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Two Antimony Activities Having Mass Number 126

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Two of the investigations carried out in our laboratories on the activities of antimony obtained from uranium fission[1] indicated half-lives of more than two days: (*a*) one of 88 ± 2 hours, characterized by gamma rays of energies 0.463, 0.772, 2.248, 0.310 and 0.060 Mev; (*b*) another one of 149 ± 4 hours, characterized by gamma rays having energies of 0.685, 0.417, 0.900, 1.100 and 1.350 Mev. The first of these activities was ascribed to Sb^{127}, whereas the second was not given a mass number.

Fränz and his group[2] found an antimony activity having a half-life of 18.8 minutes. They assigned to this activity a mass number of 126 by a measurement, in the gamma spectrum, of the most intense peak at 0.650 Mev. Thereafter, Fränz and Muenzel[3] found the same half-life and the same gamma energy by the irradiation of enriched Te^{126} with fast neutrons, confirming mass number 126.

Day and Voigt,[4] in the antimony fraction separated from natural tellurium irradiated with the bremsstrahlung of the 70 Mev synchrotron of Iowa State College, obtained gamma rays having energies of 0.058, 0.185, 0.240, 0.417, 0.456, 0.563, 0.674 and 0.764 Mev. These were ascribed to an antimony isotope having mass number 127, since only the Te (γ, p) reaction took place. An approximate computation of the cross section for Te(γ, pn) reaction in the range of energy used demonstrates that this reaction is at least as equally probable as the other. It is possible, therefore, that these authors had observed the combined activities of Sb^{127} and Sb^{126}, and that the rays determined are a mixture of those corresponding to the two isotopes.

Marty *et al.*[5] have assigned, to the first excited level of Te^{126}, an energy of 0.670 Mev; Perlmann and Welker,[6] one of 0.651 Mev; and Wu and his group,[7] one of 0.650 Mev. On the other hand, by experiments on reactions (n, n′γ) (Ref. 8), (α, $\alpha'\gamma$) (Ref. 9), and (p, p′γ) (Ref. 10) with enriched Te^{126}, energies of 0.680 ± 0.020, 0.662 ± 0.007 and 0.673 Mev respectively were assigned to this level. These figures coincide, within the experimental error, with that obtained in earlier experiments[1] of 0.685 ± 0.015 Mev, pertaining to an antimony having a half-life of approximately 6 days.

In accordance with the data obtained earlier[1] regarding the activity of 149-hour antimony, with the results mentioned above, and with the systematics of the first excited levels of the even–even nuclei, the most probable mass number† for this activity would be 126.

With the double object of finally assigning a mass number to the 149-hour antimony activity on the one hand, and of analyzing the nature of the excited levels of the Te^{126} on the other hand, we made a study of the gamma radiation from Sb^{126}, which was produced by the irradiation of Te^{126} with fast neutrons.

EXPERIMENTS

We irradiated 100 mg of Te^{126} (enriched to 96.5% and supplied by the Atomic Energy Research Establishment, Harwell) for 15 minutes, with fast neutrons from the Be^9(d, n)B^{10} reaction, in which the 28 Mev deuterons were accelerated in the synchrocyclotron of this institute. Without any chemical operation, the sample was examined by means of a single channel scintillation spectrometer using a NaI(Tl) crystal. The half-life of the total gamma activity was found to be 18.8 ± 0.3 min.

A source–crystal distance of 12 cm was chosen in order to reduce the piling up of pulses to about 1%. The gamma spectrum corresponding to the activity obtained when irradiating Te^{126} with fast neutrons in the energy range 0–0.680 Mev is shown in Fig. 1. Because of the low intensity of the source in the high energy area, the short half-life, and the limitation of the pulse selector to a single channel, it was impossible to obtain an energy spectrum with any accuracy, but the half-life was determined by discriminating above 0.900 Mev, and was found to be 18.5 minutes. We observed gamma rays of energies 0.145 ± 0.009, 0.417 ± 0.005, and 0.685 ± 0.002 Mev.

We then irradiated 100 mg of Te^{126} which had been enriched for 6 hours with fast neutrons. Without any

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† At the May 1958 session of the American Physical Society, Orth and Dropesky[11] reported that they had found two antimony activities, one of 19 minutes and the other of about 14 days, produced by the disintegration of a tin isotope of half-life about 10^5 years and both having γ rays with energies of 0.410 and 0.670 Mev.

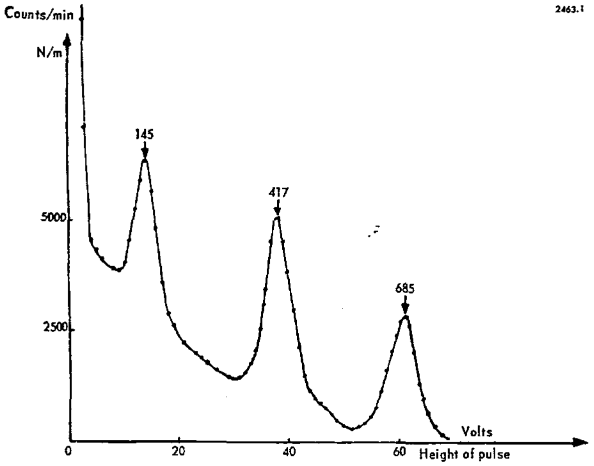

Figure 1. Spectrum from the activity of Sb^{126} having a half-life of 18.8 minutes in the energy range 0–0.685 Mev

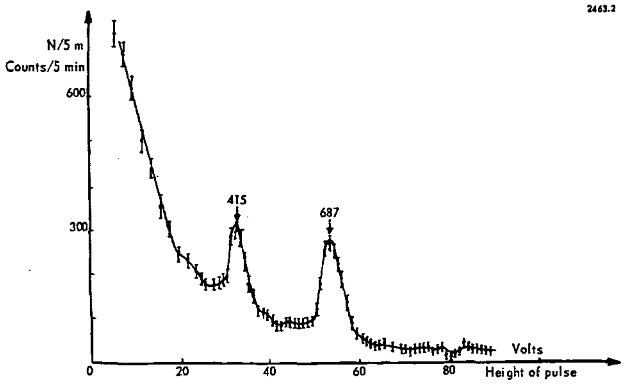

Figure 2. γ spectrum from the activity of Sb^{126} having a half-life of approximately 6 days in the energy range 0–1.300 Mev

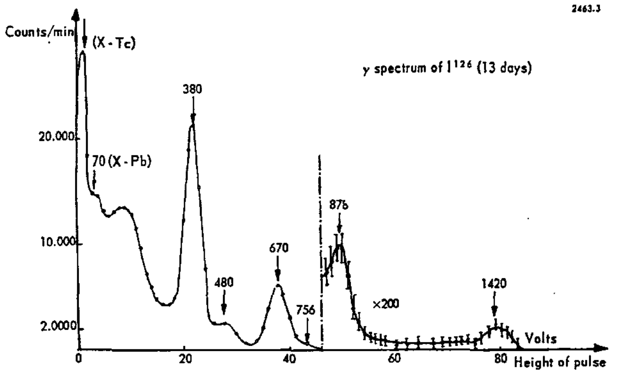

Figure 3. γ spectrum from the decay of I^{126} in the energy range 0–1.420 Mev

chemical operation, we analyzed the gamma spectrum with a single channel scintillation spectrometer. The gamma spectrum which corresponds to an activity having a half-life of about 6 days is shown in Fig. 2, where we see energies of 0.415 ± 0.005 and 0.687 ± 0.003 Mev. There is also some evidence of γ rays of higher energies.

The results inferred from the two activities obtained following the irradiation of Te^{126} by neutrons are found to agree with each other as well as with those obtained by fission. Allowing for the energies and half-lives measured and the analysis of the various reactions which may take place when irradiating Te^{126} with fast neutrons, it is permissible to assume that the activities reviewed are due to the Te^{126} (n, p)Sb^{126} reaction.

There is still an uncertainty, even if we allow for the experimental errors, regarding the value of the energy assigned to the first excited level of Te^{126}. In order to be able to determine it better with more experimental data, we produced an I^{126} activity from the (d, p2n) reaction on I^{127}. Figure 3 shows the gamma spectrum of I^{126}, in an energy range of 0–1.420 Mev. From the analysis of various spectra, we may conclude that there are γ rays of energies 0.380 ± 0.004, 0.480 ± 0.003, 0.670 ± 0.003, 0.756 ± 0.005, 0.878 ± 0.007 and 1.420 ± 0.010 Mev.

CONCLUSIONS

From the experimental results obtained starting from the irradiation of highly enriched Te^{126} by fast neutrons, we may conclude that we achieved the Te^{126}(n, p)Sb^{126} reaction and observed two Sb^{126} activities, one of 18.8 minutes and the other of about

Table 1. Gamma Transitions between Some Levels of Te^{126} as Energized from Various Sources (energies expressed in kev)

Sb^{126} (18.8 *min*)		Sb^{126} (6 *days*)		I^{126} (13 *days*)				Sb^{126} Sb^{127}	*Excited levels, Te^{126}*		
Ref. 2	*This paper*	*Ref.* 1	*This paper*	*Ref.* 6	*Ref.* 5	*Ref.* 7	*This paper*	*Ref.* 4	($n, n'\gamma$) *Ref.* 8	($\alpha, \alpha'\gamma$) *Ref.* 9	($p, p'\gamma$) *Ref.* 10
								60			
	145							185			
								240			
				382	392	386	380				
420	417	417	415					417			
				482		480	480	456			
								563			
650	685	685	687	651	672	650	670	674	680	662	673
				740		750	760	764			
				862		860	878				
	>900	900									
		1100									
		1350		1420		1420	1420		1380		

6 days. The latter may be identified from that obtained from uranium fission.[1] On the other hand, we confirmed existing data regarding the mass number of the antimony of 18.8-minute half-life.

Finally, in accordance with the known experimental results and those obtained in the course of our own work, and taking an average of all the values assigned to the first excited level of Te^{126} (Table 1), and allowing for the cases in which this level is fed by the disintegration of I^{126} or is obtained by nuclear reactions, we find a value of 0.665 ± 0.004 Mev for its energy. We are thus left with a discrepancy between this value and that obtained in the cases in which the same level is supplied by Sb^{126} disintegration.

While we could obtain no difference between the value of the resolution corresponding to the 0.670 Mev peak of I^{126} and that corresponding to the 0.685 peak of Sb^{126}, we have to assume that the 0.685 Mev peak consists of two gamma rays of energies which are close together. This hypothesis is substantiated by the fact that the mean of the values obtained in nuclear reactions, which exclude the possibility of excitation of two neighboring energy levels, is 0.671 ± 0.005 Mev, a value coinciding, within the experimental error, with other values obtained from the decay of I^{126}.

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