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New Half-Life in the Family of Antimony Isotopes

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By using scintillation techniques in analyzing the γ radiation following the β decay of a fission-product antimony sample, evidence of a new half-life of 149±4 hours was found in the family of antimony isotopes.

I. INTRODUCTION

THE half-lives of antimony isotopes have been studied by various authors[1–3] and seem to be fairly well established. The β-decay curve of fission antimony was determined by Sleight and Sullivan[3] who found a component with a half-life of 93±3 hr and one with much longer half-life. The 93±3 hr half-life was assigned to Sb^{127}.

When we determined the half-life of Sb^{127} by analyzing the γ spectra, we found a somewhat shorter value for the 93-hr half-life, *viz.*, 88±2 hr. We concluded that in the decay curve of Sleight and Sullivan,[3] a further component of longer half-life than 88±2 hr might have been included without being separated. It seems to us that our results show indeed evidence of such a component with a half-life of 149±4 hr manifesting itself in a well-defined group of γ rays.

II. EXPERIMENTAL

The energies and relative intensities of the γ radiation were measured by using a scintillation spectrometer. A calibration of both resolution and crystal efficiency at a source to crystal distance of 7 mm was made.

The source was obtained in the following way: The U_3O_8 was bombarded with 26-Mev deuterons accelerated in the "Philips" synchrocyclotron of this Institute. After adding 2 mg of Sb^{III} and 2 mg of Sb^{V} in nitric acid, the oxides were precipitated. They then were dissolved in concentrated hydrochloric acid. The Sb was purified by reduction with zinc to form volatile stibine, which was trapped in a silver nitrate solution. The precipitate obtained was measured.

Another method of preparing the source was also employed: The U_3O_8 was bombarded with 26-Mev deuterons. The oxides were dissolved in concentrated nitric acid. Ammonium diuranate was precipitated with ammonium hydroxide. The ammonium diuranate was dissolved in hydrochloric acid, with the addition of 2 mg of Sb^{III} and 2 mg of Sb^{V}. The sulfides of Sb were precipitated with H_2S. After dissolving the sulfides in Na(OH), 2 mg of Cu were added, and the copper sulfide was precipitated. This solution was treated with acetic acid and the antimony sulfides were precipitated. These were dissolved in concentrated hydrochloric acid, with the addition of 2 mg of Te in the state of potassium tellurite and tellurate, which were precipitated with sulfuric acid. The solution was made 1*N* HCl and HF. After adding 2 mg of Sn^{IV} as Cl_4Sn, antimony sulfides were precipitated. (Sn^{IV} forms a complex with HF.)

The results corresponding to both sources were the same, that is to say, the γ-ray energies and their relative intensities were identical in both samples.

Six different samples of antimony, with a total of 50 spectra, were studied. Figure 1 shows a characteristic γ spectrum of the sample between 25 and 780 kev. Figure 2 shows one for the high energies. The following

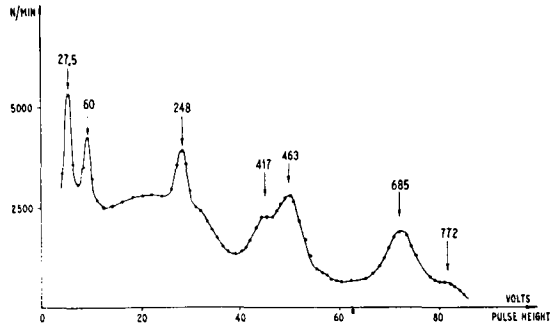

FIG. 1. Characteristic sample γ spectrum between 25 and 780 kev.

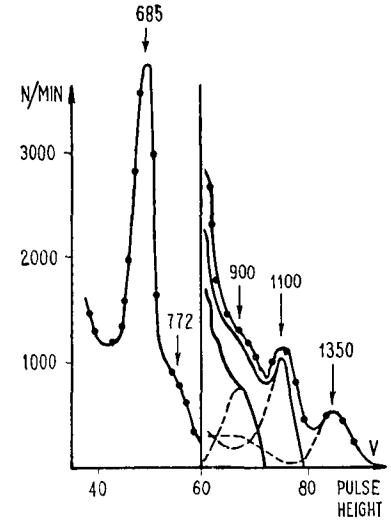

FIG. 2. Characteristic sample γ spectrum for high energies.

[1] P. Abelson, Phys. Rev. **56**, 1 (1939).
[2] J. Beydon, Compt. rend. **227**, 1159 (1948).
[3] N. R. Sleight and W. H. Sullivan, *Radiochemical Studies: The Fission Products* (McGraw-Hill Book Company, Inc., New York, 1951), National Nuclear Energy Series, Plutonium Project Record, Vol. 9, Div. IV, p. 928.

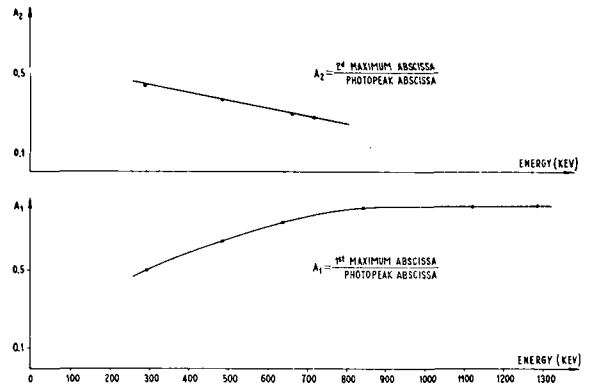

FIG. 3. Relations between the abscissas of the maxima and the abscissas of the photopeaks, as a function of the γ-ray energy.

energies (in kev) are established: 27.5 (Te x-rays), 60, 248, 417, 463, 685, 772, 1100, and 1350.

For a closer investigation of the photopeaks it is necessary to take into account the Compton background. In accordance with other authors, two maxima, apart from the photopeak, were observed in a single γ-ray spectrum. The first is due to the distribution of Compton electrons and the second is due to the external scattering.

The relations between the abscissas of the maxima and the abscissas of the photopeaks, and between the ordinates of the maxima and the ordinates of the photopeaks, both as functions of the γ-ray energy, were investigated. Figures 3 and 4 represent these relations.

It is quite difficult to obtain points for the relations A_2 and A_4 for energies greater than 840 kev. This is due to the fact that there are no substances which have a single γ ray at these energies.

By taking into account these relations, the Compton backgrounds of all γ rays were constructed. By subtracting these backgrounds, the photopeaks were isolated. Figure 5 represents this procedure. For high energies the subtraction of the Compton background appears in Fig. 2.

It can be seen that four other peaks corresponding to 310, 560, 610, and 900 kev appear.

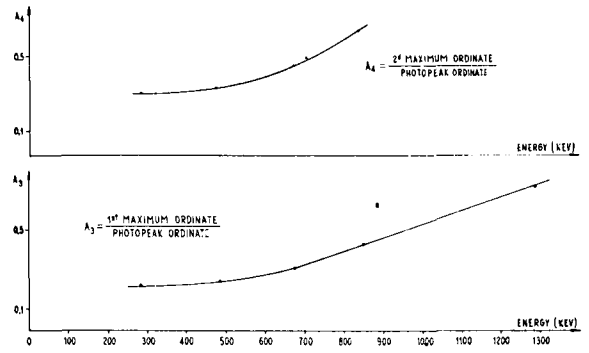

FIG. 4. Relations between the ordinates of the maxima and the ordinates of the photopeaks, as a function of the γ-ray energy.

III. CONCLUSIONS

By taking into account the areas of the photopeaks isolated as described previously, the half-lives and relative intensities corresponding to different γ rays were determined. The half-lives were also determined by the decay of the height of the corresponding peaks.

We found two different half-lives in the sample. There are γ rays which belong to a half-life of 88±2 hours and others which belong to a half-life of 149±4 hours. In Figure 6 we can see the peaks belonging to these half-lives, 4, 8, 11, and 16 days after irradiation.

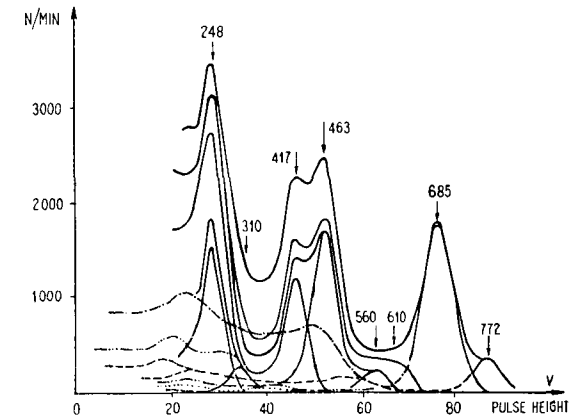

FIG. 5. Isolation of the photopeaks by subtraction of the Compton background.

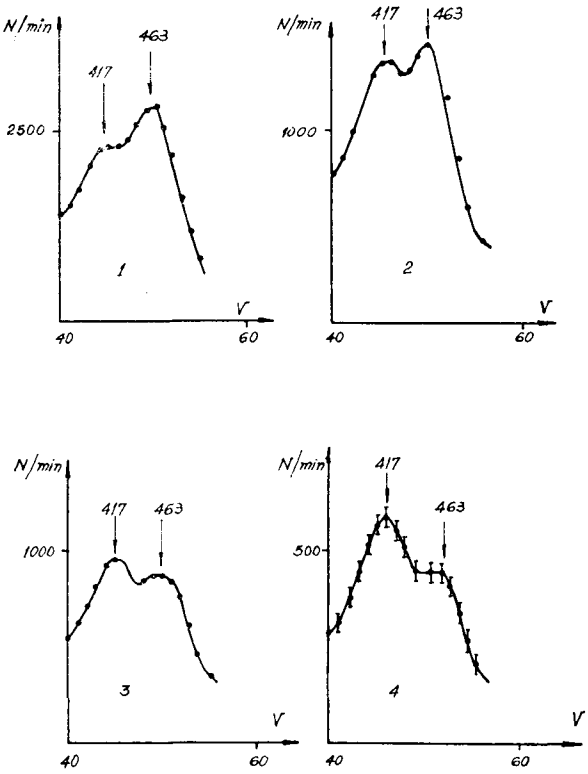

FIG. 6. Relative heights of photopeaks belonging to different half-lives 4, 8, 11, and 16 days after irradiation.

The following energies were assigned to the sample γ rays, in kev: 27.5 (Te x-rays), 60 ± 2, 248 ± 8, 310 ± 10, 417 ± 10, 463 ± 10, 560 ± 15?, 685 ± 15, 772 ± 15, 900 ± 20, 1100 ± 20, and 1350 ± 20.

The γ rays of energies (in kev): 463 (100%), 772 (45%), 248 (26%), 310 (11%), and 60 (6%) have a half-life of 88 ± 2 hours. The γ-rays of energies (in kev): 685 (100%), 417 (26%), 900 (10%), 1100 ($\sim$5%), and 1350 ($\sim$1%) have a half-life of 149 ± 4 hours. The γ ray of 610 kev belongs to another antimony of much longer half-life.

The half-life of 88 ± 2 hours was assigned to the Sb^{127}. The half-life of 149 ± 4 hours belongs to another source which cannot be separated by chemical methods from Sb^{127}.

We are now trying to identify the source of the (149 ± 4)-hour half-life. β-γ and γ-γ coincidences are being made.

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