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Abstract

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EXTRACTION OF TECHNETIUM-99 WITH ACETONE

Literature data show that, for separating technetium-99 from solutions obtained in the processing of neutron-irradiated molybdenum, extraction with ketones—methyl ethyl ketone ([1]) and methyl isobutyl ketone ([2])—can be used. The fact that acetone belongs to the simplest ketones allows one to expect that it will have the best extraction properties in comparison with other ketones. However, until now the use of acetone as an extractant has not been considered, because of its complete mutual miscibility with water.

We have established that sodium molybdate and caustic soda are salting-out agents for acetone in aqueous media. The use of alkaline solutions also makes it possible selectively to extract technetium with acetone in the presence of other radioelements. The combination of these two factors (salting out, alkalinity) made it possible to develop an effective method for the extraction recovery of technetium from neutron-irradiated molybdenum, using extremely low alkalinity of the solutions. The investigations were carried out according to the method described earlier ([3]). Acetone retains some solubility in alkaline media. On the other hand, the acetone phase extracts a certain amount of water from the aqueous phase, as a result of which the acetone layer increases in volume.

Table 1 shows the effect of the concentration of alkali and molybdate on the ratio of phase volumes during the stratification of aqueous-acetone solutions.

Table 1

Change in the volume of acetone in alkaline solutions during extraction
Volume of initial Na_2MoO_4 solution 20 ml, volume of acetone 20 ml

No. of experiments	Initial solution conc., Na_2MoO_4, g/l	Initial solution conc., NaOH, N	Density of initial solution, g/ml	Stratification	Volume after extraction, acetone phase, ml	Volume after extraction, water-alkaline phase, ml	Increase in acetone volume, % of initial
1	75	–	1.050	Does not stratify	–	–	–
2	75	0.5	1.065	Same	–	–	–
3	75	1.0	1.090	Stratifies	30	9	50
4	75	2.0	1.122	»	25	14	25
5	75	3.0	1.155	»	24	16	20
6	75	4.0	1.185	»	23	17	15
7	75	5.0	1.214	»	22	18	10
8	200	–	1.430	»	34	6	70
9	200	1	1.170	»	27	13	35
10	200	3	1.230	»	23	17	15
11	200	4	1.271	»	22	18	10
12	200	5	1.300	»	21	19	5
13	400	–	1.276	»	26	14	30

Thus, when aqueous solutions and acetone are mixed, under known conditions a clear stratification into organic and aqueous phases can be obtained, and at a solution density of 1.3 g/cm^3 a comparatively small increase in the volume of acetone (5%) can be achieved. In addition, it follows from the results presented that alkali is a better salting-out agent than molybdate.

Study of the extraction of technetium from a freshly prepared sodium pertechnetate solution made it possible to establish that the degree of extraction of technetium by acetone is very high over the entire concentration range of NaOH studied (from 2 to 6 N).

When technetium is extracted from $NaTcO_4$ solutions containing Na_2MoO_4, and at NaOH concentrations above 3 N, a slight decrease in the distribution-coefficient values is observed in comparison with purely alkaline solutions, but the degree of extraction remains sufficiently high (Table 3).

Table 2

Extraction of technetium by acetone from alkaline sodium pertechnetate solutions

Alkaline-phase volume 1 ml, acetone volume 1 ml, Tc concentration 10.2 mg/l, shaking time 5 min, temperature 25-27°

Experiment No.	NaOH conc., N	Distribution coeff., K	Degree of extraction of Tc by acetone, %
1	2	3	82
2	3	5	86
3	4	10	92
4	5	10	92
5	6	7	87

Fig. 1. Dependence of the distribution coefficient (K) of technetium on the alkalinity of solutions during extraction with acetone. 1 —solution of Na_2MoO_4 (75 g/l) and sodium pertechnetate, 2 —solution of sodium pertechnetate

Owing to the high values of the distribution coefficients of technetium between acetone and the aqueous phase, the degree of its extraction remains practically constant even with a considerable decrease in the volume of the organic phase (Table 4).

Table 3

Extraction of technetium from alkaline Na_2MoO_4 solutions

Initial Tc concentration 10 mg/l, Na_2MoO_4 concentration 75 g/l, aqueous-solution volume 1 ml, acetone volume 1 ml, shaking time 5 min, temperature 25-27°

Experiment No.	NaOH conc., N	Distribution coefficient, K	Degree of extraction of Tc, %
1	2	3	84
2	3	6	88
3	4	8	90
4	5	10	91
5	6	6	86

Table 4

Influence of the phase ratio on the degree of extraction of technetium by acetone

Volume of the initial $NaTcO_4$ solution in 4 N NaOH 10 ml, Tc concentration 20 mg/l, temperature 25-27°

Fig. 2. Beta spectrum of the isolated technetium-99 preparation

Figure 1: Fig. 2. Beta spectrum of the isolated technetium-99 preparation

Experiment No.	Acetone volume, ml	Degree of extraction of Tc, %
1	10	98
2	8	99
3	5	99
4	3	97
5	1	96

The extraction conditions for technetium by acetone that were studied made it possible to develop a convenient method for its concentration during separation from neutron-irradiated molybdenum. The starting material—metallic molybdenum or molybdenum anhydride—is preliminarily oxidized with nitric acid in order to convert technetium to the heptavalent state. The product evaporated to dryness is dissolved in a mixture of sodium hydroxide and hydrogen peroxide. NaOH is added in such an amount that, before extraction, the free alkalinity is 2-3 N. From the sodium molybdate solution, technetium is extracted with acetone at a ratio $V_{\text{aq. ph.}} : V_{\text{org. ph.}} = 2 : 1$ with vigorous shaking for 5-10 min and settling until complete separation of the aqueous-alkaline and organic phases. The acetone layer is then washed once with a small amount of 2-3 N alkali solution (1/5 of the acetone volume). After this the acetone is distilled off, and the residue is neutralized

with hydrochloric acid, and an acidity of 2-3 N with respect to hydrochloric acid is established in the solution. This is followed by precipitation of technetium heptasulfide.

Using β-γ-spectral analysis,* it was possible to establish that acetone, already after the first extraction, extracts radiochemically pure technetium-99, selectively separating it from a number of radioactive isotopes usually present in irradiated molybdenum ([4]). By means of β-γ-spectral analysis it was established that the spectrum of the isolated preparation is single-component and has a limiting energy of 290 ± 10 keV (Fig. 2).

Fig. 2. Beta spectrum of the isolated technetium-99 preparation

This agrees well with the literature data ([5]). The method of extraction with acetone can also be used in the analytical chemistry of technetium.

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