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Abstract

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STUDY OF THE PROCESS OF DISSOLUTION OF BARIUM SULFATE LABELED WITH TWO RADIOACTIVE INDICATORS

The authors previously reported ([1]) that barium sulfate labeled with radioactive sulfur shows different solubility in water depending on the magnitude of the specific activity of the salt. In the present work, a study was carried out of the dissolution process of $Ba\overset{\times}{S}O_4$, indicated by means of Ba^{140} ($T_{1/2}$ = 13 days), and of $Ba\overset{\times}{S}O_4$, labeled simultaneously with Ba^{140} and S^{35} ($T_{1/2}$ = 87.1 days).

The maximum β-radiation energy of the radioisotopes present has the following values: Ba^{140}–1.02 MeV, its daughter product La^{140}–2.20 MeV, S^{35}–0.167 MeV ([2]). The radiochemical purity of Ba^{140} and S^{35} was checked by absorption of β-radiation with aluminum.

Radioactive $BaSO_4$ preparations were prepared by mixing hot 0.1 N solutions of $BaCl_2$ and Na_2SO_4 containing the corresponding isotopes. The procedure for carrying out the experiments was reported in paper ([1]). The absolute activity of the preparations studied was established by the method described in the literature ([3]). All determinations of the solubility of barium sulfate samples were carried out by measuring the activity of solution samples after establishment of the equilibrium $Ba^{140} \rightarrow La^{140}$. For samples containing simultaneously $Ba^{140} \rightarrow La^{140}$ and S^{35}, the method of filtration of β-radiation of different energy by means of an aluminum filter was used ([3]).

Fig. 1. Kinetics of dissolution in water at 20° of $Ba\overset{\times}{S}O_4$ preparations of different specific activity:
1–0.3 mCi/g; 2–3.3 mCi/g

The results of the study of the dissolution process of $Ba\overset{\times}{S}O_4$ of different specific activity are presented in Fig. 1.

Table 1

Solubility in water of barium sulfate labeled with different radioactive indicators at a temperature of $20 \pm 0.5^{\circ}$

Preparation	Specific radioactivity, mCi/g	Solubility of $BaSO_4$, calculated from the indicator, mg/L
$Ba\overset{\times}{S}O_4$	0.7	5.39
$Ba\overset{\times}{S}O_4$	0.3	1.28
$Ba\overset{\times}{S}O_4$	1.0	41.50
$Ba\overset{\times}{S}O_4$	3.3	0.65

In the initial period of dissolution of the $Ba\overset{\times}{S}O_4$ precipitate, a maximum is observed which disappears after 25 hours of stirring. A more considerable supersaturation is characteristic of the less active salt. An analogous phenomenon was also noted by us for $Ba\overset{\times}{S}O_4$ ([1]). The magnitude of the solubility of $Ba\overset{\times}{S}O_4$ in water at 20° proves to be considerably lower than that indicated in the literature ([4]) for ordinary barium sulfate (2.3 mg/L at 18°).

In addition, the solubility of barium sulfate containing Ba^{140} is considerably lower than that of preparations labeled with S^{35} (Table 1).

The indicated observations were confirmed in studying the process of dissolution of barium sulfate labeled with two indicators. Figure 2 gives data on the dissolution kinetics of $\overset{\times}{Ba}\overset{\times}{S}O_4$, calculated separately from the activities of Ba^{140} and S^{35}. From the results obtained it is evident that the saturated solution of radioactive $\overset{\times}{Ba}\overset{\times}{S}O_4$ contains an excess of SO_4^{2-} ions and a deficiency of Ba^{2+} ions. A similar phenomenon was noted earlier ([5,6]) in measurements of the electrokinetic potentials of $BaSO_4$. In the present case it is expressed especially sharply, evidently as a result of continuous irradiation by electrons from the precipitates studied by us.

Fig. 2. Dissolution kinetics in water at 20° of $\overset{\times}{Ba}\overset{\times}{S}O_4$ with specific activity 3.7 mCi/g (Ba^{140}–1.5 mCi/g, S^{35}–2.2 mCi/g): 1–solubility by S^{35} radiation; 2–solubility by Ba^{140} radiation.

Fig. 3. Dependence of the concentration of Ba^{2+} and SO_4^{2-} ions in a saturated solution of $BaSO_4$ on the specific radioactivity of the solid phase: 1–concentration of Ba^{2+} and SO_4^{2-} ions corresponding to the normal solubility of the salt; 2–concentration of Ba^{2+} ions upon dissolution of $Ba\overset{\times}{S}O_4$; 3–concentration of SO_4^{2-} ions upon dissolution of $Ba\overset{\times}{S}O_4$.

The facts set forth indicate that radioactive preparations of $BaSO_4$ have a tendency to retain Ba^{2+} ions and repel SO_4^{2-} ions. Most strongly, the indicated process in the presence of S^{35} develops at a specific activity of the precipitates on the order of 1 mCi/g (Fig. 3). With an increase or decrease in the specific activity of $Ba\overset{\times}{S}O_4$, a smoothing out of this effect is observed, and a change in the concentrations of Ba^{2+} and SO_4^{2-} ions directed toward approximation to the values corresponding to the normal solubility of inactive $BaSO_4$. The entire complex of the phenomena described can evidently be explained by a change in the electric field of the precipitate under the action of continuous β-radiation and the associated change in the adsorption properties of the salt, as well as by absorption of β-particles in the solution.

It should be concluded that the use of radioactive indicators for measuring the solubility of sparingly soluble substances does not in all cases ensure the obtaining of correct results. The study by one of us ([7]) of the solubility of cerium oxalate led to analogous conclusions.

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