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NEW CHEMICAL COMPOUNDS

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This invention relates to new chemical compounds suitable for use as boundary lubricants. The invention also relates to methods of preparing these compounds, and to compositions of matter which contain them and which are suitable for use as boundary lubricants.

Boundary lubricants are effective in lubricating surfaces, particularly metal surfaces, which are sliding relative to one another under boundary conditions.

We have found that quaternary ammonium pyrophosphate salts as hereinafter defined, which are new compounds, may be prepared as hereinafter described, and may be used either alone or in suitable compositions of matter to provide effective boundary lubricants.

According to the present invention, therefore, we provide quaternary ammonium pyrophosphate compounds as hereinafter defined, which are new chemical compounds, and which are suitable for use as boundary lubricants. Also according to the present invention, we provide processes for the production of quaternary ammonium pyrophosphate compounds as hereinafter defined. The present invention also provides compositions of matter suitable for use as boundary lubricants which comprise one or more quaternary ammonium pyrophosphate compounds as hereinafter defined and one or more suitable liquid or solid vehicles in which the pyrophosphate compound or compounds may be dissolved or dispersed.

The quaternary ammonium pyrophosphate compounds of the present invention are salts in which two or four hydrogen atoms of pyrophosphoric acid are replaced by quaternary ammonium groups, the nitrogen atom of each of which is attached to at least one radical containing at least one alkyl group having six or more carbon atoms.

Suitable quaternary ammonium groups include cetyl trimethyl ammonium, didecyl dimethyl ammonium, cetyl pyridinium, tetradecyl pyridinium, lauryl benzyl dimethyl ammonium, octyl phenoxy-ethyl benzyl diethyl ammonium, di-octyl dimethyl ammonium, stearamido benzyl dimethyl ammonium.

Suitable liquid vehicles in which the pyrophosphate compounds of this invention may be dissolved or dispersed to provide boundary lubricants include hydrocarbons, mineral oils, vegetable oils such as castor oil, siloxane oils, aliphatic esters and alkylene glycols. Suitable solid vehicles include hydrocarbons such as petroleum jelly, animal fats, vegetable and mineral grease-like substances, solid siloxane compounds, fatty acids and soaps and esters thereof. These vehicles may be used singly, or in combination with one another, and may be mixed with one or more pyrophosphate compounds.

The pyrophosphate compounds of this invention are in general water-soluble grease-like solids. The nature of the compositions of matter of this invention may be varied by selection of the proportion of pyrophosphate compound or compounds chosen, and by selection of the vehicle or vehicles. If, for example, a boundary lubricant of comparatively low viscosity is required, then a suitable liquid vehicle is chosen, and a small proportion of pyrophosphate is dissolved or dispersed therein. If the proportion of pyrophosphate compound in a liquid vehicle is increased, then the viscosity of the resultant product is also increased. On the other hand, a composition having a high viscosity but containing only a small proportion of pyrophosphate compound may be obtained by selecting a suitable solid or semi-solid vehicle.

The preparation of pyrophosphate compounds of this invention is illustrated in the following examples:

EXAMPLE 1

200 gms. of a suitable ion-exchange resin such as that sold under the British registered trademark "Amberlite" IRA–400 (polystyrene quaternary ammonium type) packed in a column 1 inch in diameter and 18 inches long were activated by contact with 2 litres of a 5% by weight aqueous solution of sodium hydroxide, and washed with water until the washings, which were rejected, gave a pH of 7–8.

400 mls. of a 10% by weight aqueous solution of cetyl trimethyl ammonium bromide were repeatedly passed through the column until no bromide ion was detected in the collected drainings, which thus contained cetyl trimethyl ammonium hydroxide. The complete removal of bromide ion from the drainings was facilitated by reactivating the column in the manner described previously, and then continuing the passage of the collected drainings containing cetyl trimethyl ammonium hydroxide.

An aqueous solution of phosphoric oxide (P_2O_5) was prepared equivalent to a N solution of pyrophosphoric acid. Approximately 57 mls. of this solution were needed to adjust 225 mls. of the collected drainings from the column to a pH of 4.5. The resulting solution was evaporated under vacuum and the product was finally dried over phosphoric oxide in a vacuum desiccator, yielding 5.8 gms. of a whitish-yellow grease having the following analysis:

N 3.6% P_2O_5 18.3%

This compared with a theoretical analysis for di(cetyl trimethyl ammonium)dihydrogen pyrophosphate of:

N 3.8% P_2O_5 19.1%

EXAMPLE 2

250 mls. of a solution of cetyl trimethyl ammonium hydroxide, prepared according to the method in Example 1, were adjusted to a pH of 8.5 by the addition of a solution of phosphoric oxide (P_2O_5) prepared according to Example 1. Two liquid layers formed, and the upper layer after separation was dried over phosphoric oxide (P_2O_5) in a vacuum desiccator to yield 9.5 gms. of a yellow grease having the following analysis:

N 3.0% P_2O_5 9.1%

This compared with a theoretical analysis for tetra-(cetyl trimethyl ammonium) pyrophosphate of

N 4.3% P_2O_5 10.8%

EXAMPLE 3

This example illustrates an alternative method of preparing tetra-pyrophosphate salts according to this invention.

200 gms. of the ion-exchange resin sold under the British registered trademark "Amberlite" IRA–400 (polystyrene quaternary ammonium type) in a column 1 inch in diameter and 18 inches long were activated by contact with an aqueous solution containing 5% by weight

of tetra-sodium pyrophosphate and then washed with water until the washings, which were rejected, gave a pH of 7–8.

310 mls. of a solution of cetyl trimethyl ammonium hydroxide, prepared according to the method given in Example 1, were adjusted to a pH of 7.0 with an aqueous N solution of sulphuric acid. The resultant solution was then passed repeatedly down the column of ion exchange resin which had been activated with sodium pyrophosphate solution. The passage of liquid was continued until the collection drainings were free from sulphate ion. The collected drainings were then evaporated under reduced pressure and finally dried over phosphoric oxide in a vacuum desiccator, yielding 0.7 gms. of a waxy solid.

The pyrophosphate compounds as such prepared in the foregoing examples were found to be effective lubricants between pairs of mild steel and stainless steel surfaces sliding relative to one another under boundary conditions. The value of this effect is particularly important in the case of austenitic stainless steel surfaces, as it is well known to be very difficult to lubricate such surfaces under boundary conditions.

The following table gives the coefficient of friction between austenitic stainless steel surfaces sliding at a speed of 0.08 cm. per second relative to one another, and lubricated with the pyrophosphate compounds of the foregoing examples at temperatures of 20–200° C. Comparable results using petroleum jelly alone are also given.

Table

Lubricant	Coefficient of friction at 0.08 cms./second							
	20° C.	60° C.	100° C.	120° C.	140° C.	160° C.	180° C.	200° C.
D.C.D.H.	0.09	0.10	0.05	0.05	0.05	0.05	0.05	0.03
T.C.(2)	0.07	0.07	0.07	0.07	0.06	0.05	0.06	0.05
T.C.(3)	0.15	0.14	0.14	0.14	0.13	0.13	0.12	0.13
Petroleum Jelly	0.13	0.17	0.18	0.18	0.20	0.20	0.21	0.19

D.C.D.H.—Di(cetyl trimethyl ammonium) dihydrogen pyrophosphate.
T.C.(2)—Tetra(cetyl trimethyl ammonium) pyrophosphate prepared according to Example 2.
T.C.(3)—Tetra(cetyl trimethyl ammonium) pyrophosphate prepared according to Example 3.

We claim:

1. Di(cetyl trimethyl ammonium) dihydrogen pyrophosphate.

2. Tetra(cetyl trimethyl ammonium) pyrophosphate.

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