Separation of Strontium-90 and Yttrium-90 by the Thin-layer Chromatographic Method

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The thin-layer chromatographic method was investigated for the carrier-free separation of ^{90}Sr and ^{90}Y with the several kinds of adsorbents and developers. With the "Wakogel B-0" layer (the silicagel with no binder), ^{90}Sr is transferred farther than ^{90}Y by developing with ethylalcohol-10% ammonium thiocyanate (5 vol : 3 vol) or ethylalcohol-7M lithium nitrate (1 : 1). With the "Wakogel B-5" layer (the silicagel with 5% plaster of Paris), no separation of these nuclides was attained. With the Dowex 50 resin layer, ^{90}Y is transferred farther with 5% ammonium citrate solution of pH 3.8. The method has the advantage that one can prepare carrier-free ^{90}Y in a simple way and in a short while.

Introduction

The carrier-free separation of ^{90}Y from the ^{90}Sr - ^{90}Y solution can be attained in various ways: Besides the well-known coprecipitation method and the radiocolloid formation method, several workers reported the successful separation of ^{90}Y by the paper chromatographic method^{1)~4)}, ion exchange method using the cation- or anion-exchange resin^{5), 6)}, ion exchange resin impregnated paper⁷⁾ or ion-exchange membrane⁸⁾ as well as by the electrolytic method⁹⁾.

Since the thin-layer chromatographic method was applied to the separation and identification of inorganic ions by Seiler and others^{10)~14)}, many papers have already been published with respect to the separation of the various kinds of ions. On the other hand, the application of this technique to the carrier-free separation of radioisotopes is still remained very few. In this paper, the authors tried the thin-layer chromatographic separation of ^{90}Sr and ^{90}Y with the several kinds of adsorbents and developers, showing that this method is useful for the simple and rapid separation of these radioisotopes.

Experimental

1. Sample

^{90}Sr - ^{90}Y used in this experiment was supplied from Oak Ridge National Laboratory (USA). It is diluted in 0.01N hydrochloric acid. One

milliliter of the sample solution corresponds to about $5\mu\text{C}$ ^{90}Sr + ^{90}Y . The radiochemical purity was checked in advance.

2. Adsorbents and developers

Adsorbents and developers tried in this experiment are listed in the first and second columns in Table 1.

3. Apparatus

The thin-layer plate of each adsorbent was prepared by the aid of the applicator assembly supplied by CAMAG Chemie-Erzeugnisse und Adsorptionstechnik AG (Switzerland).

4. Procedures

The adsorbent was spread on a 10cm×20cm glass plate in 300 μ thickness with the applicator. The plate of ion-exchange resin was dried in the air, and that of silicagel was dried in an oven at 110°C for 1 hour.

One drop (about 1 μl) of the sample solution was mounted on the plate at the point 2.5cm from the bottom side with a glass capillary, and dried in the air. The spot was then developed with the various kinds of developers by the ascending method in a closed developing vessel up to about 10cm distance.

After the development, the layer was dried

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and each 0.5cm or 1cm section was scraped off and collected in a counting dish. Its radioactivity was then measured by a Geiger-Müller counter.

The distribution of radioactivity on the plate was also investigated by the autoradiographic method: The plate was wrapped with a thin polyvinylidene chloride foil, and laid on a non-screen type X-ray film. After about 5-10 minutes' exposure, the film was developed.

Results and Discussion

The results obtained with the various adsorbents and developers are summarized in Table 1. Developing time is the time necessary for 10cm developing. It depends upon the kind of the adsorbent and the developer, thickness of the layer and upon the temperature. The Rf-values for the definite adsorbent and the developer are also slightly influenced by the layer

thickness and temperature.

In Figs. 1~3, some examples of the distribution of radioactivity on the layer are shown in the histograms as well as in the autoradiographic pictures. The radioactivity of each fraction was measured after a lapse of 30 min. from the end of development and also after about 90 hours' standing. The radioactivity of ^{90}Y fraction decreases with time, while that of the ^{90}Sr fraction increases owing to the growth of ^{90}Y in it. In this way, the identification of each peak can be readily achieved. The half-life of the decreasing activity was found in good agreement with that of ^{90}Y (64.2 h). Each autoradiogram shown in the figures was taken after 30 min. from the end of separation.

As is shown in Table 1, when the silicagel layer is used, ^{90}Sr moves farther with the various developers tested, while ^{90}Y is retained near the original point. In the case of the

Table 1 Rf-values for ^{90}Sr and ^{90}Y
(Layer thickness: 300 μ , Developing distance: 10 cm)

Adsorbent	Developer	Temp. ($^{\circ}\text{C}$)	Time required (min)	Rf-values ^{90}Sr ^{90}Y	
Wakogel B-0	Ethylalcohol-0.5 M HCl (9:1)	12	56	no separation	
Wakogel B-0	Ethylalcohol-2 M CH_3COOH (8:2)	12	40	no separation	
Wakogel B-0	Ethylalcohol-0.01 M EDTA (5:3)	13	30	no separation	
Wakogel B-0	Ethylalcohol-10% NH_4CNS (5:3)	8	92	0.83	0.07
Wakogel B-0	Ethylalcohol-7 M LiNO_3 (1:1)	12	46	0.37	0.12
Wakogel B-0 + 5 % starch	Ethylalcohol-10% NH_4CNS (5:3)	17	45	0.54	0.05
Wakogel B-0 + 5 % starch	Ethylalcohol-7 M LiNO_3 (1:1)	13	120	0.62	0.17
Dowex 1-X 8 (RCl form) + 5 % Wakogel B-0	7 M LiNO_3	20	13	poor separation	
Dowex 1-X 8 (NH_4R form) + 5% starch	5 % ammonium citrate (pH=3.8)	15	12	no separation	
Dowex 50-X 8 (NH_4R form) + 20% starch	5 % ammonium citrate (pH=3.8)	10	35	0.05	0.93

* "Wakogel B-0" is the thin-layer chromatographic silicagel with no binder supplied by Wakō Pure Chemical Industries, Ltd., Tokyo.

Fig. 1 Distribution of ^{90}Sr - and ^{90}Y -activities on the thin-layer chromatographic plate with the corresponding autoradiographic picture.

Layer: Wakogel B-0, 300μ thickness
Developer: Ethylalcohol-10% NH_4CNS (5:3)

Temperature: 8°C

Autoradiographic detection:

Film: Sakura X-ray film, Industrial type N (high speed, non-screen type)
Exposure: 10 min.

Dowex 50 ion-exchange resin layer, however, the situation is reversed and ^{90}Y is developed farther with 5% ammonium citrate solution (pH 3.8), just in the same way as in the case of ion-exchanger column chromatography. Ion exchange separation of ^{90}Y on the thin-layer chromatographic plate has the advantage that one can readily prepare citrate-free ^{90}Y in a short while as compared with the column method.

Besides the adsorbents listed in the Table 1, "Alumina B-0"* and "Wakogel B-5"** were also tested, but both ^{90}Sr and ^{90}Y were retained at the original point and no separation was attained. It is probable that the presence of

Fig. 2 Distribution of ^{90}Sr - and ^{90}Y -activities on the thin-layer chromatographic plate with the corresponding autoradiographic picture.

Layer: Wakogel B-0 + 5% starch, 300μ thickness

Developer: Ethylalcohol-7 M LiNO_3 (1:1)

Temperature: 12°C

Autoradiographic detection:

Film: Sakura X-ray film, Industrial type N (high speed, non-screen type)
Exposure: 10 min

5% calcium sulfate in silicagel hinders the travelling of the carrier-free ^{90}Sr forming the slightly soluble sulfate.

Summary

The carrier-free separation of ^{90}Sr and ^{90}Y from each other by the thin-layer chromatographic method was investigated. The results

* "Alumina B-0" is the chromatographic alumina with no binder supplied by Wakō Pure Chemical Industries, Ltd., Tokyo.

** "Wakogel B-5" is the thin-layer chromatographic silicagel with 5% calcium sulfate binder supplied by Wakō Pure Chemical Industries, Ltd., Tokyo.

Fig. 3 Distribution of ^{90}Sr - and ^{90}Y -activities on the thin-layer chromatographic plate with the corresponding autoradiographic picture.

Layer: Dowex-50 X 8 (NH_4R -form, 200-400 mesh) + 20% starch, 300 μ thickness

Developer: 5 % ammonium citrate (pH 3.8)

Temperature: 10°C

Autoradiographic detection:

Film: Sakura X-ray film, Industrial type N (high speed, non-screen type)

Exposure: 10 min.

obtained are summarized as follows:

(1) With the silicagel layer, the development with ethylalcohol-10% ammonium thiocyanate (5 vol:3 vol) or ethylalcohol-7M lithium nitrate (1:1) gives a fairly good separation of ^{90}Sr and ^{90}Y . In these cases, ^{90}Sr travels

farther, while ^{90}Y remains near the original point.

(2) The presence of the calcium sulfate binder in the silicagel hinders the separation, retaining the both nuclides near the original position.

(3) With the cation-exchange resin layer, ^{90}Y is developed farther with 5% ammonium citrate solution of pH 3.8.

The method is suitable for the simple and rapid separation of ^{90}Sr and ^{90}Y .

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要 旨

薄層クロマトグラフ法によるストロンチウム-90とイットリウム-90の分離

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薄層クロマトグラフ法を用いて, ^{90}Sr から ^{90}Y を無担体に分離することを試みた。吸着剤として Wakogel B-0 (結着剤を含まないシリカゲル) の薄層を用いるとき, エチルアルコール—10%チオシアン酸アンモニウム (5容: 3容), またはエチルアルコール—7M硝酸リチウム (1:1) の展開溶媒で, ^{90}Sr のほうが ^{90}Y より移動距離が大きい。しかし Wakogel B-5 (5%の石膏を含むシリカゲル) を使用するときは, 分離できず, どちらも原点付近にとどまる。また陽イオン交換樹脂 (Dowex 50) で薄層を作り, 5%クエン酸アンモニウム溶液 (pH=3.8) で展開するときは, ^{90}Sr が原点にとどまり, ^{90}Y が展開先端へ移動する。本法により, ^{90}Y を簡単, 迅速に無担体に分離することができる。