

TRACES OF YTTRIUM AND LANTHANIDES RADIONUCLIDES IN AQUEOUS SOLUTIONS. II.*

DESORPTION OF TRACE AMOUNTS OF YTTRIUM FROM FILTER PAPER

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Trace amounts of the radionuclide ⁹¹Y were sorbed on filter paper from aqueous solutions at pH 1.7–11.2 and at the temperature of 25°C and their desorption has been studied using either aqueous solutions of the same pH values as the sorption solutions or the 10⁻³M solution of hydrochloric acid. The dependence of the ⁹¹Y desorption on the acidity of the desorption (and also sorption) solution showed a monotonous decrease from high values in the strongly acidic media to the rather low and roughly constant values in the alkaline media. For yttrium sorbed in the pH range from 2.9–10.2 the desorption gave high values if 10⁻³M hydrochloric acid was used as the desorbent; for both lower and higher pH values a decrease of desorption has been observed.

The desorption method is recommended by Starik¹ as a complementary method to the adsorption studies of the behaviour of trace amounts of radionuclides in solutions and on solid sorbents. In this sense it is an exceptionally convenient method for studies of sorption reversibility, *i.e.* for studies of desorption in a medium identical with the medium from which the radionuclide was sorbed. Studies of the sorption reversibility could be used to distinguish the ionic and molecular forms of the radionuclide that are sorbed reversibly from the colloidal forms (both true colloids and pseudocolloids) of the trace radionuclide that are sorbed irreversibly¹. The paper of Starik and coworkers² on the behaviour of trace amount of zirconium ⁹⁵Zr in aqueous solutions is also pertinent to the discussion of our experimental results.

The aim of our work was to study the desorption of trace amounts of the radionuclide ⁹¹Y sorbed on filter paper from aqueous solutions at various pH values using the aqueous solutions of the same pH value as that of the sorption medium and also the 10⁻³M-HCl as the desorption media.

EXPERIMENTAL

Reagents, the radionuclide and its solutions, the sorption apparatus and procedures made before the radionuclide desorption as well as the determination of the sorbent activity and of the

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solution acidity were described in our previous paper³. Schleicher-Schüll "Blue Ribbon" filter paper was used as the sorbent.

300 ml of the desorption solution together with 3–5 sorbent samples with the adsorbed radionuclide of an initial activity A_1 were transferred into a 500 ml polyethylene flask. The samples in the flask could not touch each other. The closed flask with the solution and sorbent samples was put into a desiccator filled with soda lime and kept for a given desorption period in a thermostat at the temperature of $(25 \pm 0.1)^\circ\text{C}$. The sorbent samples were then taken out of the solution, washed three times by 5 ml of water in a Büchner funnel and dried at 105°C . Their residue activity A_2 was measured under the same conditions as the activity A_1 . Also the pH value of the solution was measured. The value of desorption D_i ,

$$D_i = 100(A_1 - A_2)/A_1,$$

in per cents was calculated for individual sorbents.

In graphs the mean value D of the percentage of desorption has been plotted that has been calculated from 3–5 values of D_i . The value of D_i were within $\pm 11\%$ of the D value.

RESULTS AND DISCUSSION

It follows from the dependence of the desorption coefficient D on the logarithm of the desorption time t (Fig. 1) that the equilibrium cannot be reached even after 48 h of desorption. Any further prolongation of the desorption time is impossible without using buffer solutions. However, from the dependences of D on $\log t$

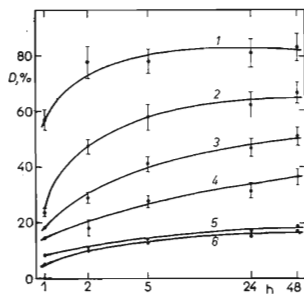


FIG. 1

Desorption D of ^{91}Y from Filter Paper as a Function of the Logarithm of the Desorption Time (Used for the Sorption Reversibility Studies)

pH: 1 1.7; 2 2.9; 3 3.8; 4 4.9; 5 8.2; 6 11.2.

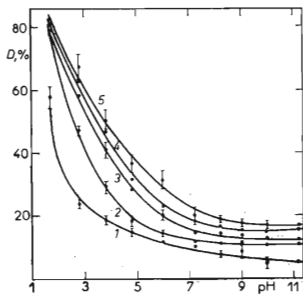


FIG. 2

Desorption D of ^{91}Y from Filter Paper as a Function of Acidity (Used for the Sorption Reversibility Studies)

Desorption time, h: 1 1; 2 2; 3 5; 4 24; 5 48.

(Fig. 1) and on pH (Fig. 2) it is possible to deduce a sufficiently complete picture about the reversibility of the sorption of ^{91}Y traces on filter paper from aqueous solutions. In the strongly acidic medium the adsorption is nearly reversible. It is evident from our previous paper³ that the molecular forms constitute only a small fraction of the ^{91}Y forms in the aqueous solutions. Therefore, it can be concluded that in the strongly acidic media the ionic forms of ^{91}Y highly predominate. Over the entire acidic and neutral regions the desorption monotonously decreases with the increasing pH value and finally it remains roughly constant in the whole alkaline region that has been studied. We can presume that the presence of the ionic forms in the solution decreases in an approximately similar fashion and that it is counterbalanced by the formation of true colloidal and pseudocolloidal forms of ^{91}Y that exhibit an irreversible sorption. From the paper³ it follows that the true colloids $^{91}\text{Y}(\text{OH})_3$ must be taken into account only at $\text{pH} > 9-11$. Therefore, at lower values of pH it must be assumed that the irreversibly adsorbed fraction of the ^{91}Y forms is formed by pseudocolloids. The curves on Fig. 2 show that these colloids overwhelm the ionic forms (*i.e.* they constitute more than 50% of the initial activity of the sorbent sample) at $\text{pH} \approx 4$. This value corresponds to the position of the sorption maximum³, the existence of which was explained by similar assumptions that are thus borne out again.

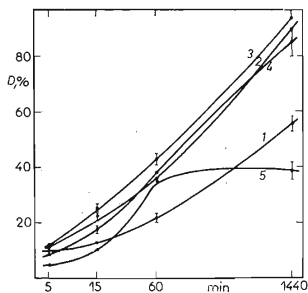


FIG. 3

Desorption D of ^{91}Y from Filter Paper as a Function of the Logarithm of the Desorption Time Using the 10^{-3}M-HCl as the Desorbent

pH: 1 1.7; 2 2.9; 3 4.1; 4 9.1; 5 11.0.

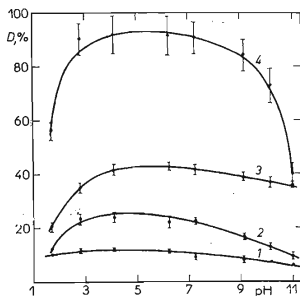


FIG. 4

Desorption D of ^{91}Y from the Filter Paper as a Function of the Sorption Solution Acidity Using the 10^{-3}M-HCl as the Desorbent

Desorption time, min: 1 5; 2 15; 3 60; 4 1440.

The functions $D = f(\log t)$ and $D = f(\text{pH})$ (Figs 3 and 4) can be used for visualization of the desorption mechanism of ^{91}Y adsorbed on filter paper at various pH values using the 10^{-3}M hydrochloric acid as the desorbent. For the sorption medium acidity between pH 2.9 and 9.1 and for the desorption times from 5 to 1440 min (24 h) the desorption proceeds linearly with the logarithm of time, *i.e.* exponentially with the desorption time and after 24 hours it reaches very high values. These functional dependences can be explained by the degradation of the sorbed pseudocolloidal and even true colloidal forms of yttrium to lower (mainly cationic) forms and by the hindrance of any sorption of cationic forms formed in this way. The sorption of cationic forms of yttrium on the $-\text{COO}^-$ groups that are present in cellulose^{4,5} is prevented by a high concentration (and competition) of the H^+ ions in the desorption medium (10^{-3}M-HCl). The degradation of the pseudocolloidal forms consists of the desorption of the (predominantly cationic) forms of ^{91}Y sorbed on an inactive "carrier" that is constituted by a particle of a colloidal impurity. The true colloid $^{91}\text{Y}(\text{OH})_3$ disappears by dissolution and formation of simpler ionic and molecular forms of ^{91}Y . A calculation proves³ that in the 10^{-3}M hydrochloric acid ($\text{pH} = 3$) and under our experimental conditions the value of the solubility product of $^{91}\text{Y}(\text{OH})_3$ cannot be reached. The true colloid $^{91}\text{Y}(\text{OH})_3$ which is present on the sorbent in our solutions at pH 11.2, is desorbed at a much slower rate than the anticipated pseudocolloidal and non-colloidal forms of ^{91}Y would be (Figs 3, 4). The decrease of the desorption rate of ^{91}Y that was sorbed under conditions generally unfavourable for desorption, *i.e.* at pH 1.7 which approximately corresponds to the 10^{-2}M-HCl and desorbed using the more dilute 10^{-3}M-HCl as a desorbent, thus seems rather logical.

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