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Figure 1

Figure 1: Figure 1

Abstract

Full Text

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ON THE MECHANISM OF COPRECIPITATION OF TRACE AMOUNTS OF YTTRIUM WITH HYDROXIDES OF POLYVALENT METALS

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The method of coprecipitation of trace amounts of radioactive isotopes with hydroxides of polyvalent metals finds wide application in various fields of radiochemistry and the radiochemical industry. In this connection, the study of the mechanism of such coprecipitation is of great scientific and practical importance. It is obvious that the mechanism of such coprecipitation depends both on the properties of the hydroxides and on the state of the microelement in solution. Without dwelling on questions of coprecipitation with hydroxides of microelements present in the form of colloids (1), it should be noted that there is no single point of view regarding the coprecipitation of microelements present in the ionic state. To explain coprecipitation, mechanisms of physical adsorption (2), chemisorption (3), and the formation of mixed hydroxides (4) are invoked.

Fig. 1. Influence of the acidity of the medium on the coprecipitation of yttrium with $Zr(OH)_4$ and $Fe(OH)_3$.
1 –refers to coprecipitation of Y with $Zr(OH)_4$; 2 –to coprecipitation of Y with $Fe(OH)_3$.

We proceed from the assumption that, in the range of medium acidity where yttrium is in the ionic state, its coprecipitation with hydroxides of polyvalent metals ($Fe(OH)_3, Zr(OH)_4$, etc.) should occur by electrostatic physical adsorption, the theory of which was given by Ratner (5). Our treatment of the experimental material of Morachevskii and Novikov (6), concerning the coprecipitation of Y and La with $Ti(OH)_4$, $Fe(OH)_3$, $Al(OH)_3$, and $Be(OH)_2$ from the standpoint of Ratner' s secondary adsorption showed the applicability of this theory. It turned out that, in a certain range of medium acidity, the following equality is obeyed:

$$\sqrt[3]{\frac{x}{a-x}} = \alpha - \beta + \gamma \mathrm{pH}, \qquad (1)$$

which is a consequence of Ratner' s adsorption theory; here α, β, and γ are constants, a is the total content of the microelement in the system, and x is the amount of it that has passed into the precipitate.

To verify the regularity we found, a special experiment was set up. The dependence of the coprecipitation of ^{90}Y without carrier with $\mathrm{Fe(OH)_3}$ and $\mathrm{Zr(OH)_4}$ on the acidity of the medium was studied.

The work was carried out as follows. Into a glass vessel equipped with a mechanical stirrer and electrodes for measuring pH, ···

30 ml of the initial solution*. Then, with continuous stirring, a solution of $\mathrm{NH_4OH}$ free of $\mathrm{CO_2}$ was slowly added to the contents of the vessel in an amount necessary to attain the required acidity of the medium. After this, the volume of the suspension was brought to 50 ml with distilled water. The resulting suspension was stirred for 30 min. As the experiments showed, during this time stabilization of the acidity of the medium occurred and an equilibrium distribution of ^{90}Y between the phases was reached. After completion of the experiment, the solid phase was separated from the solution by centrifugation; the centrifuge tube had first been rinsed no fewer than 5–7 times with the initial suspension in order to attain adsorption saturation of the glass surface of the centrifuge tube. On the basis of the radioactivity values of the solution before and after precipitation, the quantity $\sqrt[3]{x/(a-x)}$ (1) was calculated. Figure 1 shows the dependence of $\sqrt[3]{x/(a-x)}$ on the pH of the solution.

As is evident from Fig. 1, coprecipitation of yttrium with $\mathrm{Fe(OH)_3}$ and $\mathrm{Zr(OH)_4}$ obeys equation (1), and consequently takes place by electrostatic ion-exchange adsorption. As follows from Ratner' s theory (^{5}), the point of intersection of the straight lines corresponds to the isoelectric point of the precipitate. At lower acidity, adsorption proceeds mainly in the outer region of the electrical double layer, whereas at higher acidity it proceeds in the potential-determining layer of the precipitate.

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* As the initial solutions, 0.01 N solutions of $Fe(NO_3)_3$ or $ZrO(NO_3)_2$ were used; in addition to microamounts of Y^{90}, they contained 30 g/liter $NaNO_3$ and 5 g/liter NH_4NO_3.

Note: Figure translations are in progress. See original paper for figures.

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