Studies of the Behaviors of Carrier-free Radioisotopes. I. The Coprecipitation of Cadmium-115 with Ferric Hydroxide

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It is well-known that some carrier-free radioisotopes are coprecipitated with ferric hydroxide. The mechanism of the coprecipitation is not always identical, however. There are four groups of elements which are coprecipitated with ferric hydroxide; the first, the cations which are precipitated as insoluble hydroxides when a macro quantity of the cation exists in the solution (rare earths, etc.); the second, the cations which are not precipitated as hydroxides (strontium, etc.); the third, the anions which form insoluble compounds with ferric ions in the solution of a macro concentration (phosphate, etc.); the last, the anions which do not form insoluble compounds with ferric ions (sulfate, etc.).

In the present paper, the coprecipitation behavior of carrier-free cadmium with ferric hydroxide will be studied.

Experimental

A mixture of cadmium-115g (53 h) and cadmium-115m (43 d) was used as a carrier-free tracer of cadmium. These radioisotopes were separated from the uranium target, which was bombarded with 50 MeV. protons by the synchrocycrorton at the

Institute for Nuclear Study, the University of Tokyo. The target was dissolved into a few milliliters of 8 N nitric acid, and the cadmium was separated from uranium and other fission products by means of ion-exchange and coprecipitation techniques. According to the γ-ray spectrum and the decay curve of the cadmium fraction, only cadmium-115m, cadmium-115g and its daughter, indium-115m, could be detected.

The cadmium-115 solution, the ferric chloride solution, and the carrier or hold-back carrier solution were mixed in a 10~15 ml. centrifugal tube; then a freshly-prepared ammonium hydroxide or sodium hydroxide solution was added to this tube, and the contents were centrifuged. The radioactivities of the initial and supernatant solutions were measured by a scintillation counter after the two days which were required to obtain radioequilibrium between cadmium-115g and indium-115m. The coprecipitation ratio was calculated from these data.

Results and Discussion

The coprecipitation ratio of cadimium was measured as a function of the ferric, cadmium, ammonium and other ion concentrations.

It is to be expected that cadmium will form stable ammine complex ions in the presence of ammonium ions and will not be coprecipitated with ferric hydroxide. However, when ammonium hydroxide was used as a precipitant, about half the amount of carrier-free cadmium was coprecipitated with 10 mg. ferric hydroxide. This ratio increased logarithmically with the amount of precipitate (cf. Fig. 1). The ratio depended also on the concentration of ammonium ions at a constant pH value. Figure 2 shows this relation and proves that the formation of an ammine complex causes a decrease in the coprecipitation ratio. The cadmium concentration varied from a carrier-free concentration (10^{-12} M) to 1 M. The coprecipitation ratio did not change in concentrations less than 10^{-7} M, whereas in higher concentrations it decreased rapidly, as is shown in Fig. 3.

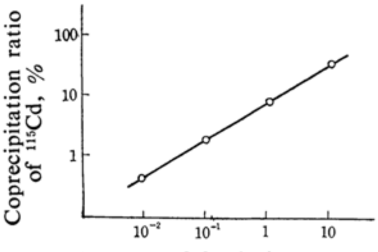

Fig. 1. Coprecipitation ratio of carrier-free cadmium with $Fe(OH)_3$ as a function of the amount of precipitate.

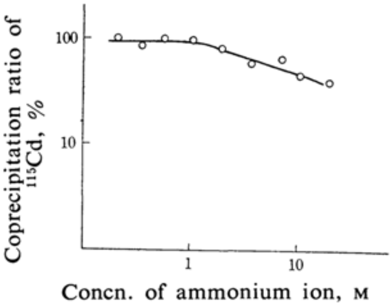

Fig. 2. Coprecipitation ratio of carrier-free cadmium with $Fe(OH)_3$ as a function of ammonium ion concentration.

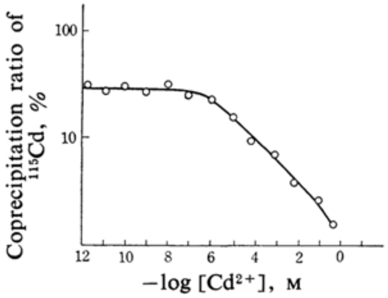

Fig. 3. Coprecipitation ratio of cadmium with $Fe(OH)_3$ as a function of cadmium ion concentration.

The existence of such ions as zinc, cobalt and copper, which form soluble ammine complexes, decreased the coprecipitation ratio of carrier-free cadmium. The addition of barium ions also depressed the coprecipitation.

When sodium hydroxide was used as a precipitant, the carrier-free cadmium was coprecipitated entirely with ferric hydroxide. These facts suggest that: 1) the coprecipitation of carrier-free cadmium is based upon the adsorption of cadmium ions and its ammine complex ions on the negatively-charged surface of ferric hydroxide, 2) the adsorption of ammine complex ions is less than that of simple ions, and 3) the cations which exist in the ammoniacal solution behave as hold-back carriers for carrier-free cadmium because of their occupation of the adsorption surface.

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