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Determination of Ba-140 in Fission Products by Substoichiometry

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Substoichiometry 법에 의한 Ba-140의 핵붕괴수률의 결정

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要 約

핵붕괴생성물을 정량함에 있어서 가한 carrier의 당량보다 적은 양의 시약으로 분리 회수하므로서 보다 신속하고 선택적으로 해당원소의 핵붕괴수률을 결정하였다.

Abstract

In previous paper,[1] the determination procedure of fission products mainly consists of many steps which are usually derived from classical analysis schemes. In the present paper a simple and more rapid method of the determination of fission products by means of a smaller amount of reagent than that correspond to the stoichiometric ratio of element to be determined is investigated. The yield of Ba-140 in fission products is determined by this method.

Introduction and Theory

The theory of substoichiometric determination [2,3] is, in general, applicable for the determination of fission products. In the present work the application of this principle for the determination of fission products is provided by the determination of Ba-140, using sulfuric acid as precipitant.

The concentration ratio of two metals (M′ and M″) in the precipitates is determined from solubility product values(Table I)

$$\text{i.e. } \frac{[M'A_{N'}]}{[M''A_{N''}]} = \frac{K_{M''AN''}[M'][A]^{N''-N'''}}{K_{M'AN'}[M'']} \quad \cdots(1)$$

$$\text{where } K_{M'AN'} = \frac{[M'][A]^{N'}}{[M'A_{N'}]}$$

$$K_{M''AN''} = \frac{[M''][A]^{N''}}{[M''A_{N'}]}$$

For N′=N″, equation (1) is

$$\frac{[M'A_N]}{[M''A_N]} = \frac{K_{M''AN}[M']}{K_{M'AN}[M'']} \quad \cdots\cdots(2)$$

Assuming the ratio of $K_{M''AN}$ to $K_{M'AN}$ equals the solubility product ratio($\simeq$32) of $SrSO_4$ and $BaSO_4$ the ratio $\frac{[Ba^{++}]}{[Sr^{++}]}$ has to be higher than 3 (for $\frac{[BaSO_4]}{[SrSO_4]} > 100$) according to equation (2) for the quantitative separation of Barium.

Table I Solubility Product.

Substances	Solubility Product
Barium Sulfate	8.7×10^{-9}
Lead Sulfate	1.0×10^{-8}
Strontium Sulfate	2.8×10^{-7}

If the concentration ratio $\frac{[Ba^{++}]}{[Sr^{++}]}$ be higher than three Ba^{++} will be precipitated by sulfuric acid without interfering of Sr^{++}.

If this concentration ratio condition and pH of determination in previous paper[3] be satisfied, the relation of added volumes of sulfuric acid and activity of Ba^{++} obtained by sulfate precipitation will form a lineality.

Experimental

Apparatus : RCL 256 Channel Pulse Height Analyzer, with 3″×3″ NaI(Tl) Crystal.

Centrifuge.

Reagent : 0.04*N* Carrier solution, Barium chloride in H_2O. 0.02*N* Sulfuric acid, prepared by diluting 3*N* Sulfuric acid and standardized with known normality solution of Sodium hydroxide, using phenolphthalein as indicator.

Irradiation : Uranium nitrate is dissolved in water (0.007950 gr. of $UO_2(NO_3)_2 \cdot 6H_2O$/ml) and irradiated for three days together with Ni and Co as fast and thermal neutron flux monitors in Rotary Spesimen Rack of TRIGA Mark Ⅱ Reactor.

Procedure : To five of 100ml. beaker one ml. of irradiated sample, 3ml. of conc. hydrochloric acid, and 10ml. of barium carrier solution are added, and diluted to about 50ml., respectively. After isotopic equilibrium is reached the solutions are heated to near boiling point. Two ml., 3ml., 5ml., 7ml. and 10ml. of 0.02*N* sulfuric acid are added to each beaker respectively. After heating, but not boiling, for 30 min. at hot plate the solutions are cooled. Each solution is centrifuged and collected into centrifuge tube. Washing and centrifuge are repeated several times. Each sample is counted with RCL 256 Channel Pulse Height Analyzer.

Results and Discussion

Count areas of 0,537 Mev. γ-ray peak and number of ml. of added sulfuric acid are ploted in Fig. 1. Fig. 2 is the γ-ray spectrum of separated Ba-140.

The straight line in Fig. 1 may conform reproducibility of the present method and mean that this determination method of Ba-140 is not interfered by any other fission product elements.

From any number of count in the range of straight line in Fig. 1 total decay rate is calculated by correction with percentage of precipitated barium to total barium carrier, total absolute efficiency[4], peak-to-total ratio[4], and the percentage of 0,537 Mev. γ-ray(25%)

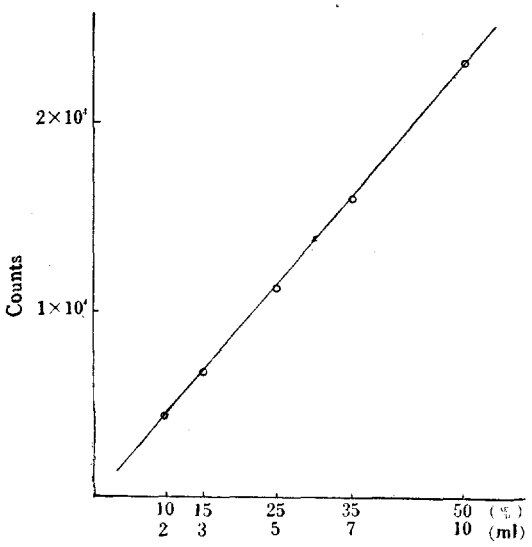

Fig. 1 The relation between counting rate and added ml of sulfuric acid. (Percentage of precipitated Barium to total added carrier)

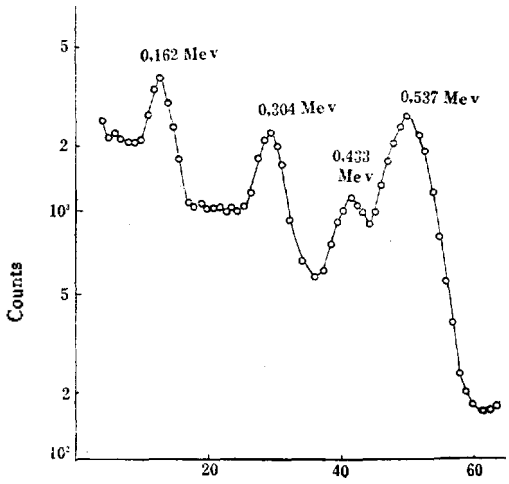

Fig. 2 Gamma-ray spectrum of Ba-140.

[5]. The calculated cumulative chain fission yield[6] of Ba-140 is 7.1 percent.

Conclusion

The main advantage of the proposed method is its great speed, selectivity, and simplicity. This principle of substoichiometric determination for fission products may be also applicable for solvent extraction and ion exchange as for the precipitation in the present paper.

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