -,  $C_6F_{13}$ -,  $C_8F_{17}$ -,  $C_{10}F_{21}$ -,  $C_{12}F_{25}$ - and  $C_{14}F_{29}$ - .

Preferably the instant compounds are those where  $R_f$  is perfluoroalkyl of 2 to 12 carbon atoms, E is alkylene of 2 to 6 carbon atoms,  $-\text{CONHCH}_2\text{CH}_2-$ ,  $-\text{CH}_2\text{CH}_2\text{N}(\text{CH}_3)\text{CH}_2\text{CH}_2-$ ,  $-\text{CH}_2\text{CH}_2\text{SO}_2\text{NHCH}_2\text{CH}_2-$ ,  $-\text{CH}_2\text{CH}_2\text{OCH}_2\text{CH}_2-$  or  $-\text{SO}_2\text{NHCH}_2\text{CH}_2-$ , and X is  $-\text{S}-$ ,  $-\text{SO}_2-$  or  $-\text{O}-$  .

Most preferred are compounds of the formulas I, Ia, Ib, II, IIa and IIb, wherein  $R_f$  is perfluoroalkyl of 6 to 12 carbon atoms, E is ethylene and X is  $-\text{S}-$ .

Interesting compounds are those, wherein M is ammonium or organoammonium.

Examples for the most interesting compounds are:

- (1) 5,5-bis(1,1,2,2-perfluorodecylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane.
- (2) 5,5-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane.
- (3) 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-3-hydroxy-1-propyl-dihydrogenphosphate.
- (4) 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3-propanedihydrogen phosphate.

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- (5) 5,5-bis(1,1,2,2-tetrahydroperfluoroalkylsulfonylmethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane.
- (6) 5,5-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-2-hydro-2-oxo-1,3,2-dioxaphosphorinane.
- 5 (7) 2,2-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-3-hydroxy-1-propyl hydrogen phosphite.
- (8) 2,2-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-1,3-propanedihydrogen-phosphite.
- (9) 2-(2,4-di-tert-butylphenoxy)-5,5-bis(1,1,2,2-tetrahydroperfluoroalkylthio-  
methyl)-1,3,2-dioxaphosphorinane.
- 10

"Perfluoroalkyl" in the compounds (2) to (9) is a mixture of  $C_6F_{13}$ -,  $C_8F_{17}$ -,  $C_{10}F_{21}$ -,  $C_{12}F_{25}$ - and  $C_{14}F_{29}$ -.

In the most preferred embodiment the compounds (1) to (9) are in the form of their ammonium or organoammonium salt.

15 5,5-Bis(perfluoroalkylheteromethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinanes of formulas I and II, and salts or esters thereof are obtained directly from heteroatom containing perfluoroalkyl terminated neopentyl glycols of the formula  $HO[CH_2C(CH_2-X-E_n-R_f)_2CH_2O]H$  by cyclization of these compounds with appropriate phosphorus containing esters or acids as described in U.S. Patent No. 4,898,981.

20 One or more perfluoroalkyl substituents can be substituted at other positions of the stable 1,3,2-dioxaphosphorinane ring to prepare analogous phosphates and phosphites. These products can be hydrolyzed to acyclic derivatives.

However, the 5,5-bis(perfluoroalkylheteromethyl) substituents cited herein are most accessible.

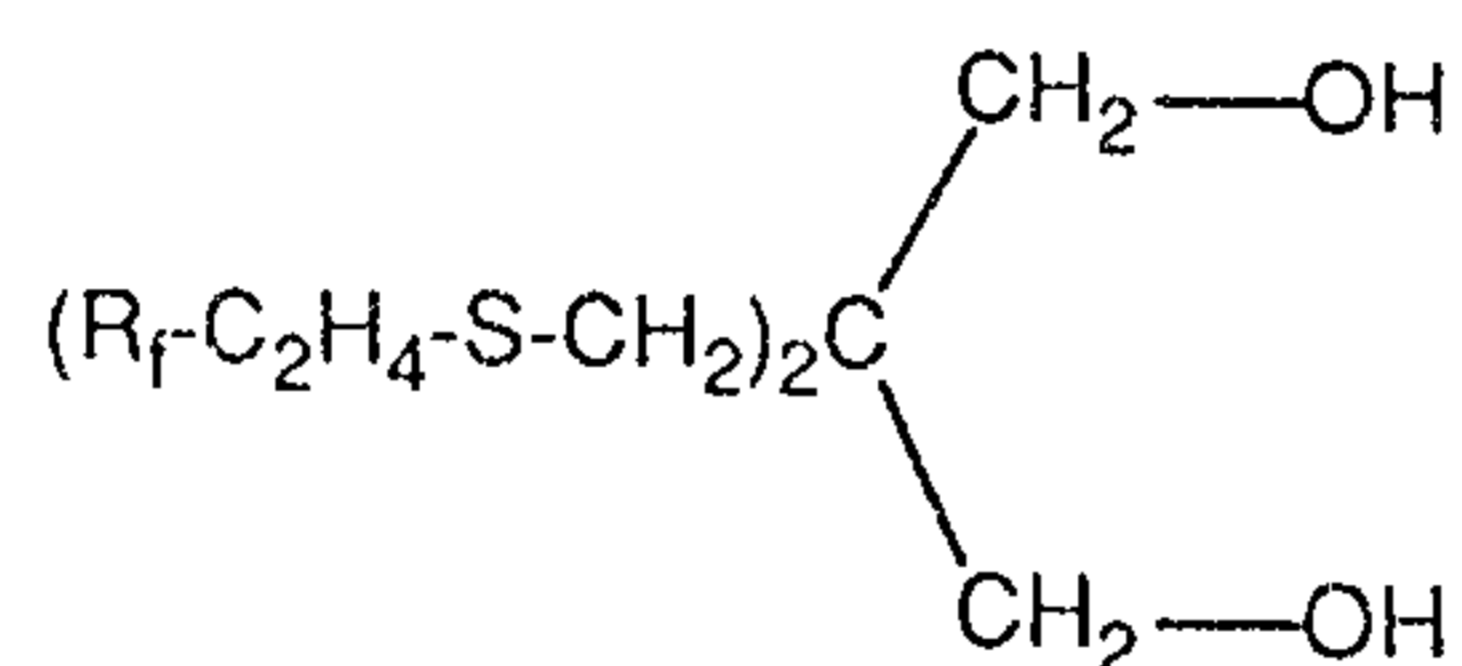
Phosphates of formula (I) are obtained by reaction with polyphosphoric acid, phosphoric acid, or esters thereof. Alternately, they are obtained indirectly by first cyclizing the glycols with  $\text{POCl}_3$  or  $\text{PCl}_5$ , followed by reaction with water of hydroxylic reactant.

Phosphites of formula (II) are obtained by reaction of heteroatom containing perfluoroalkyl terminated neopentyl glycols with phosphorus acid or phosphite esters. They may be obtained indirectly by first cyclizing the glycols with  $\text{PCl}_3$ , followed by reaction with water, or hydroxylic reactant.

Derived acyclic acids of formulae (Ia), 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylheteromethyl)-3-hydroxy-1-propyl phosphoric acid, and (IIa), 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylheteromethyl)-3-hydroxy-1-propyl phosphorus acid, and salts or esters thereof, may be obtained by hydrolysis of the respective 1,3,2-dioxaphosphorinanes. Small quantities of compounds of type (Ib) or (IIb) are usually present.

Phosphites of types (II), (IIa) and (IIb) can be converted to phosphates of types (I), (Ia) and (Ib) by conventional oxidation.

In one preferred embodiment, the starting material is a perfluoroalkyl terminated neopentyl glycol of the formula

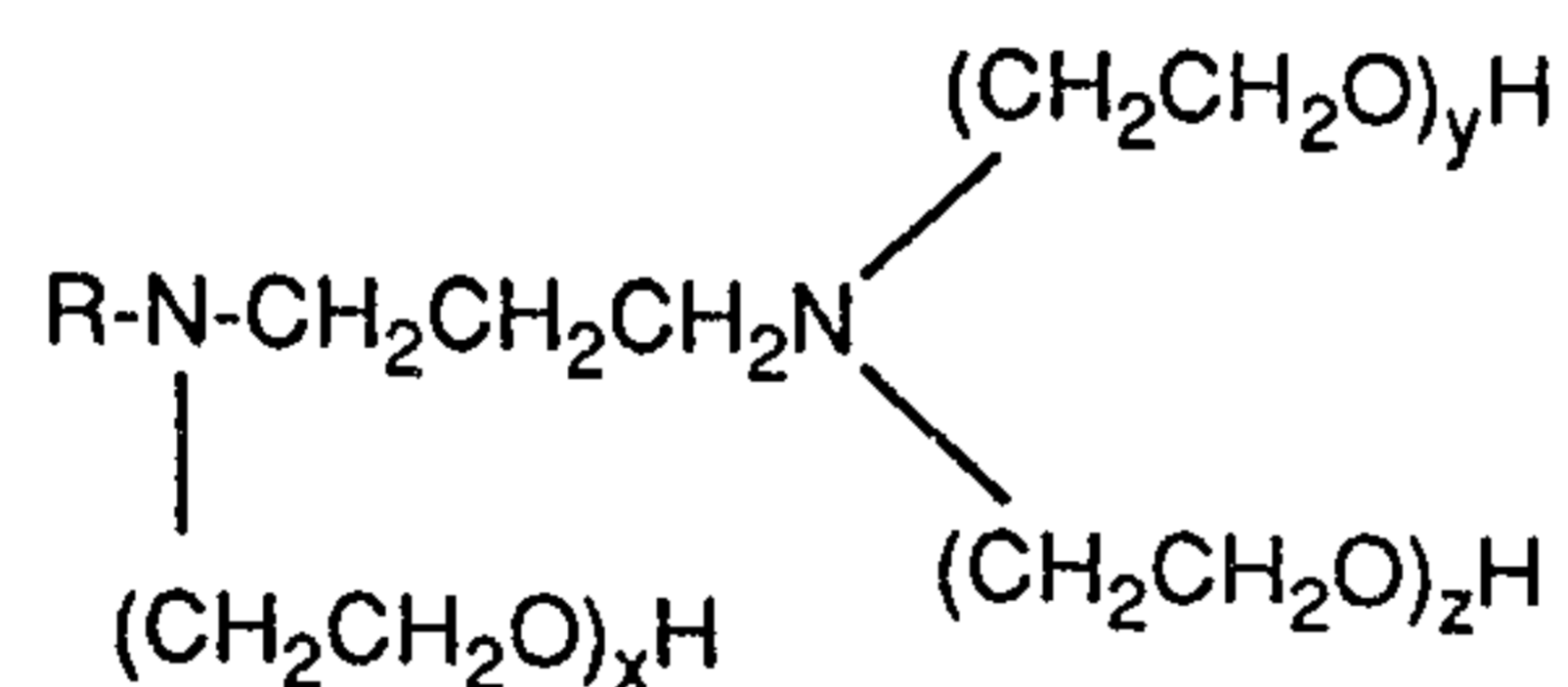


The bis-sulfido-reactants or resulting phosphorus containing products can be readily oxidized to the corresponding bis-sulfones by peracetic acid ( $\text{H}_2\text{O}_2$ /acetic acid) or by other conventional oxidants. Temperatures of 30-100°C are appropriate, and an excess of the oxidizing agent ensures that the intermediate sulfoxides are completely oxidized.

It is an object of the present invention to minimize by-products in the ammonium and amine salts of the present invention by reacting the corresponding bis-perfluoroalkyl group containing acids with ammonia or an amine in a diluent substantially inert to the acid and ammonia or amine reactants.

The reaction is neutralized at temperatures between 0°C and 100°C, preferably at ambient temperature conditions. Where the amine is introduced in gaseous forms, such as anhydrous ammonia or methylamine, it can be bubbled through the acid in the liquid diluent medium. As the reaction tends to be exothermic, cooling of the reaction vessel may be advantageously employed. Where the inert diluent is organic in nature, such as a lower alkanol, for example methanol, diethylene glycol dimethyl ether or the like, the ammonium or amine salts reaction product can be recovered by precipitation, or evaporation of the diluent. The ammonium or amine salt does not have to be separated from the solvent media.

The amines should be water soluble mono- or polyamines having a water solubility of at least 2% by weight. Suitable amines are aminomethane, aminoethane, 1-aminopropane, 2-aminopropane, 1-aminobutane, 1-amino-2-methylpropane, 1,1-dimethylethylamine, 1-aminopentane, isoamylamine, tert-amylamine, allylamine, dimethylamine, diethylamine, diisopropylamine, trimethylamine, triethylamine, tri-n-butylamine, ethylenediamine, 1,2-propanediamine, trimethylenediamine, 1,3-diaminobutane, 1,4-diaminobutane, hexamethylene diamine, diethylenetriamine, triethylenetriamine, tetraethylenepentamine, polyethyleneimine having an average of about 20, 80, 120 or 200 units, diethylaminopropylamine, ethanolamine, diethanolamine, triethanolamine, ethylenediaminetetraacetic acid, nitrilo-tris-acetic acid, N-(hydroxyethyl)ethylenediamine, N,N'-bis-(hydroxyethyl)-diethylenetriamine, N,N,N',N'-tetrakis-(2-hydroxy-propyl)-ethylenediamine, N-(2-hydroxypropyl)ethylenediamine, cyclohexylamine, dicyclohexylamine, and



where R is tallow fatty alkyl and  $x + y + z$  is 3, 10 or 15, fatty diethanolamines, mono-, di- and tri-isopropanolamines, or polyoxyethyleneamines.

Preferably the amine is an alkanolamine.

Alternately, quaternary ammonium salts can be obtained from tetraalkylammonium bases

by neutralization.

The subject bis-perfluoroalkyl terminated carboxylic acids can be used in-situ by the addition as the free acid to a basic aqueous application formulation. Alternately, it is prepared as a concentrate containing 5 to 80% by weight of the neutralized phosphate salt, optionally in the presence of excess base. The perfluorochemical is applied from water or from a solvent soluble in water to at least 0.1%.

The subject bis-perfluoroalkyl phosphorus derivatives are readily isolated in high yield and purity. As the compounds of this invention are characterized by the presence of two perfluoroalkylhetero groups in close proximity, they have a low free surface energy that provides oil and water repellency associated with low free surface energy to a wide variety of substrates. Further, the two perfluoroalkylthio groups connect via a neopentyl moiety that does not permit the thermal elimination of mercaptan by beta-elimination. Hence, these R<sub>F</sub>-phosphorus derivatives have enhanced thermal stability. Their primary use is to impart oil and water repellency to textiles, glass, paper, leather, and other compositions. The use of the described fluorochemicals provides thermally stable materials that are oil and water repellent at lower application levels than are provided by previously used treating compositions.

For topical application, suitable aqueous dilutions advantageously contain 0.01% to 5%, preferably 0.02% to 2%, by weight of the amine salts at use dilution. Conventional adjuvants such as water repellent assistants, bacteriostats, coloring agents, surface conditioners and the like, may be included in an amount between about 0.01% and 10% by weight in the emulsion. Also, sizing agents, where the emulsion is to be used on cellulosic substrates, may be present in the amounts of 0.01% to 10% by weight.

The sizing agent may be a natural sizing agent such as animal glue, asphalt emulsions, wax emulsions, rosins, starches; a semi-synthetic sizing agent such as a fatty acid salt or complex, a fortified rosin, e.g., trisodium maleopimaric acid salt, sodium alginate or sodium carboxymethyl-cellulose; or a synthetic sizing agent such as an alkylketone dimer, alkylsuccinic anhydrides, polyvinyl alcohol, styrene-maleic anhydride polymers, and the like. Also, mixtures thereof may be used, or an emulsifier may be optionally present in an amount of between about 0.001% to 3% by weight.

Thus, suitable dilutions for topical application contain the following:

- (a) 0.01 to 5% by weight of the amine salt of the acyclic phosphorus acid of 5,5-Bis-(perfluoroalkylheteromethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinanes;
- (b) 0 to 3% by weight emulsifier;
- (c) 0 to 5% water repellent assistant, filler, bacteriostat, coloring agent or surface conditioner adjuvant;
- (d) 0 to 10% sizing agent, and
- (e) the remainder water.

These formulations apply to the surface of the cellulosic, natural or synthetic material by conventional techniques, including padding, spraying, coating, washing, and brushing. After application, the treated surface is dried, with or without an intermediate washing stage. The resulting surface becomes water and oil resistant.

For use as a sizing agent to obtain oil and water repellency, the dilution of the instant aqueous formulations advantageously contains from about 0.0005% to 0.2% by weight of the instant amine salts. The formulations for dilution may be prepared as a concentrate containing between 5% and 80% by weight, preferably 30 to 80% by weight of the amine salt.

Using the  $R_F$ -compounds and compositions described herein, it is possible to prepare fluorochemical emulsions to treat textiles and provide outstanding oil and water-repellent characteristics thereto.

Suitable cellulosic and natural substrates for topical application include paper, non-woven fabrics, textiles, paperboard, wood, wood fiber products such as plywood, hair, including wool, hides, leather, and feathers. Synthetic substrates include nylon fibers and textiles.

While the instant formulations are suitable for rendering a variety of materials oil and water repellent, they are particularly advantageous in rendering articles made from paper pulp, such as paper trays, paper plates and analogous paper articles, both oleophobic and hydrophobic.

In order to further increase the efficiency of application, it is conventional to treat the paper pulp with a cationic agent, or retention aid such as an oxidized or cationically modified starch, which is adsorbed by the paper pulp and tends to increase the amount of fluorochemical transferred to the cellulose substrate.

Suitable cationic agents, conventionally used to treat cellulose materials such as paper pulp, include conventional cationic modified starches, cationic modified aminoplast resins and cationic polymers.

Suitable cationic resins are described in Bates, "Polyamide-Epichlorhydrin Wet Strength Resin, TAPPI, 52, (6) 1969 and in U.S. Patent Nos. 3,655,506 and 4,299,654.

Jointly with the perfluoroalkyl group containing acid salts of the invention, can be added one or more of wide choice of water proofing sizing agents selected from classes such as alkyl anhydrides, alkyl ketene dimers, polyurethane emulsions, acrylic resins, stearyl amine surfactants, complexed with a fatty acid, e.g., stearic acid. Suitable hydrophobic sizing agents are described by Davis et al., TAPPI, 39 (1) pp. 21-23 (1956) and in U.S. Patent Nos. 4,243,481 and 4,279,794.

The amount of adjuvant and sizing agent used for treating paper is of the range specified for topical application, supra. Thus, for internal or external sizing of paper pulp suitable aqueous dilutions contain:

- (a) 0.0005 to 0.1% by weight of the instant amine salts;
- (b) 0 to 0.05% by weight emulsifier;
- (c) 0 to 5% by weight filler, bacteriostat, fungicide, coloring agent, surface conditioner adjuvant, or retention aid;
- (d) 0 to 10% sizing agent, and
- (e) the remainder water.

Another aspect of this invention relates to the use of the phosphite group containing products as polymer stabilizers. They are very effective in the stabilization of polyolefins, polyesters, styrenics, engineering thermoplastics, PVC, elastomers, and adhesives. They contribute in achieving improved stability during fabrication compounding, and end use.

The following examples are intended for illustrative purposes only, and are not intended to restrict the scope of the invention in any way. All parts are by weight unless otherwise specified.

### Sample Preparation And Testing

#### Pad application of fluorochemicals on an external size

Samples of fluorochemicals are diluted to the test application levels with distilled water. The solutions are added to a 4% aqueous solution of paper maker's starch and then applied to unsized paper by adding (paper dipped through starch solution, and passed through single nip rollers). The resulting sheets are dried at ambient conditions for 15 minutes, then 3 minutes at 200°F in an "Emerson Speed Drier" (heated metal plate with canvas cover).

#### Internal size application and testing

Six grams of dry pulp are diluted in 289 ml distilled water and thoroughly dispersed in a blender. To this pulp slurry is added a 1% dilution (as is) of the test dispersion in distilled water and mixed in for 5 minutes. Then, 6 ml of 1% aqueous solution of cooked cationic starch is added and mixed together for an additional 5 minutes. To this, 24 ml of a 50% (on solids) dilution of a water repellent adjuvant is added and mixed in for another 10 minutes. The resulting slurry is diluted with an additional 500 ml of distilled water and mixed again. This mixture is then poured over a 100 mesh wire screen, with a vacuum applied from below, which pulls the water from the pulp mixture to form a sheet on the screen. The wet sheet is removed from the screen and dried between another screen and hard surface at a pressure of approximately 0.4 lb./in<sup>2</sup> at 110°C for 1½ hours. One ml of hot (110°C) corn oil is placed on the paper and the time noted for penetrations to occur (20 minutes max). Similarly, 1 ml of hot (80°C) water containing 0.5% of TRITON X-165 wetting agent (from Rohm & Haas) placed on the paper is tested. Paper made in the same manner, including the cationic starch and water repellent adjuvant but without a fluorochemical demonstrated an oil kit number of < 1, and held the hot corn oil and hot water/TRITON X-165 solution for less than one minute (began to penetrate as soon as applied).

#### Grease resistance test

Creased test papers are placed over a grid sheet imprinted with 100 squares. Five grams of sand are placed in the center of the crease. A mixture of synthetic oil and a dye for visualization is pipetted onto the sand and the samples are maintained at 60°C for

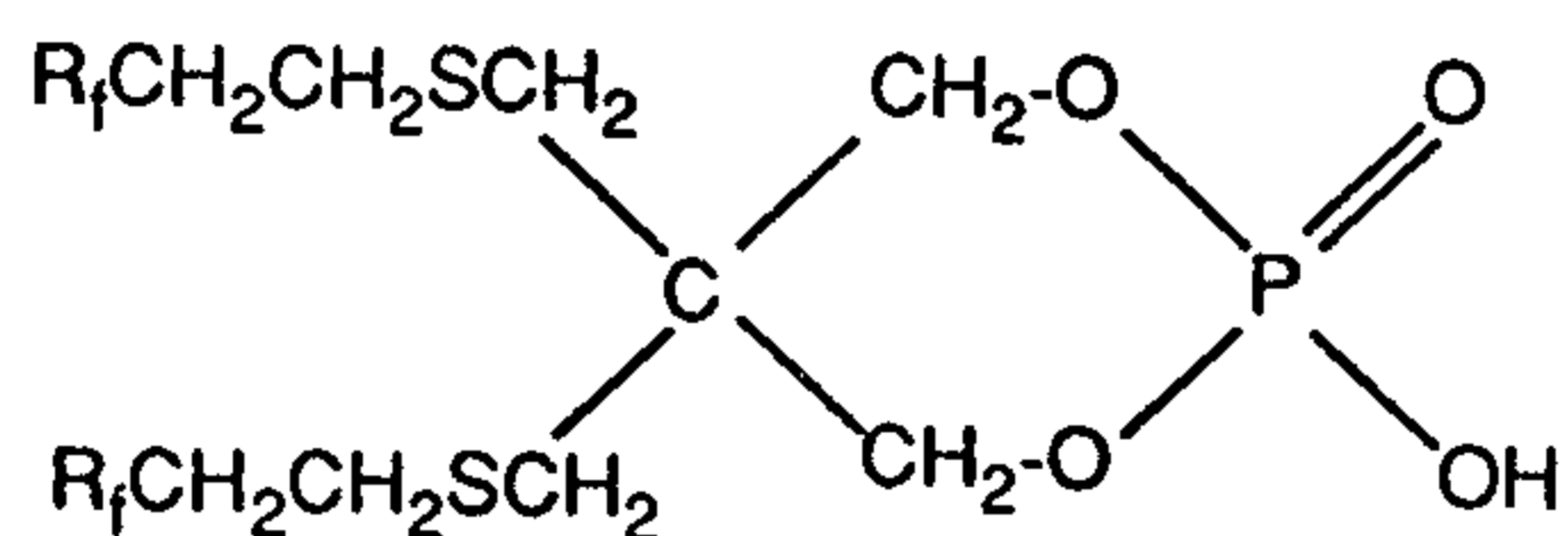


phosphorinane

2,2-Bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-1,3-propanediol (17.0 g, 0.016 mol) is charged to a three-necked flask with polyphosphoric acid (5.0 g). Ethylene glycol dimethyl ether (7.0 g) is added as solvent, and stirring is begun under nitrogen flow. The mixture is refluxed for 3 hours at 95-100°C. Water is added, and the crude product (17.3 g) is filtered and crystallized from xylene and then from chloroform. The final crystallization yields 14.5 g of an off-white solid, 83.8% recovery, m.p. 115-119°C.  $^{31}\text{P}$  NMR shows a single peak of -4.0 ppm.  $^1\text{H}$  NMR shows proton resonances at 2.45 ppm., 4 protons, (2 x  $\text{SCH}_2$ ); 2.82 ppm., 8 protons, (2 x  $\text{CH}_2\text{CH}_2\text{S}$ ); 4.30 ppm., 4 protons, (2 x  $\text{CH}_2\text{-O}$ ); OH is not specifically observed.

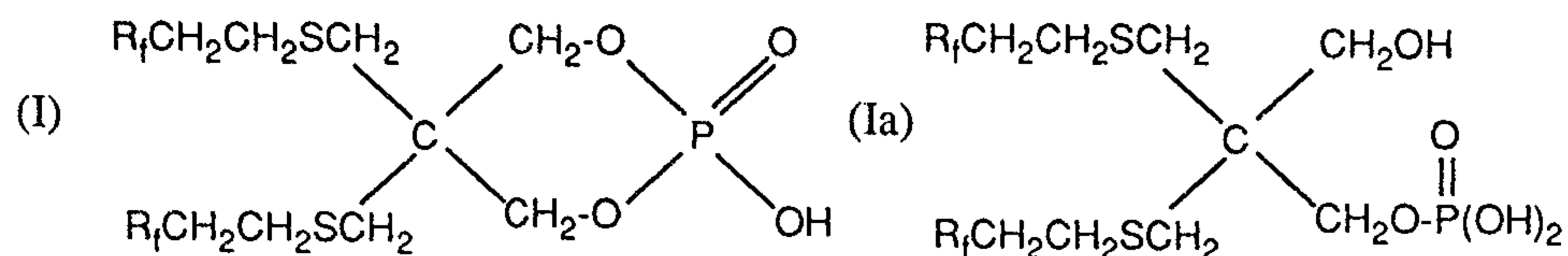
Analysis for  $\text{C}_{25}\text{H}_{17}\text{F}_{34}\text{O}_4\text{PS}_2$ :

Calculated:	C, 26.6%;	H, 1.6%;	S, 5.7%;	F, 57.2%;
Found:	C, 26.8%;	H, 1.4%;	S, 5.9%;	F, 57.1%.

Example 25,5-Bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane

where  $R_f$  is  $\text{C}_6\text{F}_{13}$ -,  $\text{C}_8\text{F}_{17}$ -,  $\text{C}_{10}\text{F}_{21}$ -,  $\text{C}_{12}\text{F}_{25}$ -,  $\text{C}_{14}\text{F}_{29}$ - in the ratio of 36.8, 35.5, 18.4, 7.4, 1.9.

2,2-Bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3-propanediol (12.8 g, 0.0027 mol) and polyphosphoric acid (5.16 g) are charged to a three-necked flask. Diethylene glycol dimethyl ether (4.0 g) is added as solvent, and the reaction mixture is heated to 100°C for four hours with agitation under nitrogen. Water is added, and the product, a white solid, is isolated by vacuum filtration.

Examples 3a and 3b

where  $\text{R}_f$  is  $\text{C}_6\text{F}_{13}$ -,  $\text{C}_8\text{F}_{17}$ -,  $\text{C}_{10}\text{F}_{21}$ - in ratio of 4.7/93.0/1.6.

(I) 5,5-Bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane

(Ia) 2,2-Bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-3-hydroxy-1-propyl Dihydrogenphosphate

2,2-Bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3-propanediol (12.8 g, 0.0027 mol) and polyphosphoric acid (5.16 g) are charged to a three-necked flask. Diethylene glycol dimethyl ether (4.0 g) is added as solvent, and the reaction mixture is heated to  $100^\circ\text{C}$  for four hours with agitation under nitrogen. In order to obtain structure (I), (Example 3a), water is added, and the product, a white solid, is isolated by vacuum filtration. To obtain structure (Ia), (Example 3b), water (40 g) is added, and the reaction mixture is heated at  $100^\circ\text{C}$  for an additional six hours with agitation. The product, a white solid, is isolated by vacuum filtration and washed several times with water. Traces of (Ib), 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3-propanedihydrogenphosphate are usually present, as indicated by  $^{31}\text{P}$  NMR.

Analysis for structure (I) follows:

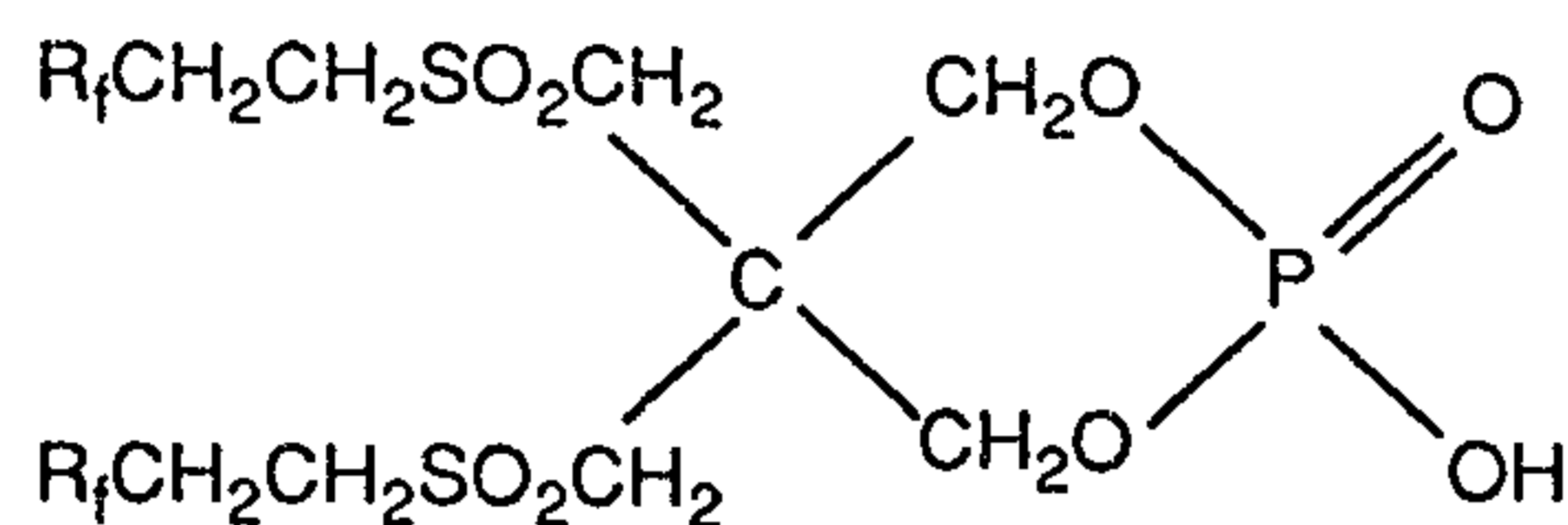
$^{31}\text{P}$  NMR shows two major peaks for samples derivatized with N,O-bis-(trimethylsilyl)tri-fluoroacetamide reagent: -30.0 ppm., 47 parts, the standard shift for phosphoric acid and -17.0 ppm., 53 parts, corresponding to structure (I). Additional proof for structure (I) comes from the addition of trichloroacetyl isocyanate (TCAI) reagent. Transformation of P-OH moiety into the more bulky P-O-TCAI ester results in freezing the spectrum from that of rapidly equilibrating chair conformations to that of a conformationally invariant species. This is most likely one in which the -O-TCAI moiety is equatorial. The resulting spectrum shows two  $\text{R}_f$  moieties and a complex region for the ring - $\text{OCH}_2$  resonances in

which the axial and equatorial protons are no longer equivalent, and show different couplings to phosphorus.  $^1\text{H}$  NMR shows proton resonances at 2.52 ppm., complex, 4 protons, (2 x  $\text{R}_f\text{CH}_2$ ); 2.82 ppm., triplet, 4 protons, (2 x  $\text{CH}_2\text{CH}_2\text{S}$ ); 2.82 ppm., singlet, 4 protons, (2 x  $\text{CH}_2\text{C}$ ); 4.29 ppm., doublet, 4 protons, (2 x  $\text{CH}_2\text{O}$ ); OH is not specifically observed.

Analysis for structure (Ia) follows:

$^{31}\text{P}$  NMR contains three major peaks for samples derivatized with N,O-bis-(trimethylsilyl)trifluoroacetamide: -19.2 ppm., 1 part, corresponding to structure (I); -22.2 ppm., 4 parts, corresponding to structure (Ia); and -30.3 ppm., 1 part, corresponding to phosphoric acid. Traces of Ib are usually present.

#### Example 4



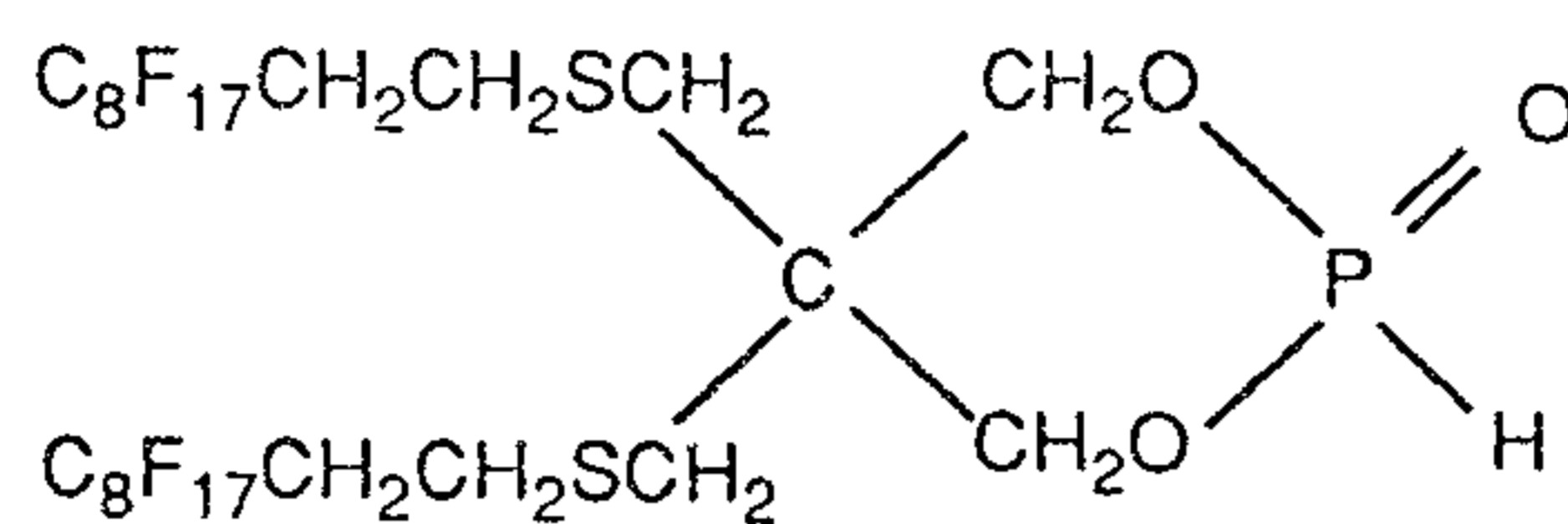
where  $\text{R}_f$  is  $\text{C}_6\text{F}_{13}$ -,  $\text{C}_8\text{F}_{17}$ -,  $\text{C}_{10}\text{F}_{21}$ - in ratio of 4.7/93.0/1.6.

#### 5,5-Bis(1,1,2,2-tetrahydroperfluoroalkylsulfonylmethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane

5,5-Bis(1,1,2,2-tetrahydroperfluoroalkylsulfonylmethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane (36.0 g, 0.032 mol) and acetic acid (48.0 g, 0.80 mol) are charged to a three-necked flask and heated to  $40^\circ\text{C}$ . Hydrogen peroxide (30%, 7.0 g) is added, and the reaction mixture is agitated for one hour under nitrogen. Additional hydrogen peroxide (30%, 14.0 g) is added, and the mixture is heated to  $100^\circ\text{C}$  for  $4\frac{1}{2}$  hours with agitation under nitrogen. The temperature is dropped to room temperature, and the crude product, a pale yellow solid, is isolated by vacuum filtration, washed several times with water and dried under high vacuum over Drierite and potassium hydroxide, yielding a white solid (30.1 g, 82% of theory), m.p.  $285\text{-}290^\circ\text{C}$ .  $^{31}\text{P}$  NMR gives a major peak at -19.0 ppm.  $^1\text{H}$  NMR gives proton resonances at 2.90 ppm., complex, 4 protons, (2 x  $\text{R}_f\text{CH}_2$ ); 3.70 ppm., complex, 4 protons, (2 x  $\text{R}_f\text{CH}_2\text{CH}_2$ ); 4.01 ppm., singlet, 4 protons,

(2 x  $\text{SO}_2\text{CH}_2$ ); 4.65 ppm., doublet, 4 protons, (2 x  $\text{CH}_2\text{O}$ ); OH is not specifically observed.

### Example 5



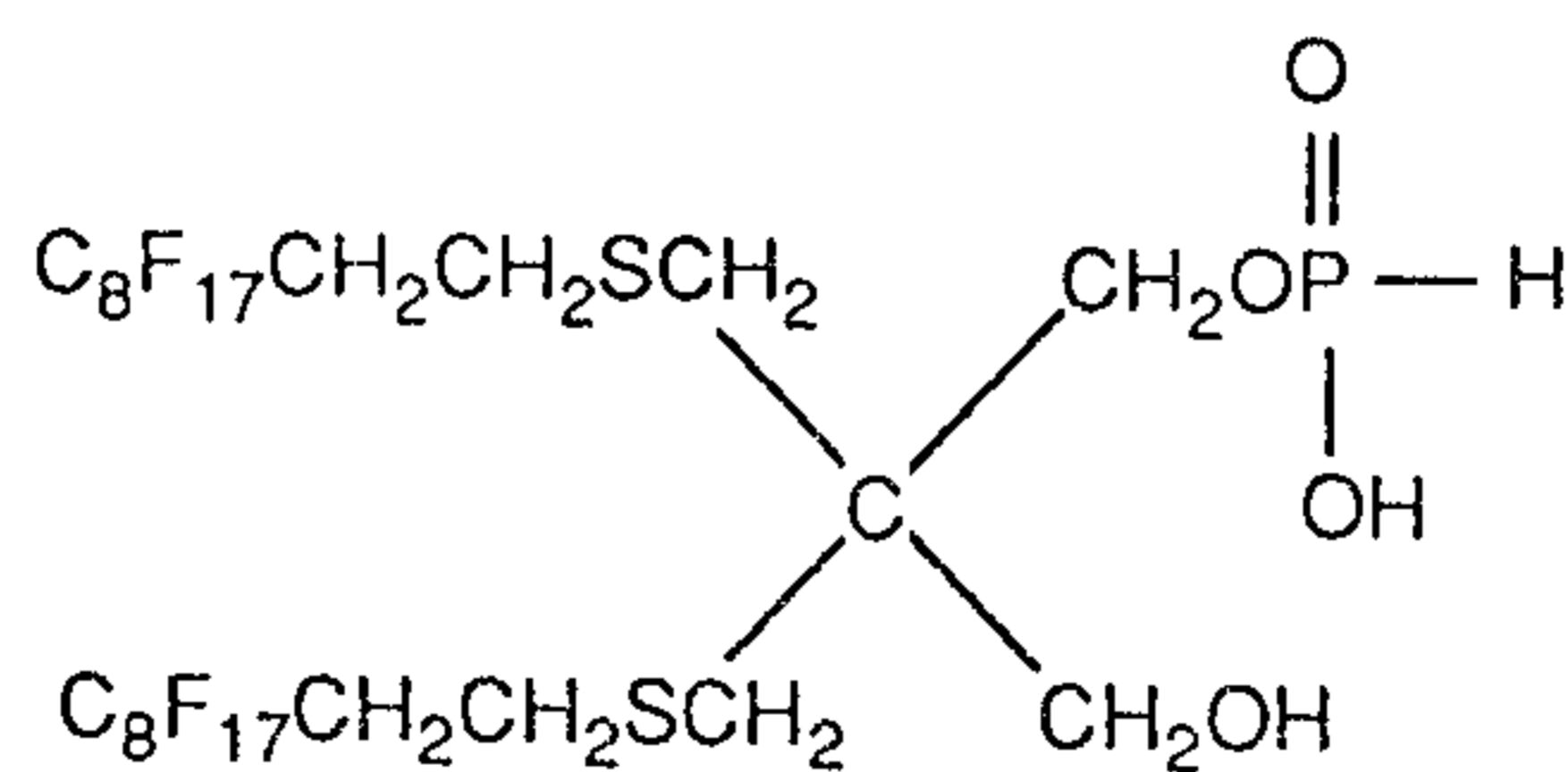
### 5,5-Bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane

2,2-Bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-1,3-propanediol (10.0 g, 0.0094 mol), diethyl phosphite (2.3 g, 0.014 mol) and sodium methoxide (25%, catalytic amount) are charged to a three-necked flask. The reaction mixture is heated to 140°C for 4½ hours with agitation under nitrogen and then cooled to room temperature. The crude product is triturated with ether, isolated by vacuum filtration and dried under high vacuum, yielding a white solid (10.22 g, 97% of theory), m.p. 107-110°C, 96% purity by GLC.  $^{31}\text{P}$  NMR shows a major peak at 3.5 ppm.  $^1\text{H}$  NMR shows proton resonances at 2.41 ppm., complex, 4 protons, (2 x  $\text{C}_8\text{F}_{17}\text{CH}_2$ ); 2.80 ppm., triplet, 4 protons, (2 x  $\text{CH}_2\text{CH}_2\text{S}$ ); 2.82 ppm., singlet, 4 protons, (2 x  $\text{SCH}_2\text{C}$ ); 4.30 ppm., complex, 4 protons, (2 x  $\text{CH}_2\text{O}$ ).

Analysis for  $\text{C}_{25}\text{H}_{17}\text{F}_{34}\text{O}_3\text{PS}_2$ :

Calculated: C, 27.0%; H, 1.5%; F, 58.1%;  
 Found: C, 26.9%; H, 1.5%; F, 56.9%.

### Example 6

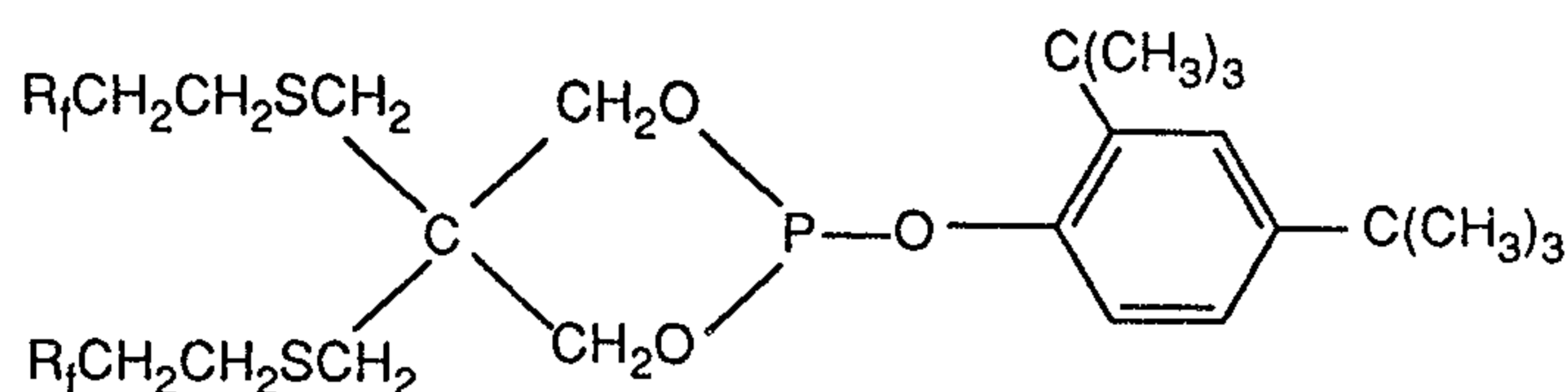


### 2,2-Bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-3-hydroxy-1-propyl Hydrogen

Phosphite

Hydrolysis of the compound prepared in Example 5, 5,5-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-2-hydro-2-oxo-1,3,2-dioxaphosphorinane, yields the monophosphite.

$^1\text{H}$  NMR of this product gives proton resonances at 2.48 ppm., complex 4 protons, ( $2 \times \text{C}_8\text{F}_{17}\text{CH}_2$ ); 2.70 ppm., singlet, 4 protons, ( $2 \times \text{SCH}_2$ ); 2.83 ppm., triplet, 4 protons, ( $2 \times \text{CH}_2\text{S}$ ); 3.54 ppm., singlet, 2 protons, ( $\text{CH}_2\text{OH}$ ); 3.7 ppm., doublet, 2 protons, ( $\text{CH}_2\text{OP}$ ); OH is not specifically observed. Traces of 2,2-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-1,3-propanedihydrogenphosphite are usually present.

Example 7

where  $R_f$  is  $\text{C}_6\text{F}_{13}$ -,  $\text{C}_8\text{F}_{17}$ -,  $\text{C}_{10}\text{F}_{21}$ - in ratio of 4.7/93.0/1.6.

2-(2,4-di-tert-butylphenoxy)-5,5-bis-(1,1,2,2-tetrahydrofluoroalkylthiomethyl)-1,3,2-dioxaphosphorinane

2,2-Bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3-propanediol (53.0 g, 0.05 mol), triethyl phosphite (18.6 g, 0.06 mol), 2,4-di-tert-butylphenol (13.52 g, 0.07 mol) and sodium methoxide (25%, catalytic amount) are charged to a three-necked flask. The reaction mixture is heated to  $140^\circ\text{C}$  with agitation for five hours under high vacuum to drive off phenol by-product. GLC still shows incomplete reaction. Thus, the temperature is raised to  $195^\circ\text{C}$ , and the reaction mixture is agitated for an additional 5 hours, when GLC shows 50% completion. Toluene is added and the reaction mixture is cooled to room temperature and vacuum filtered. The product is present in the filtrate (clear yellow liquid). For analytical purposes, flash chromatography is performed on one-third of the filtrate (75 g) using a 95:5 hexane to ethyl acetate solvent system. This procedure yields 3.93 g of a white solid, m.p.  $98-99^\circ\text{C}$ , 96% purity by GLC. A trace amount of triisopropanolamine is added to prevent decomposition.  $^1\text{H}$  NMR shows proton resonances at 1.32 ppm., singlet, 9 protons, [ $p\text{-C}(\text{CH}_3)_3$ ]; 2.40 ppm., complex, 4 protons, ( $2 \times \text{R}_f\text{CH}_2$ );

2.48 ppm., singlet, 2 protons, (2 x SCH<sub>2</sub> axial); 2.75 ppm., complex, 2 protons, (2 x SCH<sub>2</sub> equatorial); 3.84 ppm., triplet, 2 protons, (2 x CCH<sub>2</sub>O equatorial); 4.48 ppm., complex, 2 protons, (2 x CCH<sub>2</sub>O axial); 6.98 ppm., doublet, 1 proton, (POCCH); 7.18 ppm., complex, 1 proton, [C(CH<sub>3</sub>)<sub>3</sub>CHC(CH<sub>3</sub>)<sub>3</sub>]; 7.40 ppm., doublet, 1 proton, (POCCHCH).

Analysis for C<sub>39</sub>H<sub>37</sub>F<sub>34</sub>O<sub>3</sub>PS<sub>2</sub>:

Calculated: C, 36.1%; H, 2.9%; F, 49.6%;  
 Found: C, 35.9%; H, 2.5%; F, 49.7%.

#### Examples 8 to 14

Using the methods described and by techniques similar to Examples 1 to 6, the following additional phosphates/phosphites where X is -S-, -SO<sub>2</sub>-, -O-, -NR-, -CONH- and -SO<sub>2</sub>NR- are prepared.

<u>Ex.</u>	<u>Perfluoroalkyl Glycol</u>	<u>Phosphate/Phosphite (Type)</u>
8	(CF <sub>3</sub> CF <sub>2</sub> CH <sub>2</sub> SCH <sub>2</sub> ) <sub>2</sub> C(CH <sub>2</sub> OH) <sub>2</sub>	I
9	(C <sub>6</sub> F <sub>13</sub> (CH <sub>2</sub> ) <sub>4</sub> SO <sub>2</sub> CH <sub>2</sub> ) <sub>2</sub> C(CH <sub>2</sub> OH) <sub>2</sub>	II
10	(C <sub>8</sub> F <sub>17</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OCH <sub>2</sub> ) <sub>2</sub> C(CH <sub>2</sub> OH) <sub>2</sub>	Ia
11	(C <sub>8</sub> F <sub>17</sub> CH <sub>2</sub> CH <sub>2</sub> N(CH <sub>3</sub> )CH <sub>2</sub> CH <sub>2</sub> SCH <sub>2</sub> ) <sub>2</sub> C(CH <sub>2</sub> OH) <sub>2</sub>	Ia
12	(C <sub>8</sub> F <sub>17</sub> SO <sub>2</sub> NHCH <sub>2</sub> CH <sub>2</sub> OCH <sub>2</sub> ) <sub>2</sub> (CH <sub>2</sub> OH) <sub>2</sub>	Ib
13	(C <sub>8</sub> F <sub>17</sub> CH <sub>2</sub> CH <sub>2</sub> SO <sub>2</sub> NHCH <sub>2</sub> CH <sub>2</sub> SCH <sub>2</sub> ) <sub>2</sub> C(CH <sub>2</sub> OH) <sub>2</sub>	IIa
14	(C <sub>7</sub> H <sub>15</sub> CONHCH <sub>2</sub> CH <sub>2</sub> SCH <sub>2</sub> ) <sub>2</sub> C(CH <sub>2</sub> OH) <sub>2</sub>	II

#### Example 15

This example describes comparative internal size performance evaluations of the subject 5,5-bis(perfluoroalkylthiomethyl)-2-hydroxy-2-oxy-1,3,2-dioxaphosphorinane, triethanolammonium salts, Examples 2 and 3a versus a commercial phosphate size, a bis-perfluoroalkyl phosphate ester, ammonium salt. The subject phosphoric acids are prepared in water as triethanolamine salts with an excess of triethanolamine.

The results indicate equivalent performance.

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Hold-out Tests

<u>Fluorine on Wt. of Paper</u>	<u>Oil Kit Number</u>	<u>Hot, 110°C Corn Oil</u>	<u>Hot, 80°C Water + 0.5% TRITON X-165</u>
Compound of	4	> 20 min.	> 20 min.
Ex. 2 0.05	4	> 20 min.	> 20 min.
Ex. 3a 0.05	4	> 20 min.	> 20 min.
5 FC-807 0.05	4	> 20 min.	> 20 min.

Example 16

This example describes comparative external size performance of the subject 5,5-bis-(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane, (Example 3a); its mixture with the acyclic acid ester, 2,2-bis(1,1,2,2-tetrahydroperfluoro-  
 10 alkylthiomethyl)-3-hydroxy-1-propyl dihydrogen phosphate (Example 3b), both as triethanolammonium salts, and SCOTCHBAN<sup>\*</sup> FC-807 (3M). The products are applied to paper by pad application and tested for Oil Kit Rating and the Grease Resistance Test.

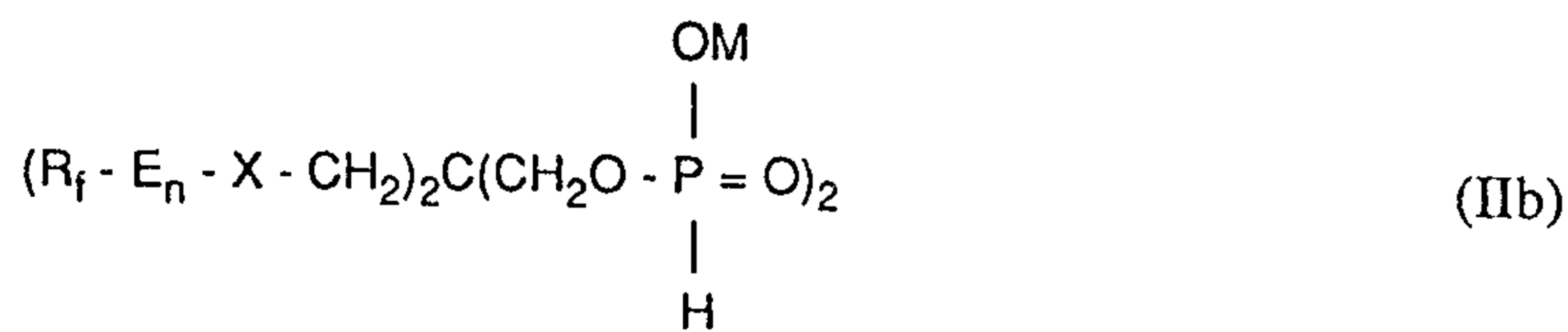
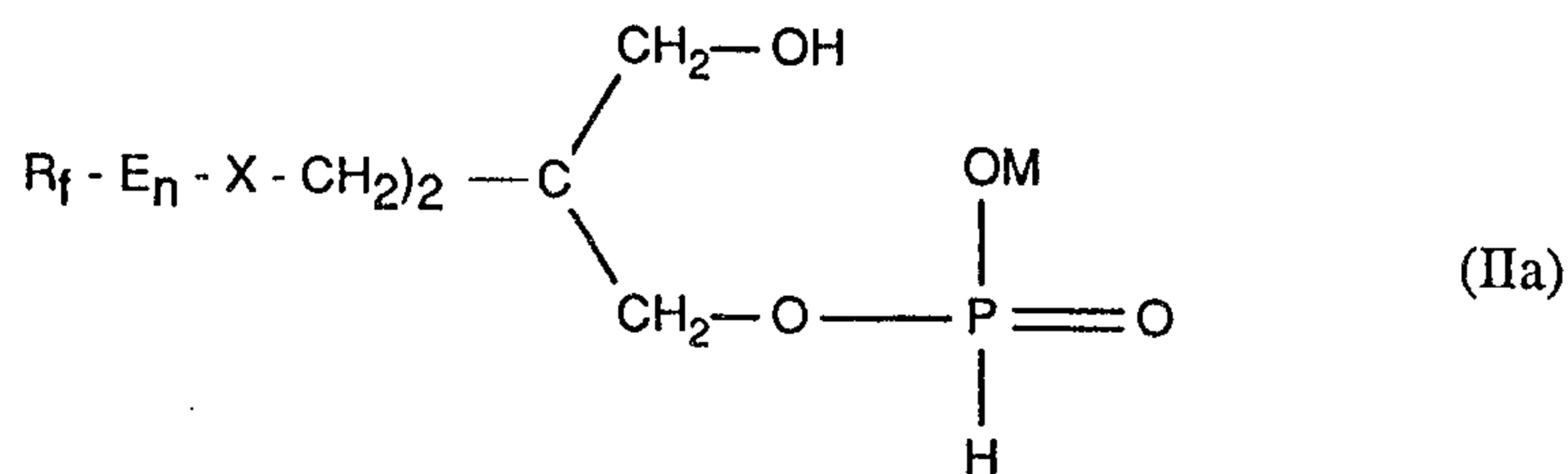
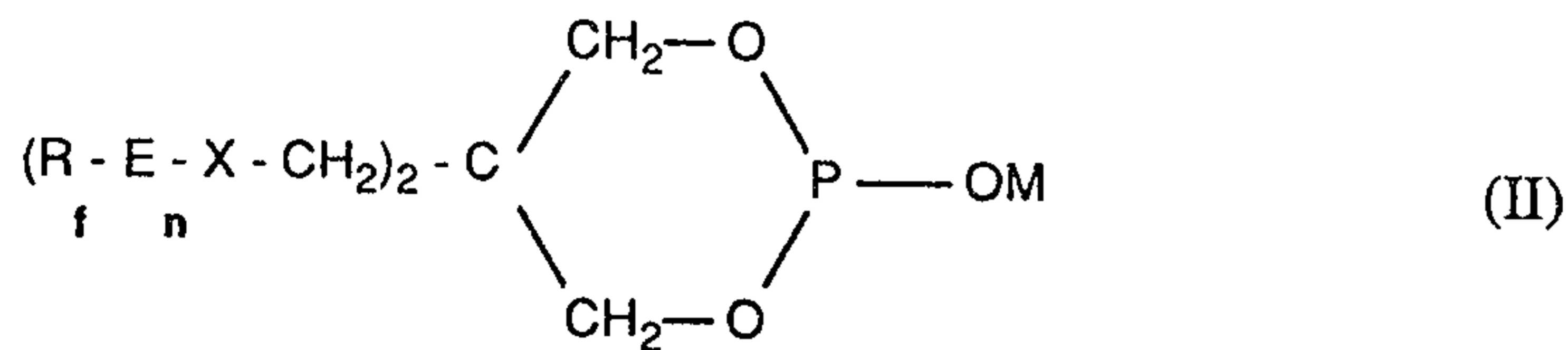
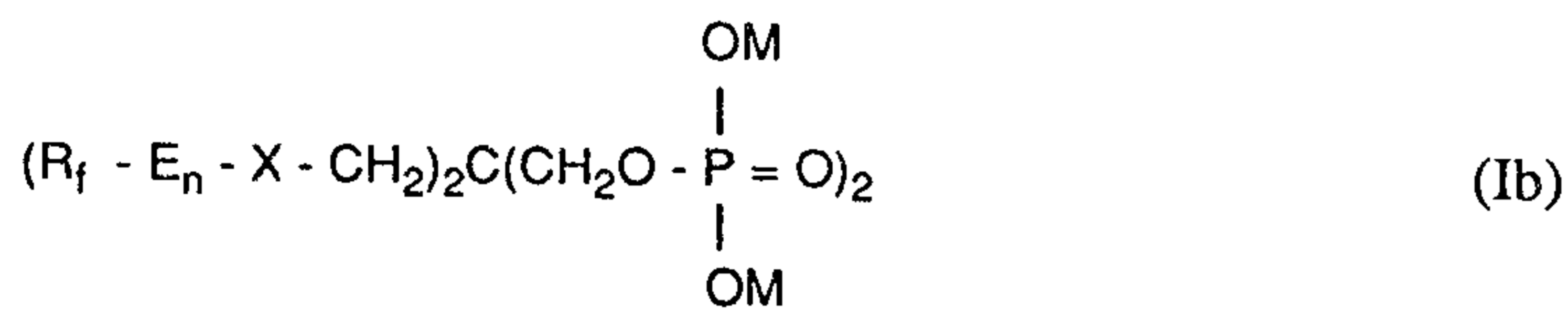
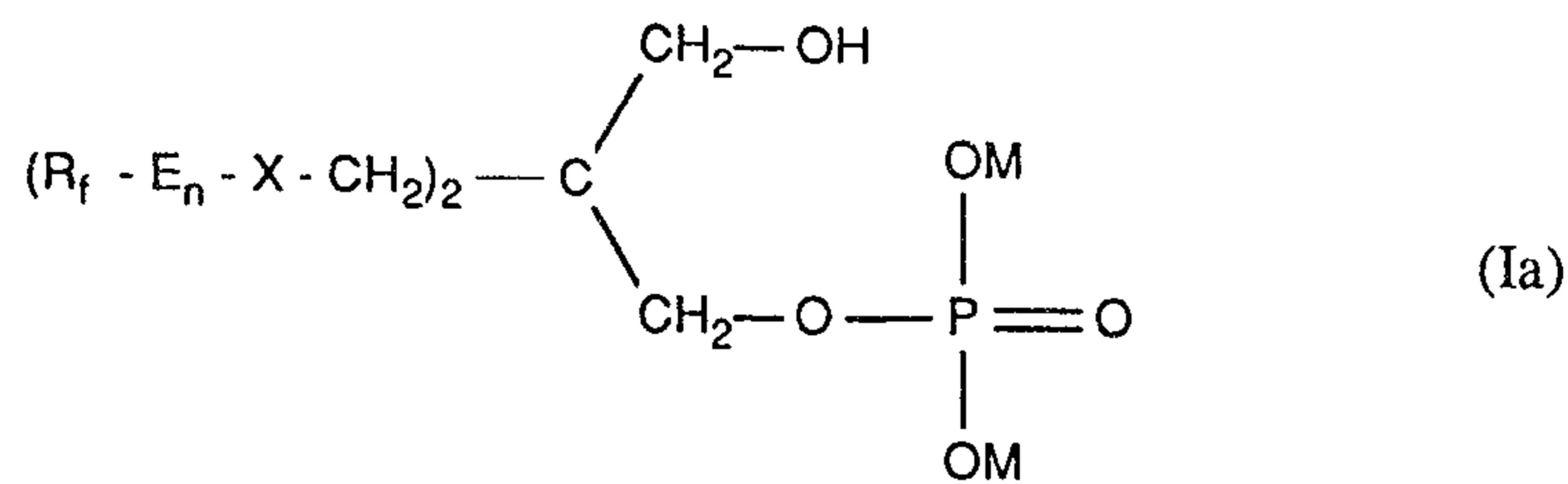
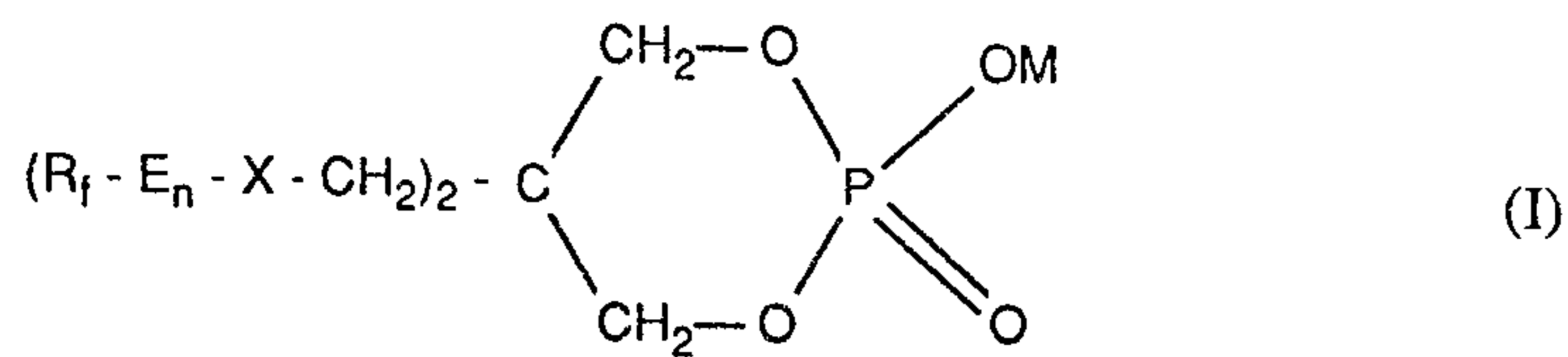
The results show that the subject phosphates have superior performance at much lower application levels. Further, the novel phosphates have the potential to pass the Grease  
 15 Resistance Test at lower Kit Numbers. This allows their application to products requiring better adhesive bonding, better label adhesion, and lessened problems with printing.

<u>% Fluorine on Wt. of Paper</u>	<u>Oil Kit Number</u>	<u>Grease Resistance Test</u>
Compound of		
Ex. 3a 0.045	7	pass
20 Ex. 3b 0.045	5	pass
FC-807 0.065	6-7	pass

\*Trade-mark

WHAT IS CLAIMED IS:

1. A compound of formula I, Ia, Ib, II, IIa and IIb:



wherein  $R_f$  is a straight or branched chain perfluoroalkyl of 2 to 12 carbon atoms or

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perfluoroalkyl of 2 to 6 carbon atoms substituted by perfluoroalkoxy of 2 to 6 carbon atoms,

$n = 1$  or  $0$ , and when  $n = 1$ ,

E is a branched or straight chain alkylene of 2 to 10 carbon atoms or said alkylene  
 5 interrupted by one to three groups selected from the group consisting of -NR-, -O-, -S-,  
 -SO<sub>2</sub>-, -COO-, -OOC-, -CONR-, -NRCO-, -SO<sub>2</sub>NR- and -NRSO<sub>2</sub>-, or terminated at the R<sub>f</sub>  
 end with -CONR- or -SO<sub>2</sub>NR-, where R<sub>f</sub> is attached to the carbon or sulfur atom, and X is  
 -S-, -O-, -SO<sub>2</sub>-, or -NR-, and when  $n = 0$ , X is a direct bond, -CONR- or -SO<sub>2</sub>NR-, where  
 R<sub>f</sub> is attached to the carbon or sulfur atom, and where R is independently hydrogen, alkyl  
 10 of 1 to 6 carbon atoms or hydroxyalkyl of 2 to 6 carbon atoms, and M is independently  
 hydrogen, lower alkyl, an alkyl- or mixed polyalkyl-substituted aromatic group, or  
 represents an ammonium, organoammonium, alkali metal or alkaline earth metal salt of  
 the respective phosphite or phosphate group.

2. A compound of formula I, Ia, Ib, II, IIa and IIb according to claim 1 wherein R<sub>f</sub> is a  
 15 straight or branched chain perfluoroalkyl of 2 to 12 carbon atoms.

3. A compound of formula I, Ia, Ib, II, IIa and IIb according to claim 1 or 2, wherein R<sub>f</sub> is  
 a straight or branched chain perfluoroalkyl of 2 to 12 carbon atoms, E is alkylene of 2 to 6  
 carbon atoms, -CONHCH<sub>2</sub>CH<sub>2</sub>-, -CH<sub>2</sub>CH<sub>2</sub>N(CH<sub>3</sub>)CH<sub>2</sub>CH<sub>2</sub>-, -CH<sub>2</sub>CH<sub>2</sub>SO<sub>2</sub>NHCH<sub>2</sub>CH<sub>2</sub>-,  
 -CH<sub>2</sub>CH<sub>2</sub>OCH<sub>2</sub>CH<sub>2</sub>-, or -SO<sub>2</sub>NHCH<sub>2</sub>CH<sub>2</sub>-, and X is -S-, -SO<sub>2</sub>- or -O- .

4. A compound of formula I, Ia, Ib, II, IIa and IIb according to any one of claims 1 to 3,  
 20 wherein R<sub>f</sub> is perfluoroalkyl of 6 to 12 carbon atoms, E is ethylene and X is -S-.

5. A compound according to any one of claims 1 to 4, wherein M is  
 ammonium or organoammonium.

6. A compound according to any one of claims 1 to 5 which is  
 5,5-bis(1,1,2,2-perfluorodecylthiomethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane.

25 7. A compound according to any one of claims 1 to 5 which is  
 5,5-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-2-  
 hydroxy-2-oxo-1,3,2-dioxaphosphorinane, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-,  
 C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>- .

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8. A compound according to any one of claims 1 to 5 which is 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-3-hydroxy-1-propyl dihydrogen phosphate, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.
- 5 9. A compound according to any one of claims 1 to 5 which is 2,2-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3-propanedihydrogen phosphate, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.
10. A compound according to any one of claims 1 to 5  
10 which is 5,5-bis(1,1,2,2-tetrahydroperfluoroalkylsulfonylmethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinane, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.
11. A compound according to any one of claims 1 to 5  
15 which is 5,5-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-1,3,2-dioxaphosphorinane, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.
12. A compound according to any one of claims 1 to 5  
20 which is 2,2-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-3-hydroxy-1-propyl hydrogen phosphite, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.
13. A compound according to any one of claims 1 to 5  
25 which is 2,2-bis(1,1,2,2-tetrahydroperfluorodecylthiomethyl)-1,3-propanedihydrogenphosphite, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.
14. A compound according to any one of claims 1 to 5  
30 which is 2-(2,4-di-tert-butyl-phenoxy)-5,5-bis(1,1,2,2-tetrahydroperfluoroalkylthiomethyl)-1,3,2-dioxaphosphorinane, where "perfluoroalkyl" is a mixture of C<sub>6</sub>F<sub>13</sub>-, C<sub>8</sub>F<sub>17</sub>-, C<sub>10</sub>F<sub>21</sub>-, C<sub>12</sub>F<sub>25</sub>- and C<sub>14</sub>F<sub>29</sub>-.

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15. An ammonium or organoammonium salt of the compound according to any one of claims 6 to 14.

16. A method of preparing 5,5-Bis(perfluoroalkylheteromethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinanes comprising the step of cyclization of heteroatom containing perfluoroalkyl terminated neopentyl glycols of the formula  $\text{HO}[\text{CH}_2\text{C}(\text{CH}_2\text{-X-E}_n\text{-R}_f)_2\text{CH}_2\text{O}]\text{H}$

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with appropriate phosphorus containing esters or acids.

17. Use of the compounds of any one of claims 1 to 15 as coatings on paper, textiles, glass, linoleum, leather, wood, tile, metals, plastics or paper.
- 5 18. Use according to claim 17 wherein the coating substrate is paper.
19. Use of the compounds of any one of claims 1 to 15 as polymer stabilizers.
20. An aqueous dilution for topical application containing
- (a) 0.01 to 5% by weight of the amine salt of the acyclic phosphorus acid of 5,5-Bis-  
10 (perfluoroalkylheteromethyl)-2-hydroxy-2-oxo-1,3,2-dioxaphosphorinanes;
- (b) 0 to 3% by weight emulsifier;
- (c) 0 to 5% water repellent assistant, filler, bacteriostat, coloring agent or surface conditioner adjuvant;
- (d) 0 to 10% sizing agent, and
- 15 (e) the remainder water.

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**Patent Agents**