Fission Yield of Gd^{159} and Tb^{161}

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Normal uranium, irradiated with thermal neutrons, has been examined for the presence of Gd^{159} and Tb^{161}. Both isotopes were found and their fission yields measured. For purposes of calibration, the yields for Sm^{153} and Eu^{156} have also been determined. The chemical separations were made using a combination of ion exchange and extraction techniques.

RECENTLY, the formation of Gd^{159} (18 hr), and Tb^{161} (7.0 days) in uranium fission has been reported.[1] Similar work was proceeding independently in this laboratory at the time, and since no fission yields of gadolinium or terbium were published, their determination was undertaken.

Two 0.43-gram samples of U_3O_8, I-1, and I-2, were irradiated for 7 days in the Oak Ridge reactor at 50 percent maximum flux. Besides the gadolinium and terbium measurements, the fission yields of Sm^{153} (46.8 hours) and Eu^{156} (15.4 days) were also determined for calibration purposes. All values were calculated on the basis of a Mo^{99} thermal fission yield of 6.2 percent.[2] The values obtained are listed in Table I.

The chemical purification consisted, briefly, of the following steps:

To an aliquot containing at least 5×10^{14} fissions, 10 mg each of the four rare earths were added. Samarium and europium were extracted with sodium amalgam from an acetate-acetic acid buffer. The samarium and europium were then separated from each other, and from the 60 percent of the Np^{239} that was also extracted, on a 45-cm column of 200–400 mesh, ammonium form Dowex 50-X4, 0.9 cm^2 in area, and maintained at 80°C. The elutriant, 4.25 percent lactic acid, *p*H 3.42, was passed through the bed at 30 ml/hour. The terbium and gadolinium were separated from each other, as well as from yttrium and the other rare earths, on an identically operated column. The elution pattern for the four rare earths and yttrium is plotted in Fig. 1.

TABLE I. percent fission yields.

Isotope	I-1	I-2
Sm^{153}	1.3×10^{-1}	1.3×10^{-1}
Eu^{156}	1.2×10^{-2}	1.2×10^{-2}
Gd^{159}	1.1×10^{-3}	1.0×10^{-3}
Tb^{161}	7.4×10^{-5}	7.1×10^{-5}

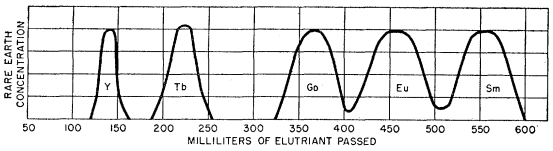

FIG. 1. The elution of rare earths from Dowex 50-X4 with 4.25 percent lactic acid, *p*H 3.42, at 80°C.

In actual practice, of course, all five elements were not eluted from the same column.

All samples were counted on an aluminum end-window proportional-flow counter. The counting rates were corrected for self absorption, scattering, and for air and window losses. The instrument's geometry was assumed to be identical for all samples being counted since all mounts were of the same dimensions.

Finally, no allowances were made for the possible presence of gadolinium impurity in the uranium except that prior to the irradiation, reagent grade uranium was subjected to several purification steps designed to remove trace quantities of rare earths.

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[1] E. C. Freiling and L. R. Bunney, J. Am. Chem. Soc. **76**, 1021 (1954).

[2] Finkle, Hoagland, Katcoff, and Sugarman, *Radio Chemical Studies: The Fission Products* (McGraw-Hill Book Company, Inc., New York, 1951), Paper No. 96, National Nuclear Energy Series, Plutonium Project Record, Vol. 9, Div. IV.