Cation-exchange Properties of Phosphoantimonic(V) Acid

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Limitation of the use of organic ion-exchange resins, in recent years, brought much attention to the development of synthetic inorganic ion exchangers[1,2].

This paper describes some of the ion-exchange properties of phosphoantimonic(V) acid recently discovered. The experimental results indicate that the material is one of the very promising ion exchangers.

Experiment was made with an attempt to obtain the precipitate which was composed of antimony pentoxide and phosphoric acid. When antimony pentachloride was poured in the aqueous solution of phosphoric acid, the rate of formation of the precipitate obtained by the hydrolysis of the said chloride became extremely slow as the concentration of phosphoric acid increased. In case that the concentration of phosphoric acid was suitable relative to that of antimony pentachloride, gelatinous precipitate which was very difficult to filter was gradually formed in warming the solution. After filtering under suction and drying at 80°C, glassy materal was obtained. The material was physically and chemically stable against water, salt solutions and solutions of strong mineral acids, and showed strong cation-exchange properties even in dilute acid solutions.

When the material was added to 0.1 M ammonium nitrate solution its pH fell rapidly at first and then reached to a stational value (approximately 1.8), due to the liberation of H^+ produced by exchange with the cation in the solution. The adsorption of NH_4^+ on the material was 1.4 meq./g.

The analytical results of the glassy material indicate that the mole ratio of antimony pentoxide to phosphorus pentoxide contained was about 2 : 1.

This new material was provisionally given a name of "Phosphoantimonic Acid". This glassy acid was able to exchange reveresibly its H^+ with NH_4^+, alkali, alkaline earth and other metal ions (e. g. Ag, Cu etc.).

As one example of ion-exchange reversibility, 0.1 M ammonium nitrate solution was passed down a column (0.8 cm² × 7 cm.) filled with this glassy ion exchanger of H-form. H^+ was liberated as a result of quantitative adsorption of NH_4^+. The adsorbed NH_4^+ was quantitatively eluted by treatment with 3 N nitric acid.

Extremely interesting is the strong adsorption of K^+ on the material in acid solutions. When the 0.01 M potassium chloride solution

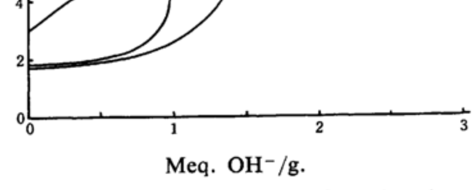

Fig. 1. pH-titration curve for phosphoantimonic acid.

I : 0.01 N H_2SO_4 100 ml.
II : Phosphoantimonic acid
III : Zirconium phosphate (quoted from Ref. 2)

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[1] K. A. Kraus, H. O. Philips, T. A. Carlson and J. S. Johnson, Paper 1832 presented at the 2nd International Conference of the Peaceful Uses of Atomic Energy, Geneva, 1958.

[2] C. B. Amphlett, L. A. McDonald and M. J. Redman, *J. Inorg. & Nuclear Chem.*, 6, 220 (1958).

was added to a column in [H-form, K^+ was adsorbed very easily and completely just as NH_4^+ done. The adsorbed K^+ could not eluted even by treatment with 3 N hydrochloric acid or 3 N nitric acid and it was, however, easily eluted with 1 M ammonium nitrate solution. It seemed to us that the abnormal absorbability on this material in strong acid solution might be perhaps attributed to the unordinary structure of phosphoantimonic acid.

The pH-titration curve of the glassy material showed that it was a strong monobasic acid (Fig. 1). It seems extremely possible that phosphoantimonic acid shows strong acid cation-exchange property, because antimonic acid (formally, hexahydroxyl antimonic acid $H[Sb(OH)_6]$) itself is monobasic and has the same strength of acidity as that of acetic acid (viz. dissociation constant; $H[Sb(OH)_6]=4\times10^{-5}$, $CH_3COOH=1.66\times10^{-5}$).

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