Ytterbium-167

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Proton bombardment of pure Tm_2O_3, followed by ion-exchange separations, has yielded an activity with an 18.5-minute half-life. Determination of the excitation function and identification of the daughter Tm^{167} assigns the activity to Yb^{167}. A gamma-ray spectrum shows it to decay by electron capture with a 0.118 Mev and possibly other gamma rays.

CAREFULLY purified Tm_2O_3 was bombarded with 24-Mev protons in the ORNL 86-inch cyclotron.[1] Following bombardment, chemical separations were performed by an ion-exchange method similar to that developed by Ketelle and Boyd.[2] It was necessary to modify the method somewhat in order to obtain a separation rapidly enough to detect the 18.5-minute half-life. The ion exchange column was 35 cm long and 1.8-cm i.d. and was filled with Dowex 50, 250 to 500 mesh; it was heated by a steam jacket. The elutriant, 0.25*M* citric acid adjusted to a *p*H of 3.18 with ammonia, was preheated with steam and infrared heat lamps. The storage bottle for the elutriant was placed 20 feet above the column to produce sufficient hydrostatic pressure for a flow rate of 180 ml/hr. The detection system consisted of a pipette counter[2] with the output of the GM tube fed into a log-count rate meter and then into a Brown recorder to provide a continuous record of the eluted activities.

A typical elution curve, Fig. 1, shows that, with suitable techniques, column separations may be performed on relatively short-lived activities. Absorption on the column was completed and elution began 20 minutes from the end of the bombardment, point *A*. The first peak (*B*) is composed of impurities of anions and divalent cations. The ytterbium peak begins to elute at approximately 2.1 hours from end of bombardment. Analysis of the Yb peak by decay curves and gamma spectra reveals three components: 18.5-minute Yb^{167}, 33-day Yb^{169}, and 9.4-day Tm^{167}. The half-lives for Yb^{169} and Tm^{167} are those actually observed. Analysis of the Tm peak shows it to consist of 9.4-day Tm^{167} and 87-day Tm^{168}. In each case, the half-life was established by following the decay for at least five half-lives. The elution peaks, Fig. 1, are not symmetrical because of the decay of the 18.5-minute Yb^{167} and the grow-in of its daughter, 9.4-day Tm^{167}.

The 73-minute activity assigned to Yb^{167} by Michel[3] was not observed as a component of either peak or of

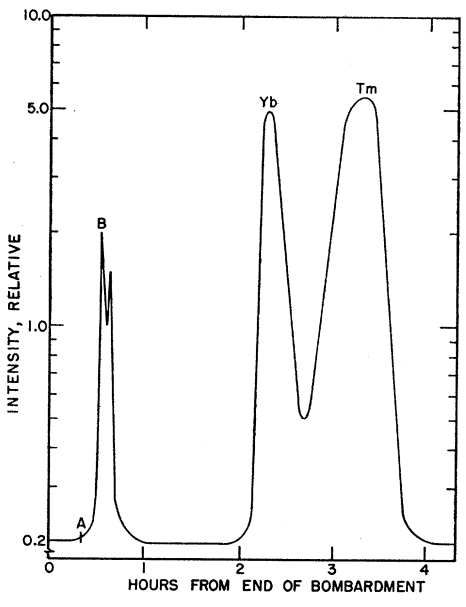

FIG. 1. Elution curve for Yb and Tm.

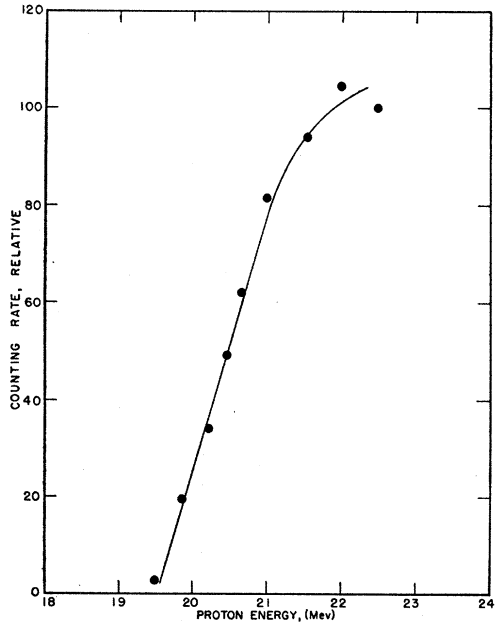

FIG. 2. Excitation function for the reaction $Tm^{169}(p,3n)Yb^{167}$.

[1] R. S. Livingston, Nature **170**, 221 (1952).
[2] B. H. Ketelle and G. E. Boyd, J. Am. Chem. Soc. **69**, 2800 (1947).
[3] L. Michel, University of California Radiation Laboratory Unclassified Report UCRL-2267 (unpublished).

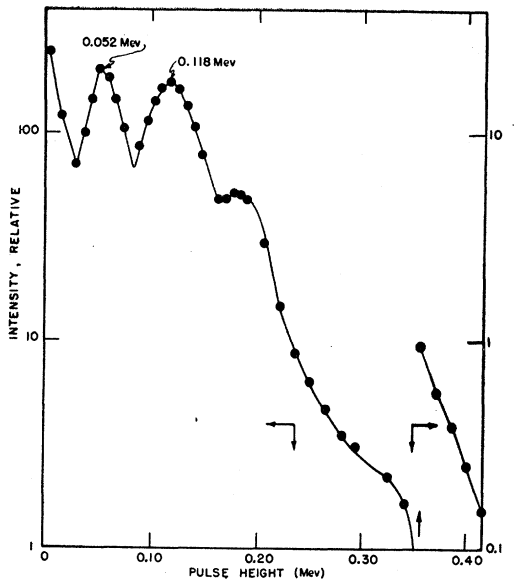

FIG. 3. Gamma-ray spectrum for Yb^{167}.

the gross decay curve obtained before separation. The products were examined specifically for such a half-life by using different counting techniques and by following the decay of various points on the spectrum. If the activity does have a mass of 167, it should have been produced in this bombardment.

For further proof of the mass assignment of the 18.5-minute Yb^{167}, an excitation function, Fig. 2, was determined for production of the activity. This shows a threshold of 19.0±0.5 Mev, which indicates a $(p,3n)$ reaction and, of course, assigns a mass of 167 to the activity.

The gamma-ray spectrum, as measured with a NaI(Tl) scintillation spectrometer, is shown in Fig. 3. A gamma ray of 0.118-Mev energy is apparent, also possible low intensity peaks near 0.18 and 0.33 Mev. The 0.052-Mev peak is the x-ray peak. The 0.51-Mev annihilation peak was not observed; if positrons are present, they constitute a very small fraction of the total radiation.

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Yields of Fission Products from U^{238} Irradiated with Fission Spectrum Neutrons

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A radiochemical investigation of the fission yields of 15 products in the fission of U^{238} is described. The average energy of the neutrons effective in inducing fission is estimated as 2.8 Mev. The familiar twin-peaked yield-mass distribution is observed with a peak-to-trough ratio of 200 to 1. A comparison of the fission yield-mass curve for U^{238} with those for other fissile nuclei is made.

I. INTRODUCTION

RADIOCHEMICAL determinations of the yields of fission products from the fission of various fissile nuclei have indicated that, in general, asymmetric fission results at low energies[1,2] with the contribution from symmetrical modes ("trough"), and perhaps, also very asymmetric modes ("wings"), increasing as the energy content of the compound nucleus is increased.[3–9] With increasing mass of the fissioning nucleus, the light group distribution shifts toward higher masses, while the heavy group remains relatively constant, with perhaps a slight shift in the direction of smaller masses.[3] A tendency toward wider mass distribution with increasing mass of the fissile nucleus has also been noted.[3,10]

Studies have been made of the fission of Th^{232} [10] and U^{238} [11] with fission spectrum (fast) neutrons to extend the knowledge of the characteristics of fission mentioned above. In the earlier U^{238} investigation[11] samples of of U_3O_8 powder, depleted seventeenfold in U^{235}, and normal uranium metal disks were irradiated in a cadmium can placed inside a hollow uranium cylinder. The U_3O_8 powder became contaminated with Cd^{115} in the process of opening the activated cadmium container making it impossible to determine directly in the depleted uranium the fission yield of Cd^{115} (which essentially establishes the trough yield). An attempt was therefore made to calculate this yield from the

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